E-ELT PROGRAMME

THE E-ELT DESIGN REFERENCE SCIENCE PLAN

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1	09/08/2010	All	First Issue
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Contents

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1 Scope

This document presents the outcome of the E-ELT Design Reference Science Plan (DRSP). The DRSP was set-up in order to capture the broad input of the community to the E-ELT detailed design phase. Close to 200 science cases were collected by the DRSP. They statistical analysis is presented in this document together with first conclusions with respect to telescope, instruments and operations.

2 Applicable/Reference Documents

Applicable documents:

AD1 E-ESO-SPE-313-0066 Issue 4, 30.3.2010, Common definitions and acronyms

Reference documents:

RD1 E-TRE-ESO-725-0639 Issue 1, 7.1.2010, Operational Requirements from ELT DRSP Science Cases

3 Executive Summary

The E-ELT Design Reference Science Plan (DRSP) was designed and conducted to explore the full range of science cases for which the E-ELT will be used. It was meant to be a large collection of science cases provided directly by the future users of the E-ELT. Ultimately, it helped to define the boundaries of the parameter space over which the E-ELT will operate. It was used to guide the performance optimisation of the telescope, the prioritisation of the instruments, as well as to plan the science operations modes.

The DRSP differs fundamentally from the Design Reference Mission (DRM). The DRM focusses on a few selected, prominent science cases that are being simulated in detail (partly end-to-end) in order to better understand the observatory's performance for these key science areas, and to assist critical design decisions. The DRSP, in contrast, does not attempt to detail the individual science cases, but rather explores the broad spectrum of science planned at the E-ELT by the community.

The DRSP was launched at JENAM 2008 in Vienna. In order to collect input efficiently from the community, the DRSP was set-up as a web questionnaire, guiding the users through the submission of a dummy proposal for the E-ELT. The questionnaire prompted for the science case (title, abstract, category, …), the identity of the authors (institute, stage of career, …) before getting into the details of the targets, spatial requirements, spectral requirements, type of instrumentation required, operations requirements, synergies, etc. The users were guided through the submission.

The questionnaire was available to the community from September 2008 until June 2009. During that period, 187 science cases were submitted by 151 principal investigators from 73 institutes across Europe. This well exceeded our goal to collect at least 100 cases. The entries have been collected in a large database and were analysed statistically. The information of each DRSP submission was collected under 9 main sections: General Information, Author Information, Target Information, Spatial Information, Spectral Information, Instrument Information, Time Requirements, Operational Information and Additional Information that prompts for synergies and critical aspects of the science case. The data were analysed in terms of i) number of DRSP cases, ii) the total time required for observations and iii) the sufficient time required by observations.

Proposals have been received from all ESO member states. The UK, Germany and Spain feature prominently, followed by Italy and France. The number of ESO proposal was partly artificially inflated by the E-ELT Science Office who additionally "submitted" all those DRM cases not already covered by the community. About 2/3 the PIs were faculty member, the other 1/3 being made up by post-doctoral researchers.

The proposals were classified in the four categories established for the ASTRONET Roadmap (see www.astronet-eu.org). Three quarters of the proposal were shared between the categories "How do galaxies form and evolve?" and "What is the origin and evolution of stars and planetary systems?".

On the technical side, all instruments studied in phase A have been requested and almost all equally, with a slightly higher number of proposals for the only mid-infrared instrument, and a slightly lower one for the most specialised instrument: the planet finder. However, analysed in terms of total and sufficient time required by observations, the high resolution, high stability visual spectrograph takes the highest percentage, and the preference for the planet- finder increases, whereas the slightly less requested instrument was the diffraction-limited near-infrared camera. Only very few proposals requested capabilities not included in the current studies, confirming that the suite of instruments presently under investigation covers the entire needs of the community.

In terms of spatial resolution, the largest share went to diffraction limited image quality. Not surprisingly, beating even the JWST spatial resolution at a given wavelength by a factor of seven unleashed some ambitious science thoughts. A quarter of the proposals requested seeing limited image quality though; partly because towards the blue end of the wavelength range not much better spatial resolution will be available (at least in the first years), and partly because some high resolution spectroscopy cases did not need high spatial resolution, but rather use the E-ELT as giant light collecting bucket (1200m^2 indeed far exceed the 50m^2 of the VLT). Overall, time-wise the high spatial resolution ($\leq$ 50 mas) observations and lower spatial resolution ($\geq$75 mas and seeing limited) share the time equally.

The field-of-views were requested accordingly: 85% of the proposal requested 1 arcmin or less, still 60% requested a field of view of 10 arcsec or less.

The range of requested spectral resolution is very wide. About a quarter of the proposals requested broad or narrow band imaging, the rest spreads from R~100 to R~100.000. Peaks are seen near the 'standard' NIR resolutions (3000 – 10.000) and above R~50.000.

The targets of the proposals have a very uniform distribution in right ascension. In terms of declination, targets in the Southern hemisphere (declination < 15 degrees) prevail over the targets in the Northern hemisphere (declination > -15 degrees).

Finally, the authors were asked to indicate whether their proposal would work in synergy with another facility. More than a third of the proposals mentioned JWST, and about a fourth mentioned VLT/VLTI. The next most mentioned ones are the ALMA and the SKA (incidentally all located in the Southern Hemisphere).

Overall, the DRSP was an extremely useful direct input of the community to the project. It has led to direct requirements on the operation scheme, and guided strongly the Science Working Group in their recommendations.

Note the DRSP science cases will not be retained for execution once the E-ELT has taken up operations. They were collected for statistical purposes only.

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4 Introduction

4.1 Aim

Design Reference Science Plan (DRSP) was designed and conducted to explore the full range of science cases for which the E-ELT will be used. Ultimately, it provides help in defining the boundaries of the parameter space over which the E-ELT will operate. It is used to guide the performance optimisation of the telescope, the prioritisation of the instruments, as well as to plan the science operation modes.

4.2 Method

DRSP was set up as a web questionnaire to collect the input from the community efficiently. The web questionnaire remained open from 8 September 2008 until 30 June 2009. The questionnaire was designed to collect information for dummy proposals for the E-ELT. In total 41 questions were posed where 21 of them were mandatory. The full web form is given in Appendix B.

The web questionnaire started with questions related to the science case such as the title, abstract of max. 100 words, to which of the four ASTRONET categories the science case belongs, critical aspects and limiting factors of the science case and an optional detailed description. There were also questions related to the identity of the authors such as the institute, country of employment and stage of career of the PI. The majority of the questions were related to the details of the targets, spatial requirements, spectral requirements, type of instrumentation required, operations requirements, and synergies. There were 9 yes/no questions with a blank field to specify the details in case the answer was positive. In almost all multiple choice questions there was an “other” field where the user could specify, if needed, a choice that was not listed. The only multiple choice questions which did not have an “other” fields were Project Category (where the users could only select one of the four ASTRONET categories), Spatial Resolution, Field-of-View, Spectral Resolution, and AO for which, however, there was an option labeled “best for my needs”.

The users were guided through the submission both with an explanation text at the top of the web page and via prompt help/explanation texts that appeared as the mouse was hovered over each question.

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5 DRSP Statistics

The information of each DRSP submission is collected under 9 main sections: General Information, Author Information, Target Information, Spatial Information, Spectral Information, Instrument Information, Time Requirements, Operational Information and Additional Information that prompts for synergies and critical aspects of the science case. Each of these sections contained questions or fields to collect relevant information, the analysis of which will be presented in the same order as in the DRSP questionnaire.
The basic histogram analysis are presented in terms of i) number of DRSP cases, ii) the total time asked and iii) the sufficient time asked by the submitters.

5.1 General Information

The General Information section of the DRSP prompted for the information regarding the science case, like the title and the category of the project.

5.1.1 Project Title

The project titles of the 187 DRSP science cases can be seen in the Appendix A. These titles were used to uniquely identify each science case in case of re-submissions or corrections to the submitted science cases.

5.1.2 Project Category

The proposals were classified in the four categories established for the ASTRONET Roadmap (see www.astronet-eu.org): 1. “Do we understand the extremes of the Universe?”, 2. “How do galaxies form and evolve?”, 3. “What is the origin and evolution of stars and planetary systems?” and 4. “How do we fit in?”. This is done both to link the E-ELT with ASTRONET and to have a prospect on what the future science topics will be.

Three quarters of the proposal were shared between the categories “How do galaxies form and evolve?” and “What is the origin and evolution of stars and planetary systems?”.

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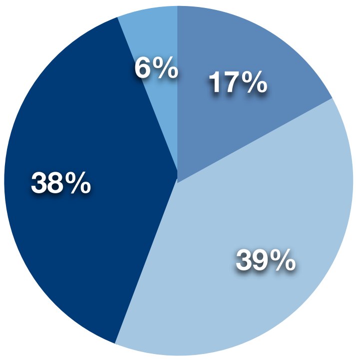
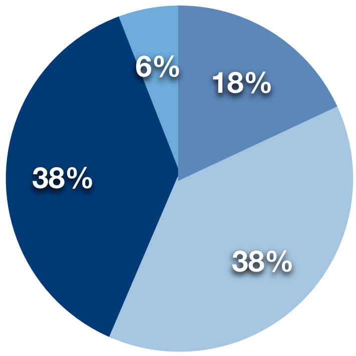
Project Category	# of DRSP submissions	Total time (hr)	Sufficient time (hr)
1 - Do we understand the extremes of the universe?	32	9045	4257.1
2 - How do galaxies form and evolve?	73	19310.5	8179.55
3 - What is the origin and evolution of stars and planetary systems?	72	18895	7793.45
4 - How do we fit in?	11	2918	1080.46

- 1 - Do we understand the extremes of the universe?
- 2 - How do galaxies form and evolve?
- 3 - What is the origin and evolution of stars and planetary systems?
- 4 - How do we fit in?

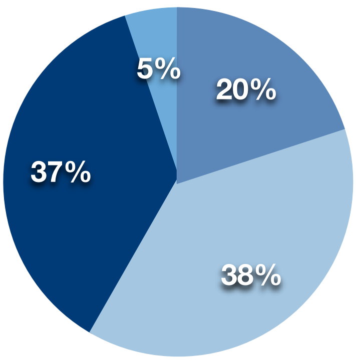
Project Category per # of DRSP submissions



Project Category per Total time



Project Category per Sufficient time



The distribution of the project categories were also analysed w.r.t. the selected spatial resolution, spectral resolution, instrument, field-of-view and the wavelength range.

In terms of spatial resolution, more than a quarter of all DRSP submissions fall under the project category 3 with diffraction limited observations.

The majority of the cases, in terms of number of DRSP proposals in the project category 1, ask for diffraction limited observations. However, when analysed in terms of total time or sufficient time required by the DRSP proposals, the majority of the cases in project category 1 ask for seeing limited observations.

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For project category 2, the required spatial resolution is almost equally distributed over the provided range with a slight excess of seeing limited observations.

For project category 3, diffraction limited observations vastly dominate, whereas the spatial resolutions asked by rest of the of the cases in this category are distributed almost equally over the provided range with a slight excess of seeing limited observations.

For project category 4, there is no clear preference for any of the provided spatial resolutions.

Project Category	Spatial Resolution	# of DRSP submissions	Total time (hr)	Sufficient time (hr)
1	diffraction	13	1320	210.9
1	5 mas	0	0	0
1	10 mas	2	400	130
1	50 mas	2	55	34
1	75 mas	0	0	0
1	100 mas	2	120	60
1	250 mas	1	400	200
1	seeing	12	6750	3622.2
2	diffraction	15	2451.5	1036
2	5 mas	2	900	475
2	10 mas	8	1191	674.95
2	50 mas	10	2886	1424.35
2	75 mas	8	3726	902.2
2	100 mas	5	960	521
2	250 mas	5	900	600
2	seeing	20	6296	2546.05
3	diffraction	37	11879	4252.75
3	5 mas	2	190	38
3	10 mas	10	920	366.3
3	50 mas	7	1300	575
3	75 mas	1	500	250
3	100 mas	4	660	316
3	250 mas	2	58	13
3	seeing	9	3388	1982.4
4	diffraction	2	124	27.2
4	5 mas	1	800	720
4	10 mas	1	500	50
4	50 mas	1	500	50
4	75 mas	0	0	0
4	100 mas	0	0	0
4	250 mas	1	500	50
4	seeing	5	494	183.26

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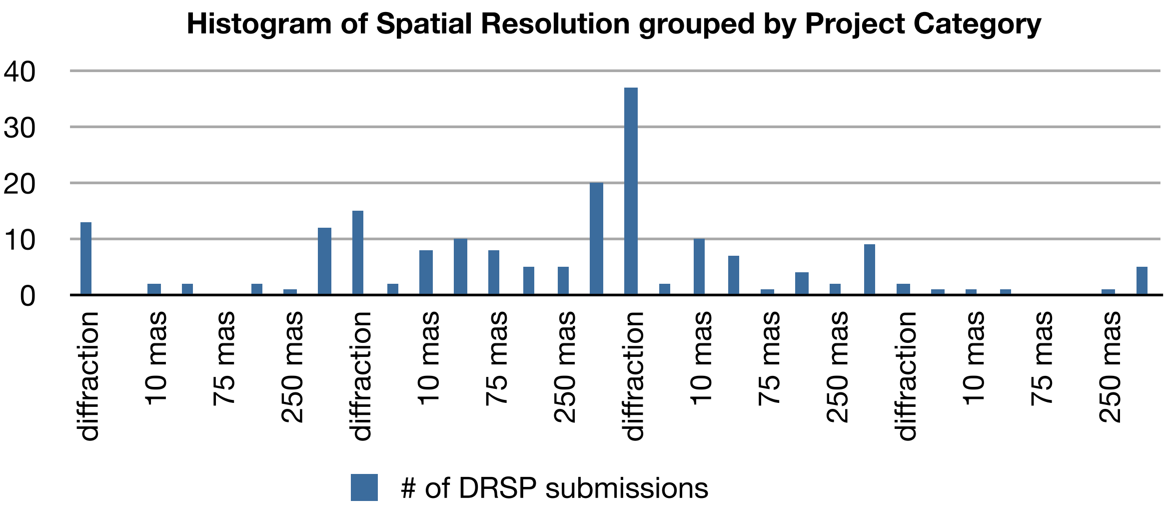

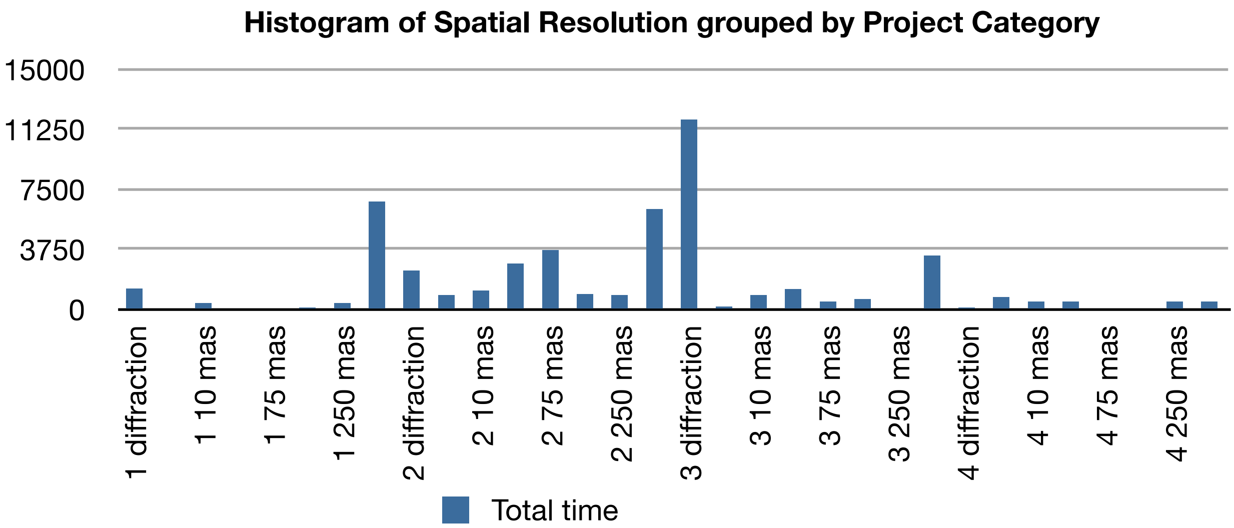

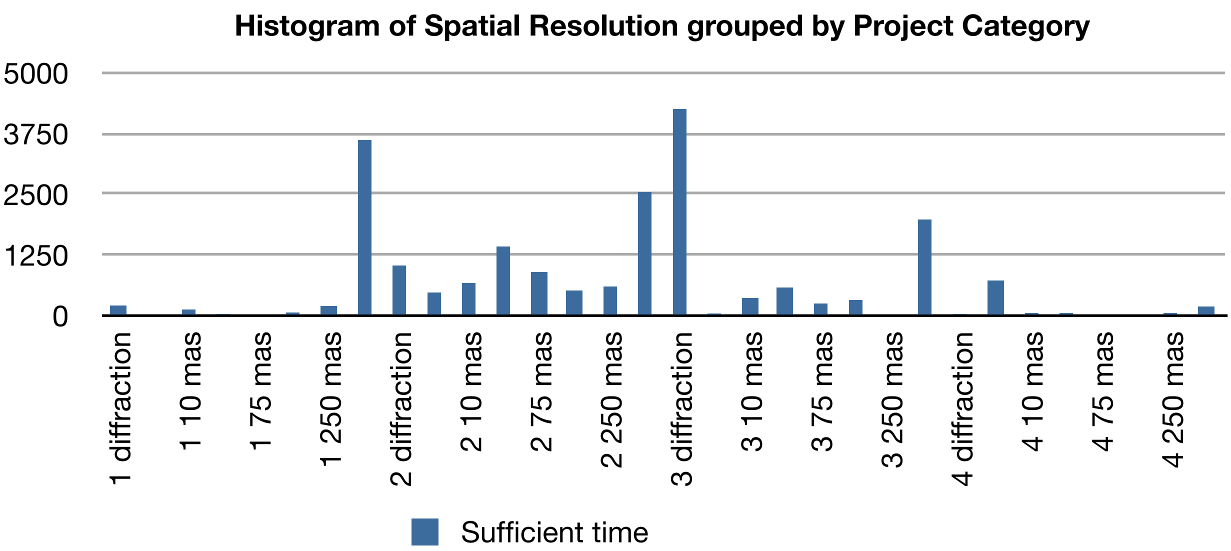

There is no obvious dominating case when distributed in terms of the number of DRSP proposals based on the required spectral resolution for all project categories.

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For project category 1, the broad-band imaging cases dominate when analysed in terms of the number of DRSP proposals. However, the cases that require very high spectral resolution (R > 100000) clearly take over in terms of the total time and sufficient time required by the observations.

The spectral resolution requirements in the project category 2 are dominated by the cases asking for medium spectral resolution (R~3000 – 10000).

For project category 3 and 4, the spectral resolution requirements are gathered at the two ends of the resolution range: imaging and very high resolution cases (R > 50000).

Project Category	Spectral resolution	# of DRSP cases	Total time (hr)	Sufficient time (hr)
1	broad-band imaging	13	1395	285.2
1	narrow-band imaging	8	1543	765.5
1	100-300	3	1400	750
1	300-500	4	1700	780
1	500-1000	4	227	176.4
1	1000-2000	6	300	159
1	2000-3000	5	400	200
1	3000-5000	8	930	309
1	5000-10000	9	1100	542
1	10000-20000	3	240	154
1	20000-50000	3	300	200
1	50000-100000	3	300	110
1	>100000	4	4350	2760
2	broad-band imaging	9	1755	770
2	narrow-band imaging	4	895	513.5
2	100-300	0	0	0
2	300-500	0	0	0
2	500-1000	2	216	203.2
2	1000-2000	8	2450	775.3
2	2000-3000	7	1790	845
2	3000-5000	23	7617	3604.15
2	5000-10000	17	5246	1963.4
2	10000-20000	10	2907.5	1572.65
2	20000-50000	2	540	110
2	50000-100000	7	1459	784.5
2	>100000	5	1380	744
3	broad-band imaging	24	4158	1456.3
3	narrow-band imaging	11	1882	601.55
3	100-300	8	4860	1383.5
3	300-500	4	950	380
3	500-1000	3	2750	1625
3	1000-2000	1	100	30
3	2000-3000	3	700	330
3	3000-5000	4	542	218.5
3	5000-10000	3	950	325
3	10000-20000	11	1548	697.2

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Project Category	Spectral resolution	# of DRSP cases	Total time (hr)	Sufficient time (hr)
3	20000-50000	6	1590	305
3	50000-100000	16	3037	1093.5
3	>100000	8	2408	1688.4
4	broad-band imaging	2	824	725.76
4	narrow-band imaging	1	15	7.5
4	100-300	1	300	30
4	300-500	0	0	0
4	500-1000	4	1070	162.5
4	1000-2000	1	55	55
4	2000-3000	1	55	55
4	3000-5000	0	0	0
4	5000-10000	0	0	0
4	10000-20000	0	0	0
4	20000-50000	1	24	7.2
4	50000-100000	2	600	135
4	>100000	2	200	105

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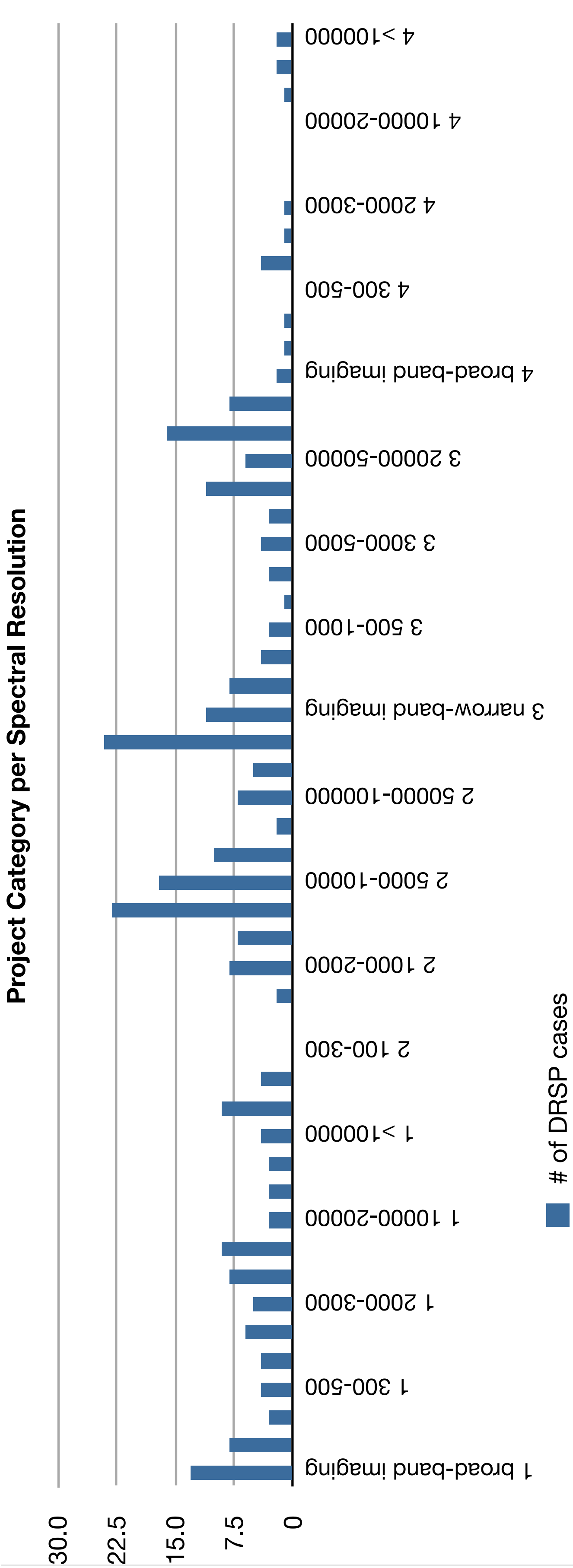
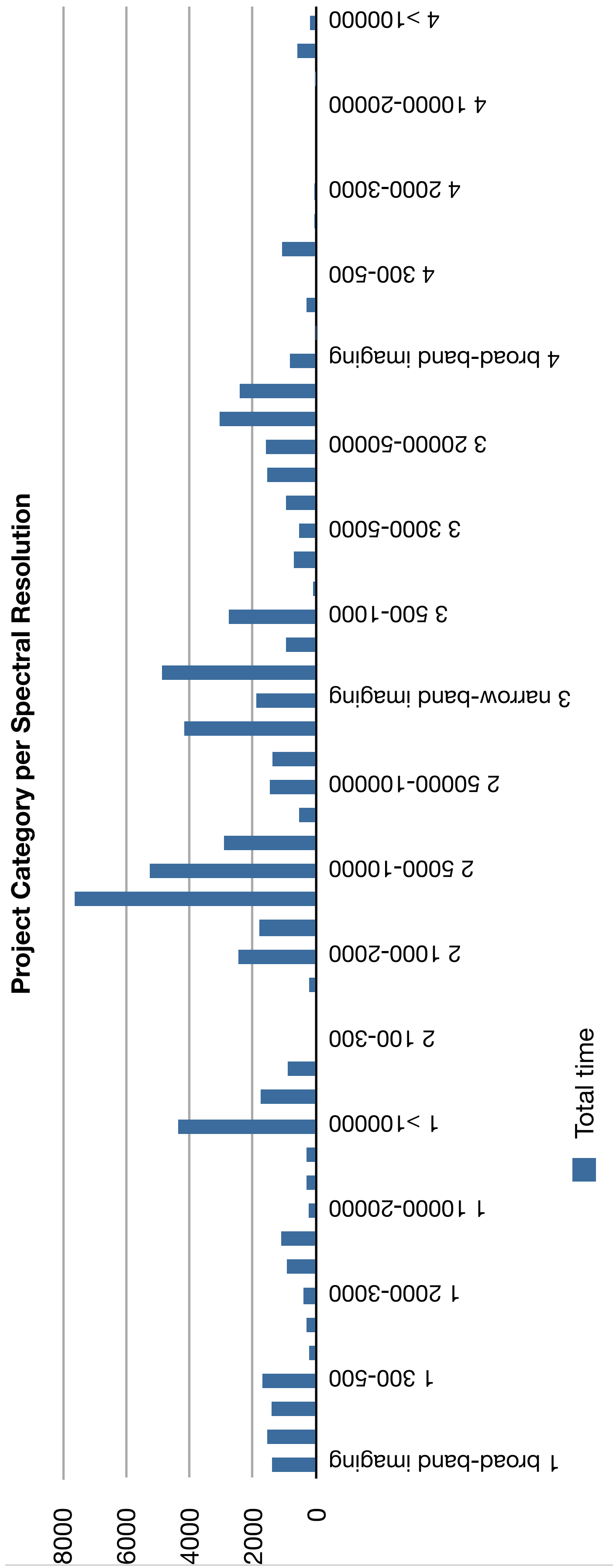
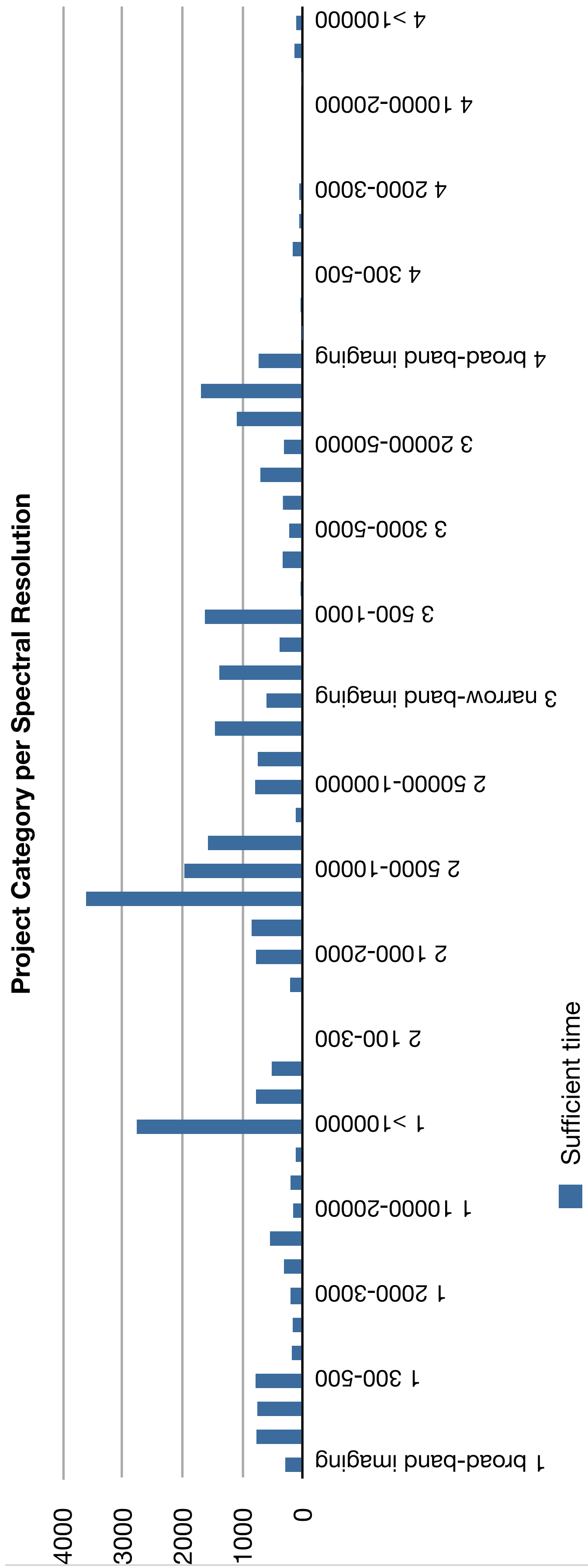

Project Category per Spectral Resolution
30.0
22.5
15.0
7.5
0
1 broad-band imaging
1 300-500
1 2000-3000
1 10000-20000
1 >100000
2 100-300
2 1000-2000
2 5000-10000
2 50000-100000
3 narrow-band imaging
3 500-1000
3 3000-5000
3 20000-50000
4 broad-band imaging
4 300-500
4 2000-3000
4 10000-20000
4 >100000
# of DRSP cases


Project Category per Spectral Resolution
8000
6000
4000
2000
0
1 broad-band imaging
1 300-500
1 2000-3000
1 10000-20000
1 >100000
2 100-300
2 1000-2000
2 5000-10000
2 50000-100000
3 narrow-band imaging
3 500-1000
3 3000-5000
3 20000-50000
4 broad-band imaging
4 300-500
4 2000-3000
4 10000-20000
4 >100000
Total time


Project Category per Spectral Resolution
0
1000
2000
3000
4000
1 broad-band imaging
1 300-500
1 2000-3000
1 10000-20000
1 >100000
2 100-300
2 1000-2000
2 5000-10000
2 50000-100000
3 narrow-band imaging
3 500-1000
3 3000-5000
3 20000-50000
4 broad-band imaging
4 300-500
4 2000-3000
4 10000-20000
4 >100000
Sufficient time

With regard to the distribution in terms of instruments requested by the DRSP proposals: METIS dominates in project category 3 and OPTIMOS in project category 2 when analysed in terms of the number of DRSP cases. On the other hand, when analysed in terms of total time and sufficient time required by the observations, this dominance vanishes. Note that, EPICS is only asked by cases that fall into the project category 3, and one case in project category 4.

For project category 1, the instruments are almost equally distributed in terms of the number of DRSP cases. In terms of the total time and sufficient time, CODEX dominates the instruments asked by the DRSP cases in project category 1.

For project category 2, there is no dominating instrument choice when analysed in terms of the number of DRSP cases. However OPTIMOS, EAGLE and HARMONI are preferred when analysed in terms of the total time and sufficient time required by the observations.

For project category 3, METIS is the dominant choice in terms of the number of DRSP cases, whereas EPICS take over when analysed in terms of the total time and sufficient time required by the observations.

For project category 4, METIS dominates the instrument choices in terms of the number of DRSP cases and the total time required, whereas EPICS is also prominent when analysed in terms of the sufficient time required by the observations.

Instrument	Project Category	# of DRSP cases	Total time (hr)	Sufficient time (hr)
METIS	1	5	242	64.4
SIMPLE	1	3	500	210
OPTIMOS	1	9	1505	573
MICADO	1	8	945	87
HARMONI	1	5	980	218
EAGLE	1	4	270	113
CODEX	1	4	4400	2800
EPICS	1	0	0	0
OTHER	1	10	1013	465.5
METIS	2	5	1725	642.5
SIMPLE	2	4	680	350.15
OPTIMOS	2	19	6472	2815.55
MICADO	2	11	1393.5	555.7
HARMONI	2	15	3213	1903
EAGLE	2	16	5615	2094.5
CODEX	2	8	1829	818.5
EPICS	2	0	0	0
OTHER	2	5	924	653
METIS	3	26	4045	1556.85
SIMPLE	3	13	2974	1115
OPTIMOS	3	7	1320	616
MICADO	3	13	2202	751.5

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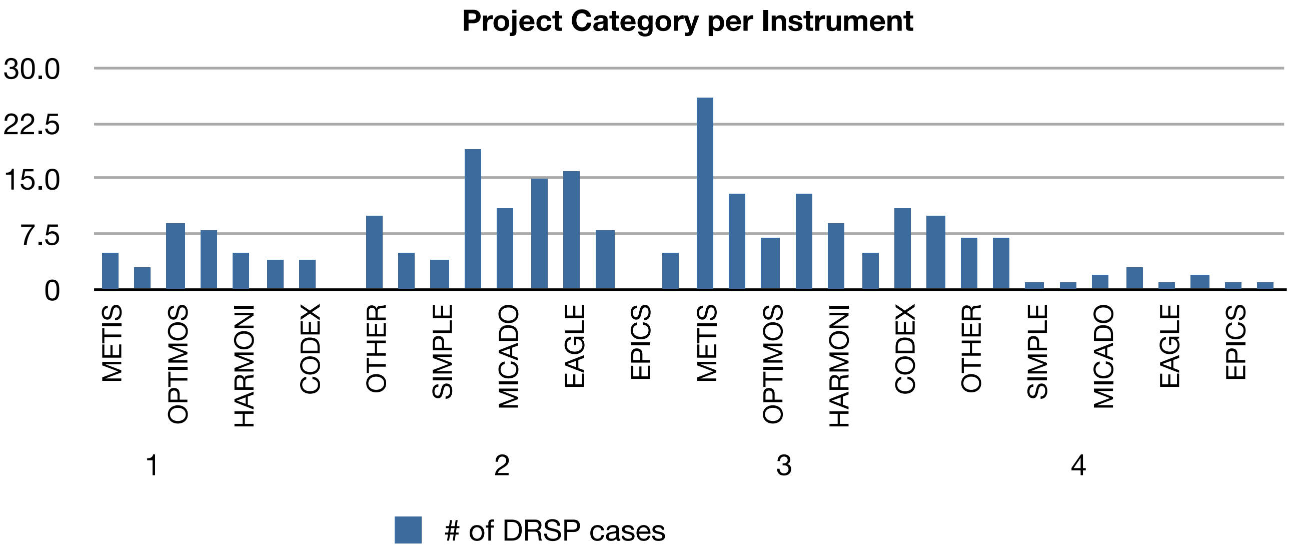
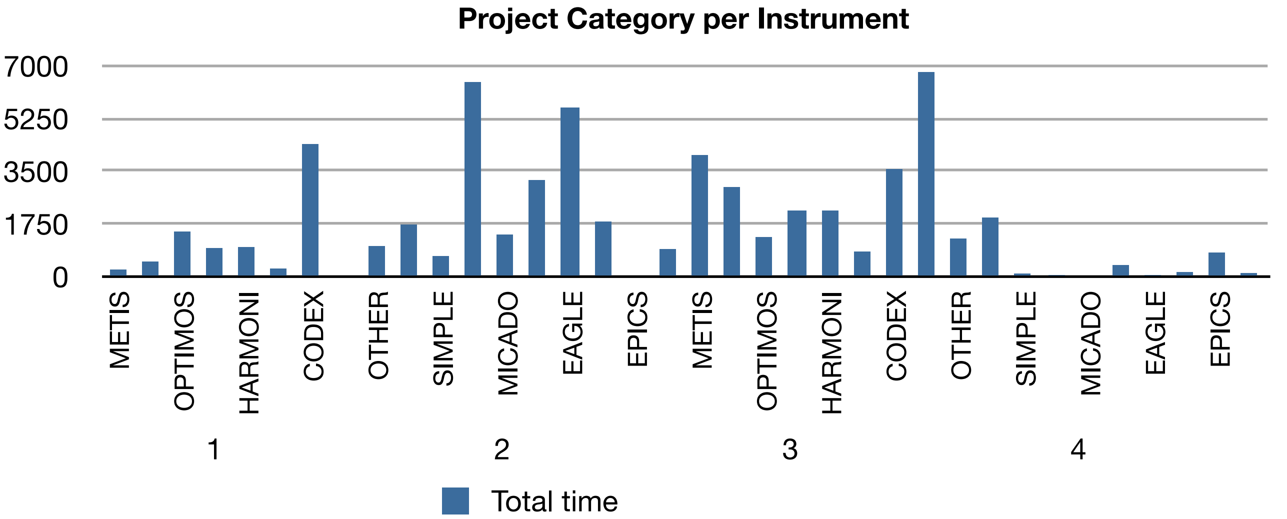
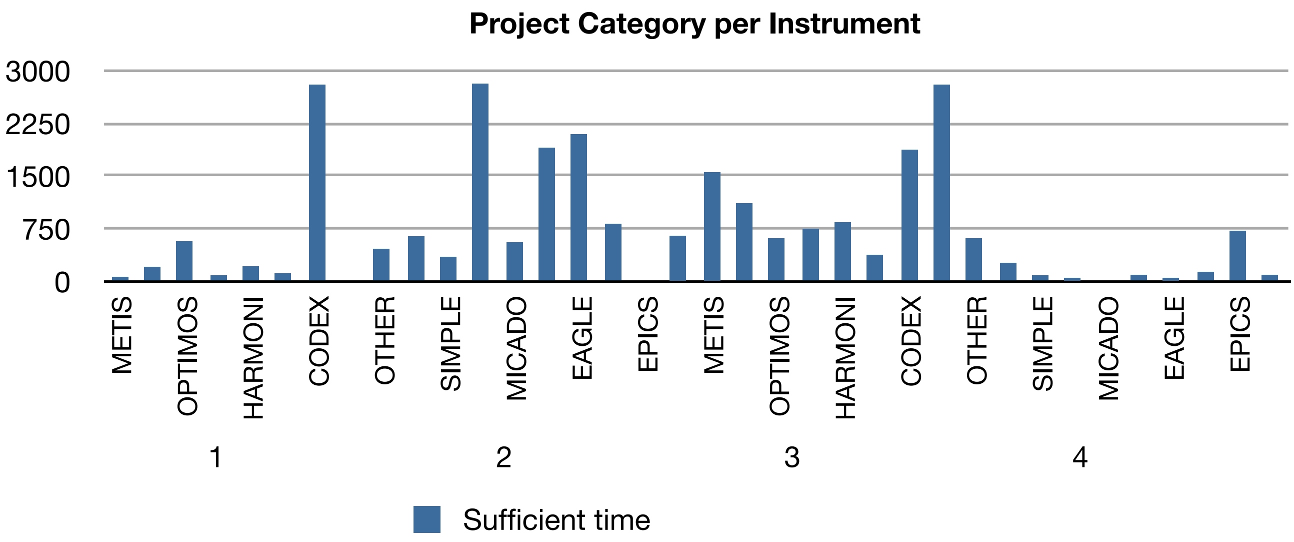
Instrument	Project Category	# of DRSP cases	Total time (hr)	Sufficient time (hr)
HARMONI	3	9	2202	843.5
EAGLE	3	5	830	381
CODEX	3	11	3576	1872.4
EPICS	3	10	6790	2797
OTHER	3	7	1268	615.2
METIS	4	7	1970	262.5
SIMPLE	4	1	100	85
OPTIMOS	4	1	55	55
MICADO	4	2	39	13.26
HARMONI	4	3	379	92.2
EAGLE	4	1	55	55
CODEX	4	2	155	140
EPICS	4	1	800	720
OTHER	4	1	115	92.5







In terms of the field-of-view (FoV) required by the DRSP proposals, for cases in project category 1, FoVs of 30´´×30´´ – 1´×1´ seems to be preferred when analysed in terms of the number of DRSP cases. However, the cases asking for fibre dominates when analysed in terms of the total time and sufficient time required by the observations.

For project category 2, the required FoVs are almost equally distributed with a deficiency of longslit observations and 2´×2´ FoV.

For project category 3, the small FoVs from 1´´×1´´ to 5´´×5´´ dominates.

The required FoVs in project category 4 are slightly dominated by FoVs of 30´´×30´´ – 1´×1´ when analysed in terms of the total time and sufficient time required by the observations.

Project Category	Field-of-view	# of DRP submisions	Total time (hr)	Sufficient time (hr)
1	1x1 arcsec	0	0	0
1	2x2 -5x5 arcsec	3	550	190
1	10x10arcsec	5	835	411.5
1	30x30arcsec - 1x1 arcmin	10	1392	143.1
1	2x2arcmin	1	40	4
1	5x5arcmin	3	128	36.5
1	10x10arcmin	2	280	28
1	fiber	3	4300	2750
1	longslit	5	1520	694
2	1x1arcsec	13	2985	1686
2	2x2 - 5x5 arcsec	10	2088.5	819.6
2	10x10arcsec	10	3257	1631.9
2	30x30 arcsec - 1x1arcmin	9	2028	511.8

Project Category	Field-of-view	# of DRP submisions	Total time (hr)	Sufficient time (hr)
2	2x2arcmin	3	311	134.2
2	5x5arcmin	13	2177	863.4
2	10x10arcmin	9	3770	1589.65
2	fiber	5	2670	931
2	longslit	1	24	12
3	1x1arcsec	18	6615	1945.5
3	2x2 - 5x5 arcsec	20	6546	3718.8
3	10x10arcsec	13	2093	855
3	30x30 arcsec - 1x1arcmin	4	1181	242.55
3	2x2arcmin	3	860	430
3	5x5arcmin	0	0	0
3	10x10arcmin	3	390	145
3	fiber	6	992	406.4
3	longslit	5	218	50.2
4	1x1 arcsec	0	0	0
4	2x2 - 5x5 arcsec	3	579	112.2
4	10x10arcsec	1	500	50
4	30x30arcsec - 1x1 arcmin	2	815	727.5
4	2x2arcmin	1	24	5.76
4	5x5arcmin	1	300	30
4	10x10arcmin	0	0	0
4	fiber	1	100	85
4	longslit	2	600	70

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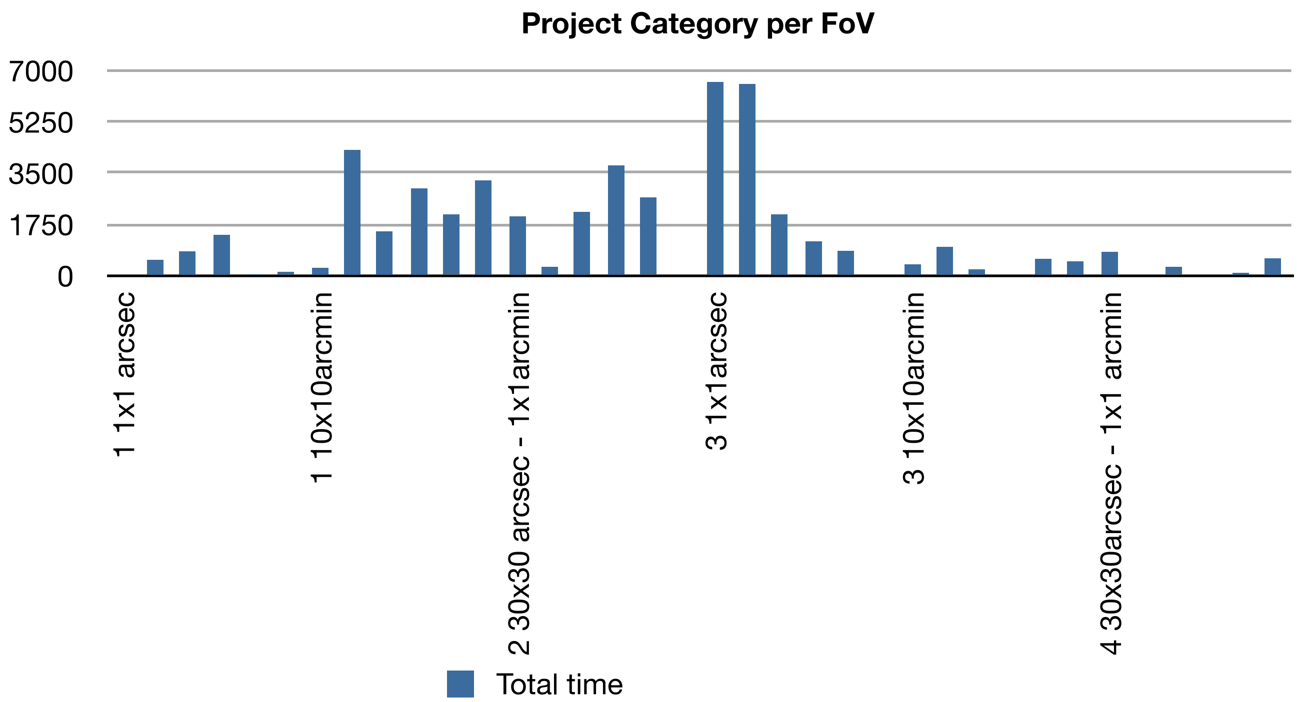
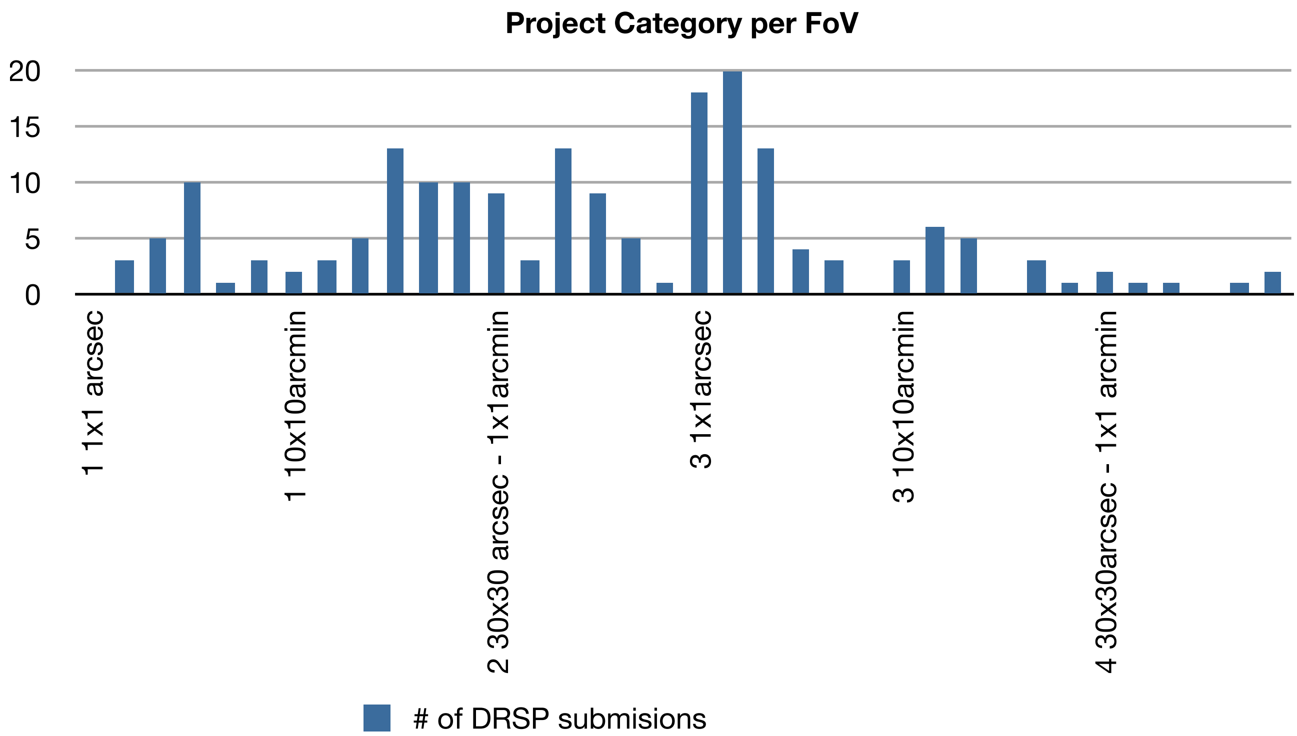
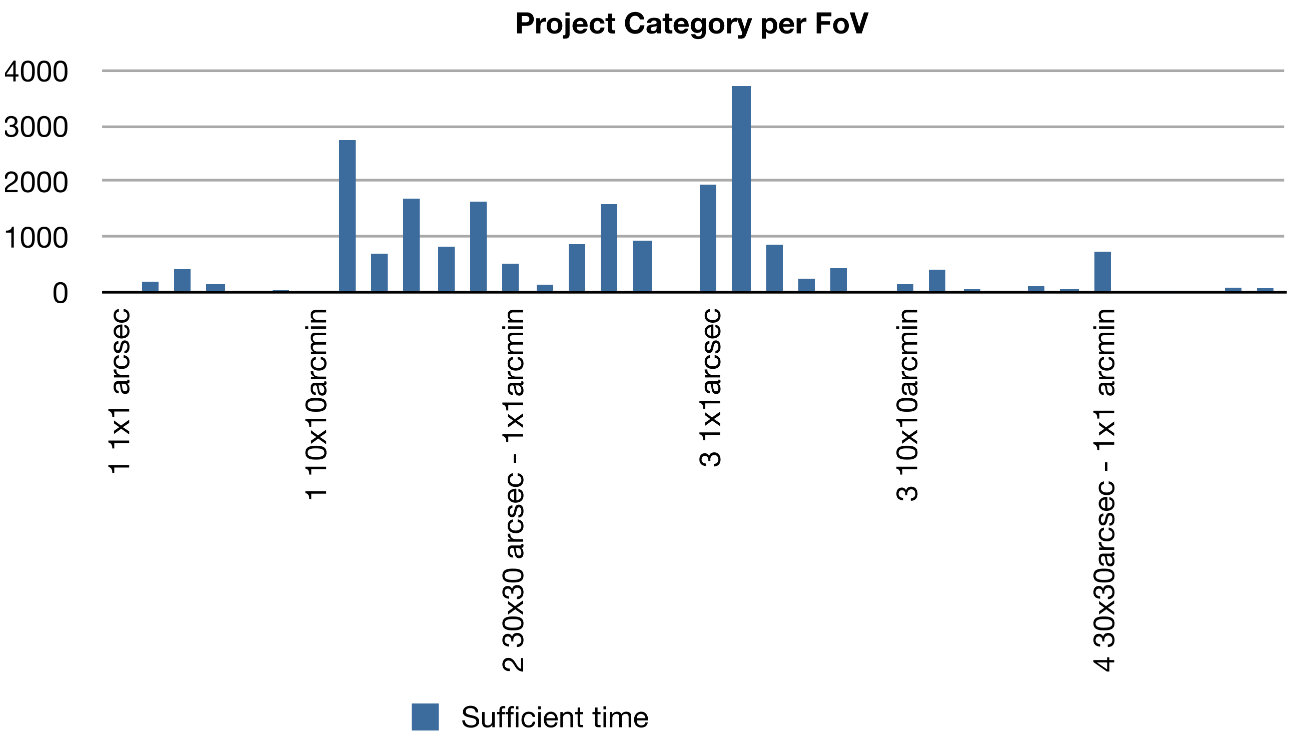

Project Category per FoV
7000
5250
3500
1750
0
1 1x1 arcsec
1 10x10arcmin
2 30x30 arcsec - 1x1arcmin
3 1x1arcsec
3 10x10arcmin
4 30x30arcsec - 1x1 arcmin
Total time

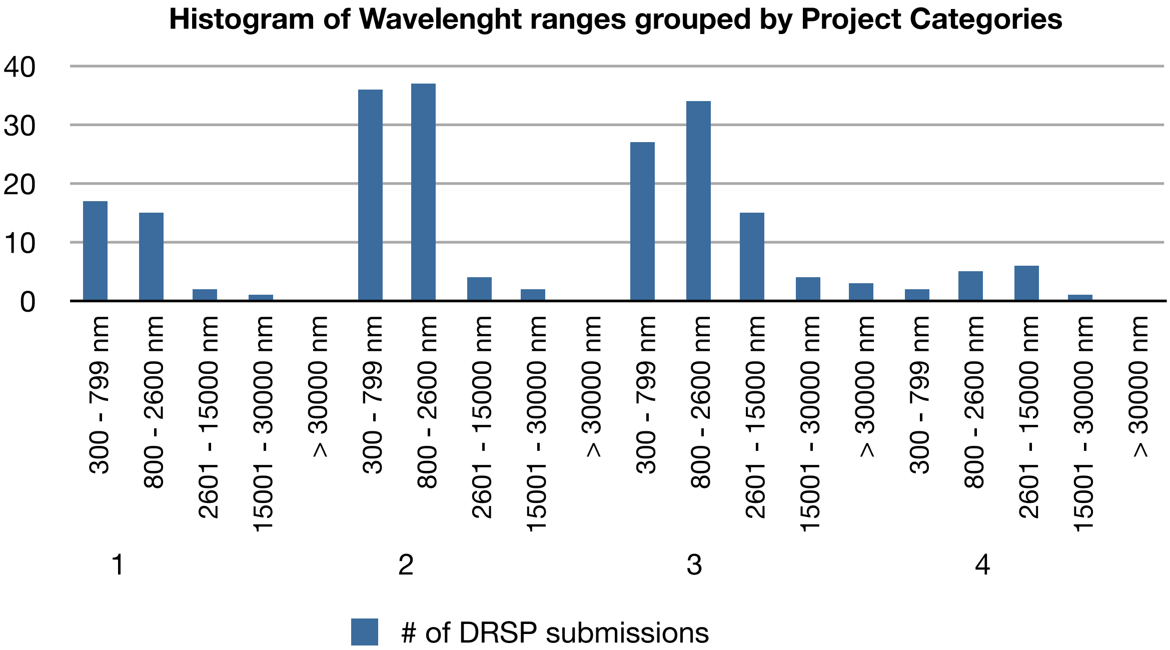

Project Category per FoV
20
15
10
5
0
1 1x1 arcsec
1 10x10arcmin
2 30x30 arcsec - 1x1arcmin
3 1x1arcsec
3 10x10arcmin
4 30x30arcsec - 1x1 arcmin
# of DRSP submisions

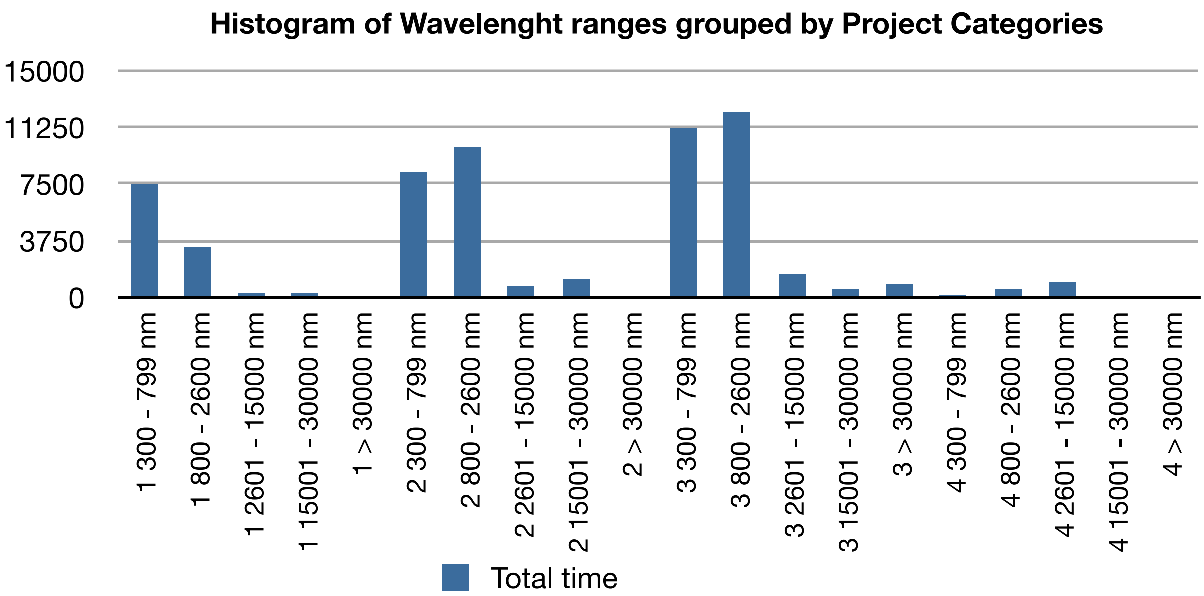


When analysed in terms of the wavelength range, mid-infrared wavelengths (2601 – 15000 nm) are preferred more by cases that fall into project category 3 and 4. The optical (300 – 799 nm) and near-infrared (800 – 2600 nm) wavelengths are equally preferred for each project category, however when analysed in terms of the total time and sufficient time required by the observations, the optical cases are twice as many as the near-infrared cases in project category 1. The opposite is true for the cases in project category 4.

Project Category	Wavelength range	# of DRSP cases	Total time (hr)	Sufficient time (hr)
1	300 - 799 nm	17	7498	4080.5
1	800 - 2600 nm	15	3358	1324.5
1	2601 - 15000 nm	2	300	150
1	15001 - 30000 nm	1	300	30
1	> 30000 nm	0	0	0
2	300 - 799 nm	36	8269	3941.55
2	800 - 2600 nm	37	9922	4574.15
2	2601 - 15000 nm	4	765	282.5
2	15001 - 30000 nm	2	1200	200
2	> 30000 nm	0	0	0
3	300 - 799 nm	27	11216	5090.6
3	800 - 2600 nm	34	12234	4449
3	2601 - 15000 nm	15	1516	401
3	15001 - 30000 nm	4	581	341

Project Category	Wavelength range	# of DRSP cases	Total time (hr)	Sufficient time (hr)
3	> 30000 nm	3	850	415
4	300 - 799 nm	2	155	140
4	800 - 2600 nm	5	525	232.5
4	2601 - 15000 nm	6	985	170
4	15001 - 30000 nm	1	15	7.5
4	> 30000 nm	0	0	0





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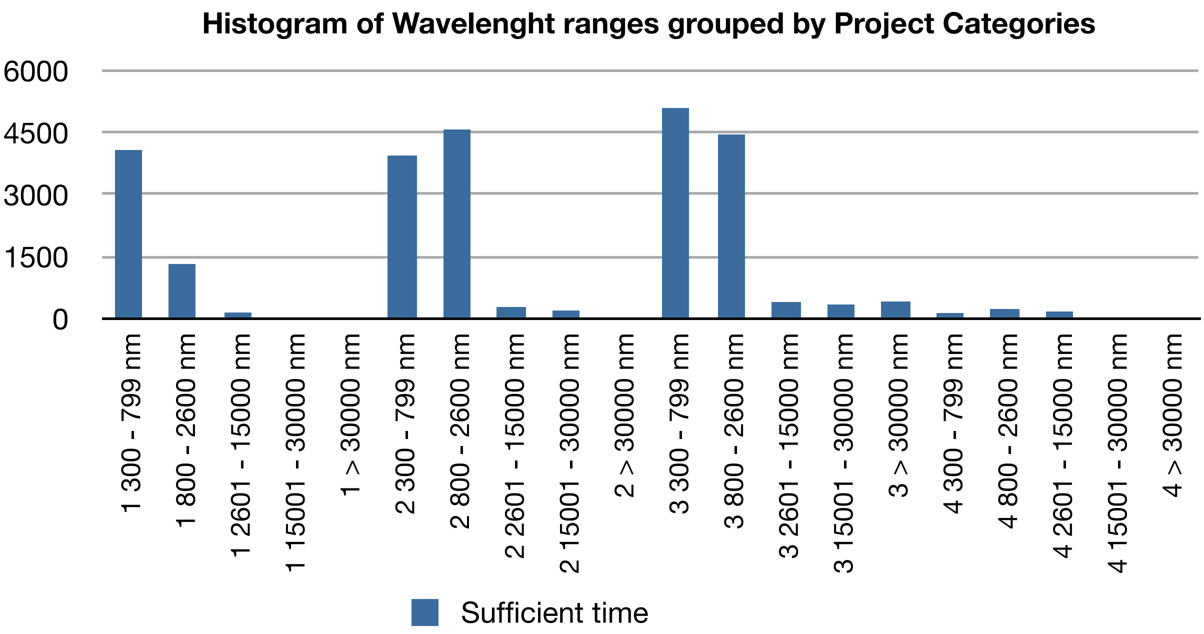


5.1.3 Publication Agreement

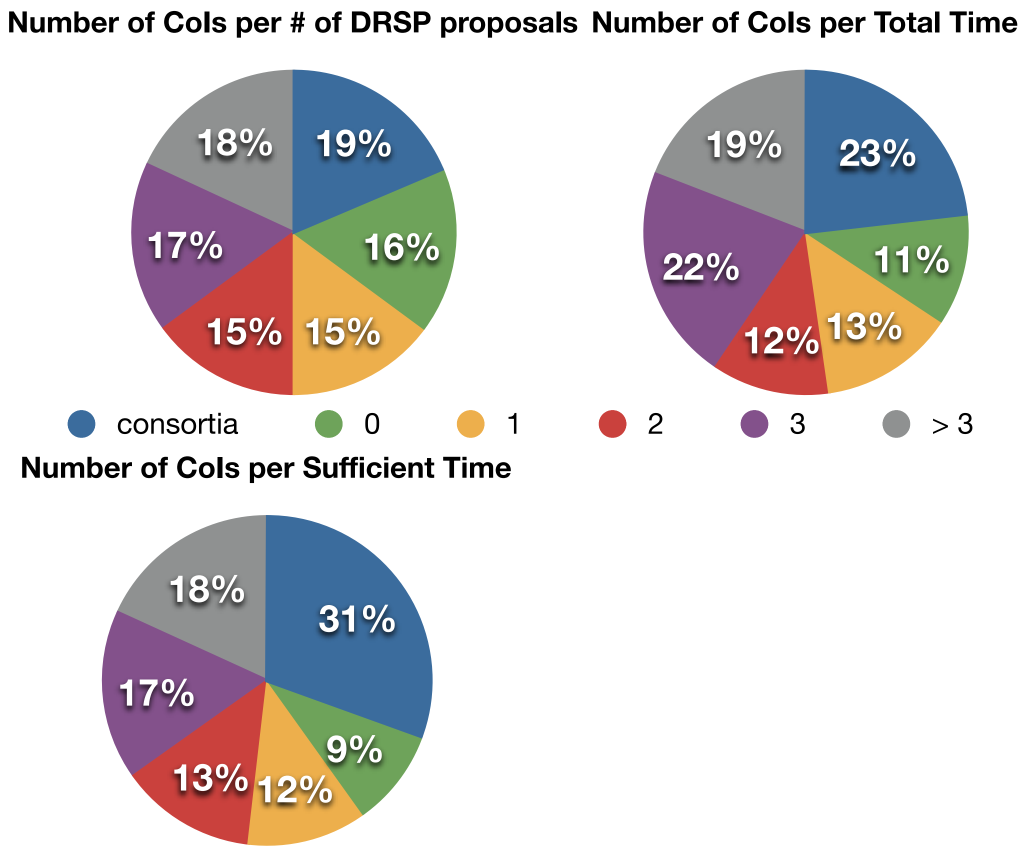
The statistical analysis of the DRSP is done using all 187 submissions, however only those that agreed for publication are fully published in the Appendix C. More than 90% of the cases (170 out of 187) have agreed for publication.

5.2 Author Information

5.2.1 Co-Investigators

The DRSP proposals are dominated by single PIs and two to four author submissions summing to 63% of all submissions. The remaining 37% are submitted by large consortia/instrument teams and multiple author (> 4 including the PI) collaborations. The percentage of the large collaboration programs increase to 49% when analysed in terms of total time and sufficient time required by observations. In other words, the time asked by large collaborations and small collaborations are equal.

# of CoIs	# of DRSP cases	Total time (hr)	Sufficient time (hr)
consortia	35	11646	6519.46
0	31	5531	2018.9
1	28	6749	2501.05
2	28	5876	2842.9
3	32	10793	3554.25
> 3	34	9573.5	3874



5.2.2 Institute of Principal-Investigator

The PIs of the DRSP proposals are from 73 different institutes mostly in Europe. The number of proposals are almost equally distributed among all these institutes except a larger contribution from ESO (with 28 out of 187 proposals) and IAC, Spain (with 14 out of 187 proposals). Analysed time-wise, PIs from ESO have asked ~20% of the sufficient time required for all DRSP observations whereas PIs from Krakow, Geneva and IAC have asked for ~5% each. The rest of sufficient time asked by the DRSP proposals are almost equally distributed among the remaining 69 institutes.

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5.2.3 Country of Employment of Principal-Investigator

The highest number of DRSP proposals were submitted by PIs from the institutes in UK making 17.6% of all submissions. The next three are PIs from Germany (14.4%), ESO (13.8%) and Spain (12.2%). All other countries have submitted less than 10% of all DRSP proposals. The non-European contribution is 1.6% from Chile and 4.3% from the other institutes around the world. This picture changes when analysed in terms of the total time and sufficient time required by the observations. The time required by the proposals from ESO PIs make the quarter of the time required by all proposals (a number artificially inflated by the submission of the E-ELT Science Office of the large DRM proposals). The next big slices are proposals from Spain and UK each making around 10% of the time required by all proposals. The non-European contribution is again around 7–8% including Chile.

Country	Total Time (hr)	Sufficient Time (hr)	# of DRSP cases
AT	797	317.4	7
BE	1192	641.25	8
CH	2280	1460	3
DE	5053	1198.5	27
CL	142	52.9	3
ES	6880.5	2843	23
DK	1300	650	2
ESO	12579	5455.06	26
FR	3885	1441.2	13
IT	2367	1394.9	14
NL	2942	1064.7	10
other	2675	1677.5	8
PT	654	307	4
SE	1274	270	7
UK	6148	2537.15	33

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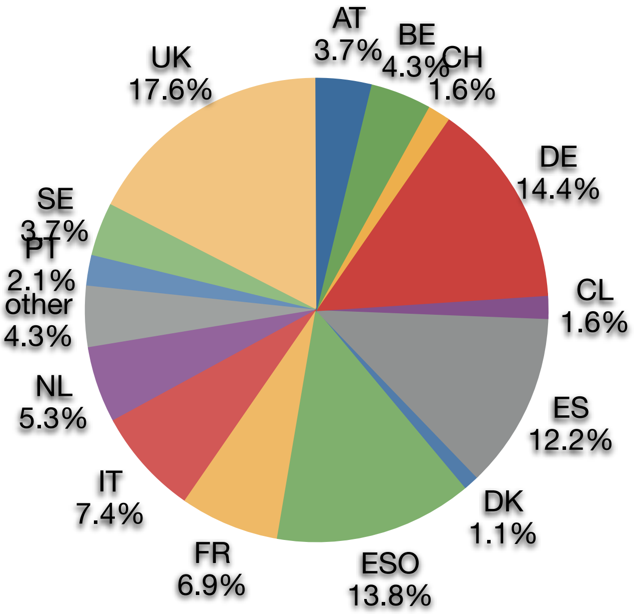
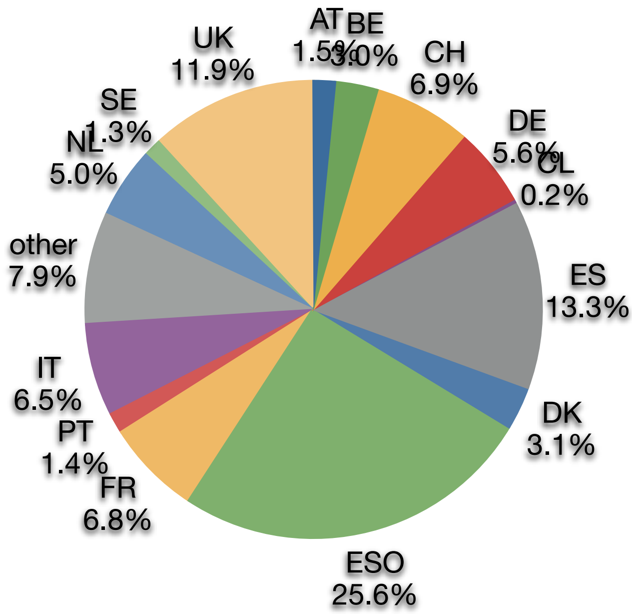
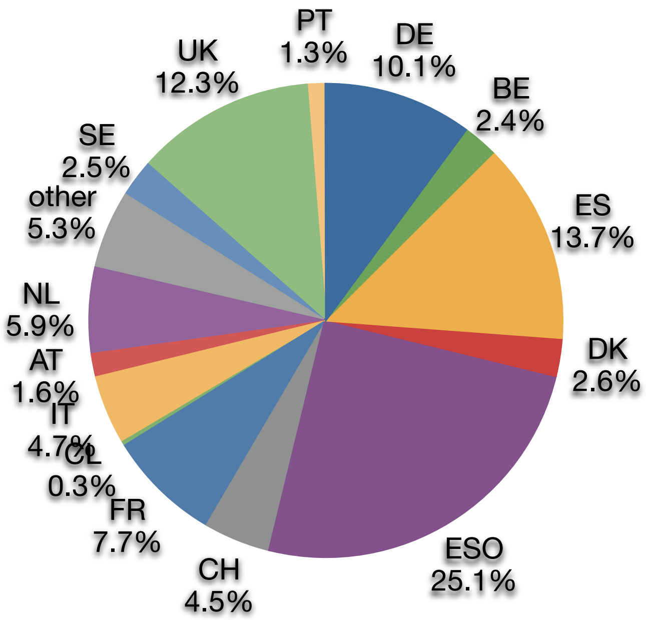
# of DRSP cases



Sufficient Time



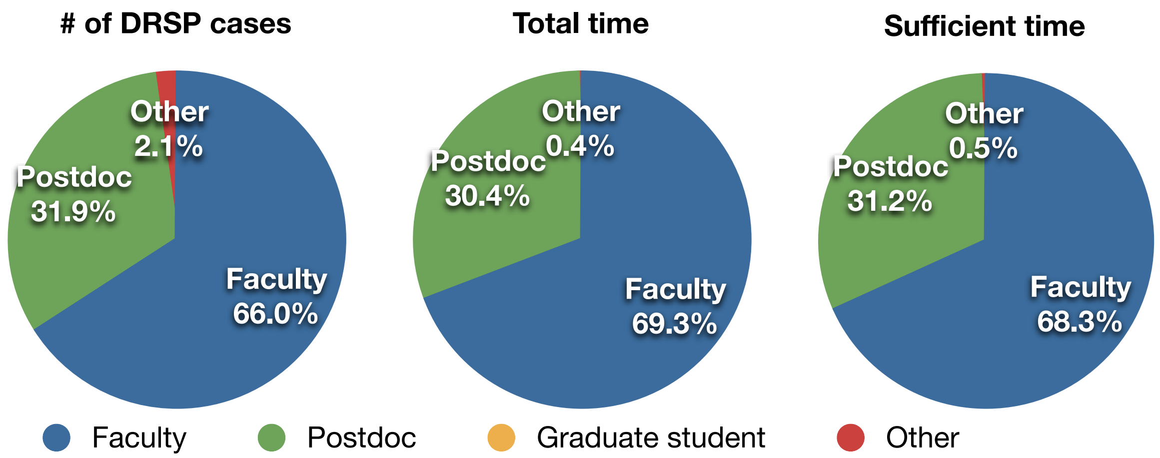
Total Time



5.2.4 Career Stage of Principal-Investigator

About two thirds of the PIs were faculty members, the other third being made up of postdoctoral researchers.

Career Stage of PI	Total time (hr)	Sufficient time (hr)	# of DRSP cases
Faculty	34756	14553.31	124
Postdoc	15232.5	6642.75	60
Graduate student	0	0	0
Other	180	114.5	4



5.3 Target Information

This section of DRSP contains information about the targets of the DRSP science cases including the source of the targets, required preparatory work and the basic proper ties of the targets like the coordinates, size, brightness, variability.

5.3.1 Sources of Targets

DRSP submitters were asked to state the facility or existing survey or catalogue or resource that will be the source of the targets. The most common source of targets is the VLT as listed in more than a third (69 out of 187) of the DRSP proposals. Vizier/NED/Simbad (38 out of 187), VISTA (34 out of 187), SDSS (30 out of 187), HST (26 out of 187), Spitzer (23 out of 187), JWST (21 out of 187), ALMA (18 out of 187) and Herschel (15 out of 187) are the other commonly preferred facilities for target selection.

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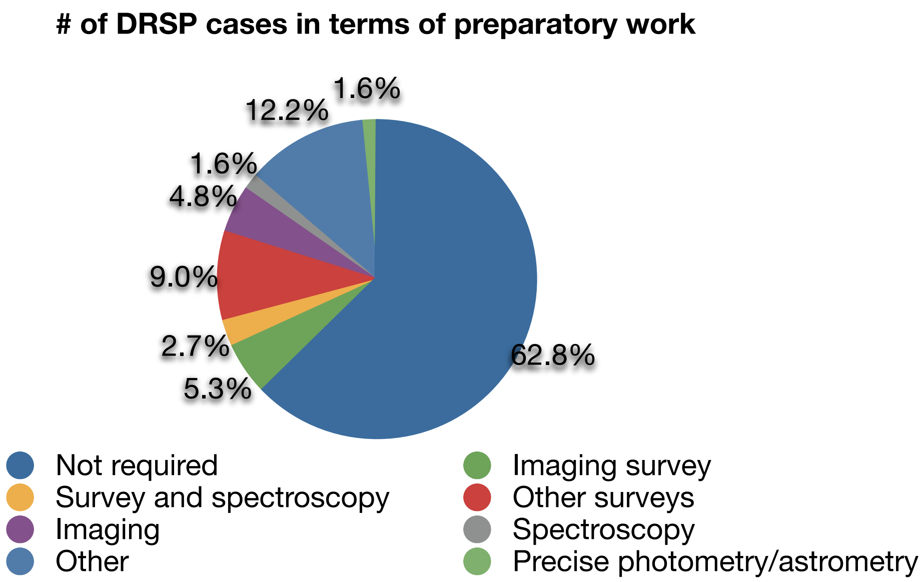
Analysed in terms of total time, VLT is a source of targets for those proposals that ask for almost half of the time asked by all DRSP proposals. Proposals using VISTA and SDSS as a source of targets equally share two thirds of the total time asked by all DRSP proposals. Analysed in terms of sufficient time required by observations, ~40% of the DRSP proposals will use VLT and/or VISTA and/or SDSS as sources of their targets.

5.3.2 Preparatory Requirements for Observations

DRSP submitters were asked whether any preparatory work is required prior to their observations and if so to state the requirements. This question was not obligatory to answer and the default option was 'no', i.e., no preparatory work is required. Almost two thirds (63%) of the DRSP proposals do not require preparatory work. For those DRSP proposals that require preparatory work, the most common preparation is to conduct imaging surveys with other facilities or pre-imaging with E-ELT or other facilities.

Preparatory work	# of DRSP cases
Not required	118
Imaging survey	10
Survey and spectroscopy	5
Other surveys	17
Imaging	9
Spectroscopy	3
Other	23
Precise photometry/astrometry	3



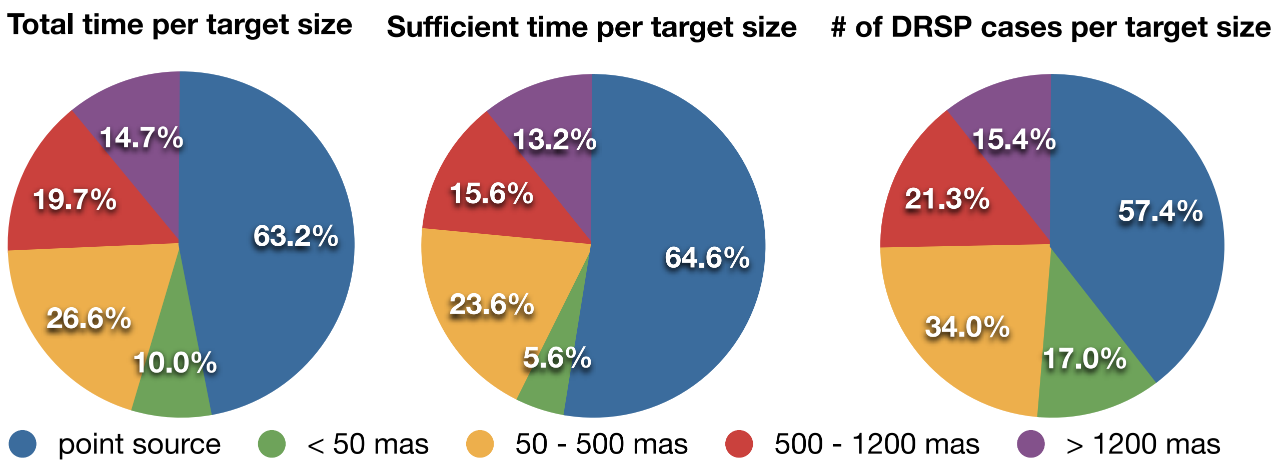
5.3.3 Target Brightness

The brightest targets of all DRSP proposals are those with -1.4 mag in V-band and 0 mag in K-band, in units of Vega magnitude, and 10000 mJy in N-band. The faintest targets are those with 32 mag in R-band, 34 mag in K-band, in units of Vega magnitude, and 0.1 mJy in N-band.

5.3.4 Target Size

Majority of the DRSP proposals (108 out of 187; ~63% time-wise) asked to observe point sources, whereas the remaining 80 out of 187 proposals asked to observe extended sources. DRSP submitters were free to give a range of half-light radii for their sources instead of choosing from a pre-defined ranges. We grouped these user defined sizes of the proposed extended sources into four categories as < 50 mas, 50–500 mas, 500–1200 mas and >1200 mas. Note that some proposals fall into more than one category but the percentages shown in the following table and pie-charts are the true values that are calculated via dividing by the total time asked by all proposals, sufficient time asked by all proposals, and total number of DRSP proposals, respectively.
Around 20% of the extended sources are larger than 1200 mas, ~25% have sizes between 500–1200 mas, 40% have sizes between 50 and 500 mas and the rest are smaller than 50 mas.

Target size	Total time (percentage)	Sufficient time (percentage)	# of cases (percentage)
point source	63.20	64.62	57.45
< 50 mas	10.05	5.65	17.02
50 - 500 mas	26.59	23.65	34.04
500 - 1200 mas	19.74	15.58	21.28
> 1200 mas	14.75	13.23	15.43



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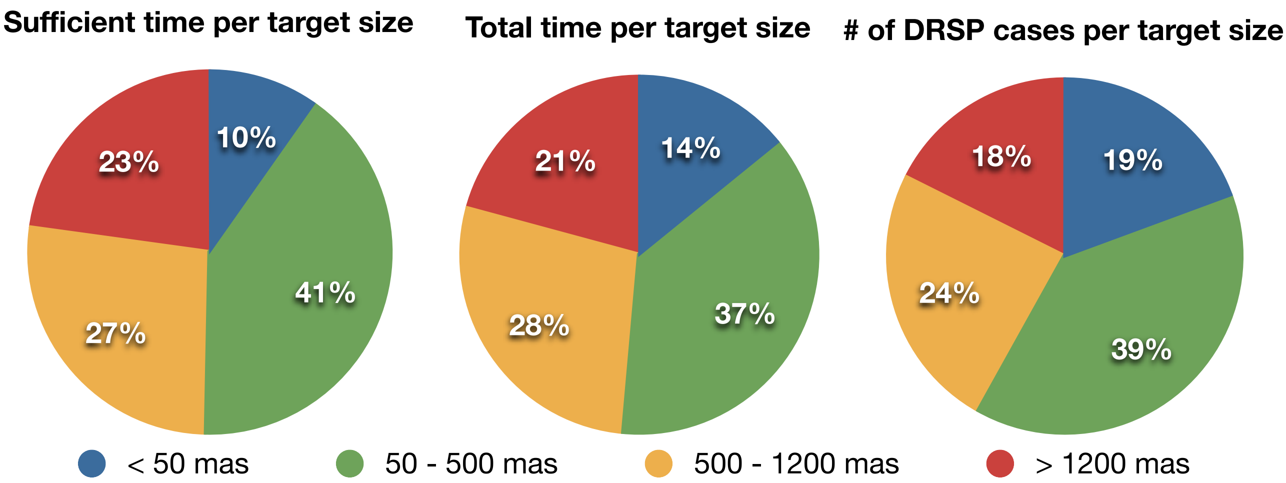

5.3.5 Number of Targets

Half of the DRSP proposals asked to observe less than 50 targets, whereas this percentage drops down to ~37% for extended targets and rise above half for point sources, when analysed in terms of total time or sufficient time required by observations. The rest is divided into DRSP proposals that require observations between 51–100 targets, 101–1000 targets and more than 1000 targets. Two fifths of the DRSP proposals with extended source observations requires observing more than 100 targets, whereas this ratio is one thirds for point source observations.

Number of Targets	Target size	Total time (hr)	Sufficient time (hr)	# of DRSP cases
< 10	extended	376.5	122.85	12
10 - 50	extended	6586	2629.35	29
51 - 100	extended	3454	1742.8	15
101 - 1000	extended	4696	1973.75	20
> 1000	extended	3350	1070	4
< 10	point source	2302	944.76	14
10 - 50	point source	12833	6718.8	33
51 - 100	point source	5462	1739.4	23
101 - 1000	point source	10618	4177.5	29
> 1000	point source	491	191.35	9

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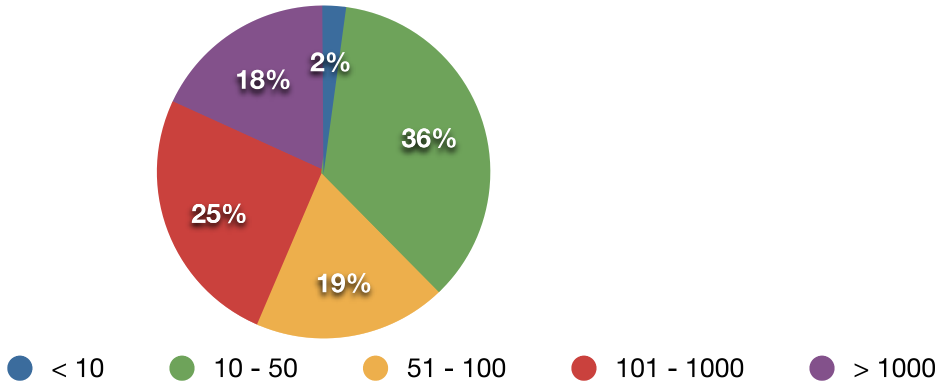
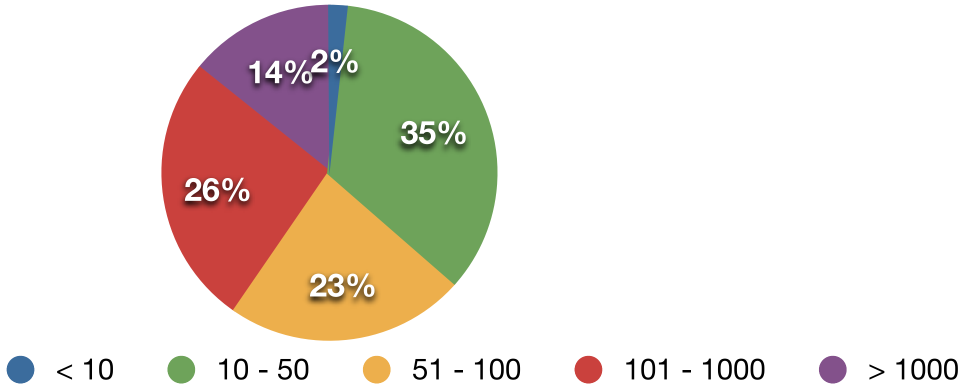
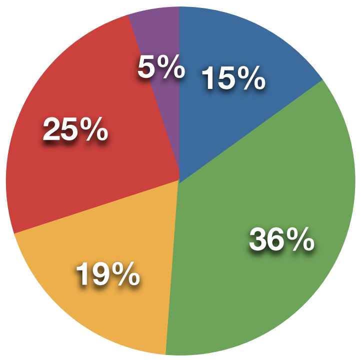
Number of Targets for Extended sources (per Total time)



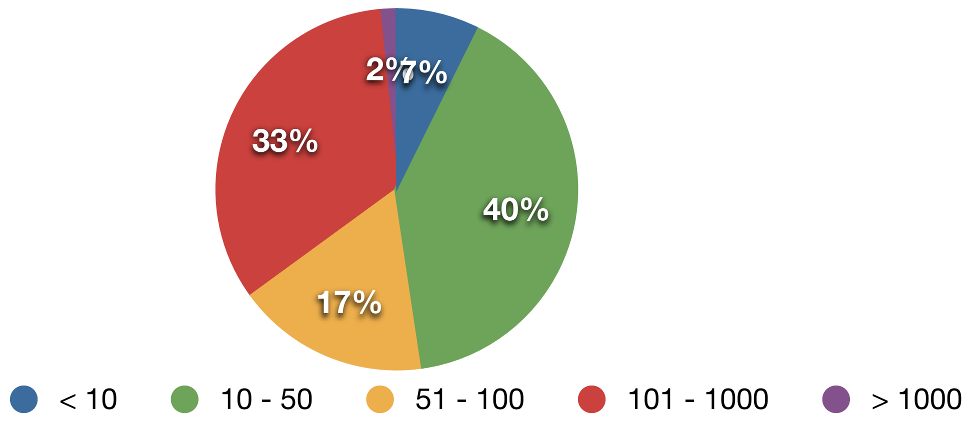
Number of Targets for Extended sources (per Sufficient time)



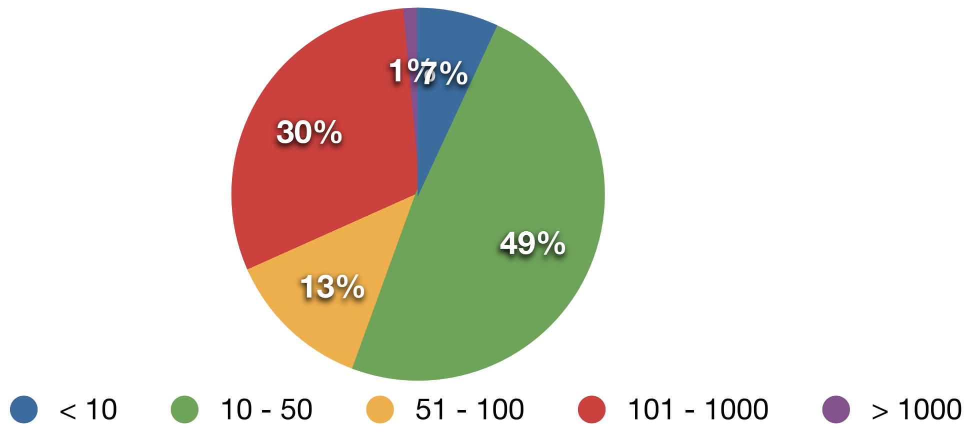
Number of Targets for Extended sources (per # of DRSP cases



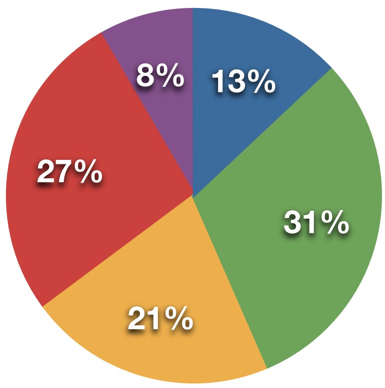
Number of Targets for Point sources (per Total time)



Number of Targets for Point sources (per Sufficient time)



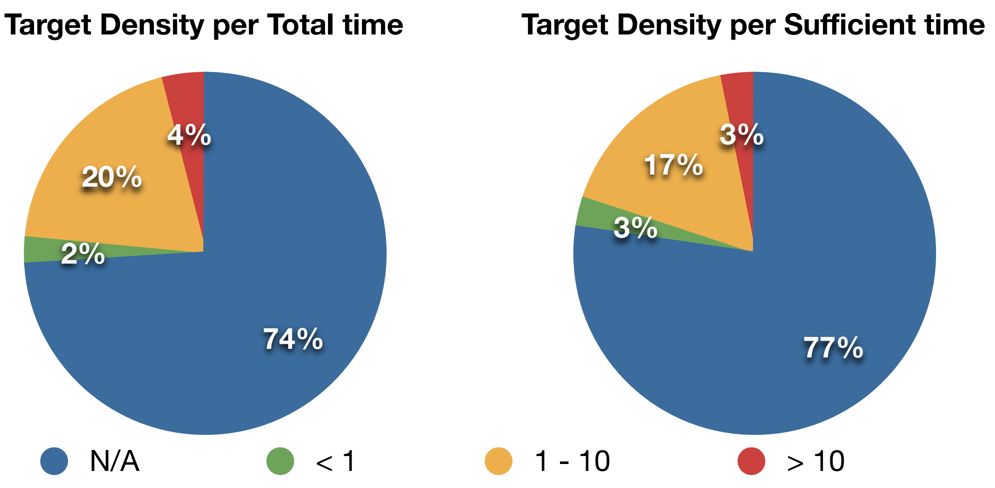
Number of Targets for Point sources (per # of DRSP cases)



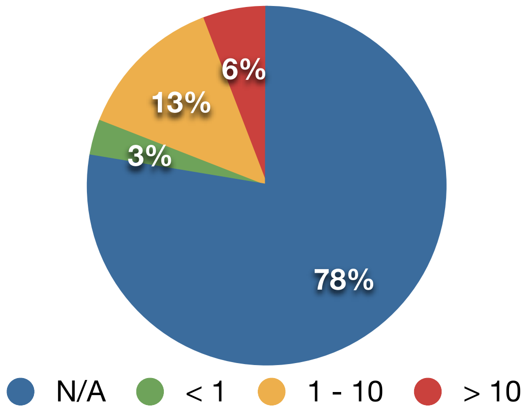
5.3.6 Density of Targets

For most of the DRSP proposals the target density is either not known or not applicable to the proposed observations. The ratio of DRSP proposals with known target density values is less than one fifth for point sources and similar for extended sources. Analysed in terms of total time or sufficient time, this ratio drops to as low as 12% for point sources equally distributed as sources with densities less than 10 per square-arcminutes and with densities higher more than that. For extended sources analysed in terms of total time or sufficient time, the ratio of known target densities increases up to two fifths vastly dominated with target densities between 1 and 10 square-arcminutes. The DRSP proposals asking for targets with densities less than 1 square-arcminute are less than 5%.

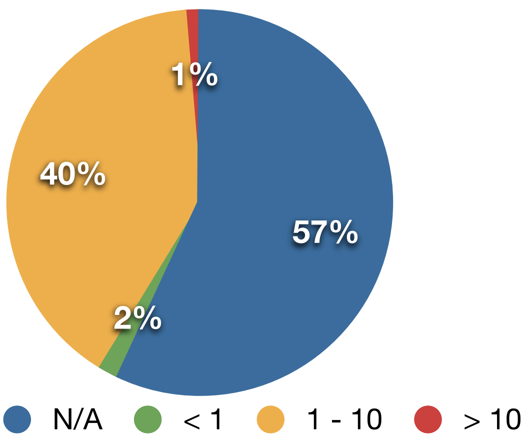
Target density (per arcmin-sq)	Target size	Total time (hr)	Sufficient time (hr)	# of DRSP cases
N/A	extended source	10526.5	4329.9	58
< 1	extended source	302	301.4	2
1 - 10	extended source	7410	2862.65	18
> 10	extended source	225	44.8	2
N/A	point source	26631	12154.46	88
< 1	point source	870	257	4
1 - 10	point source	2430	732	7
> 10	point source	1775	628.35	9



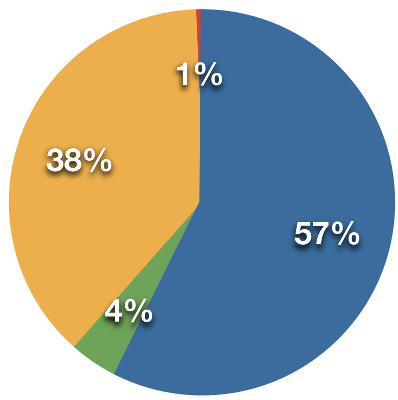
Target Density per # of DRSP cases



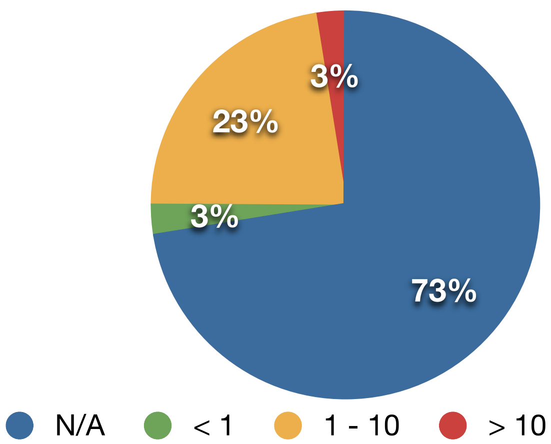
Target density of Extended sources (per Total time)



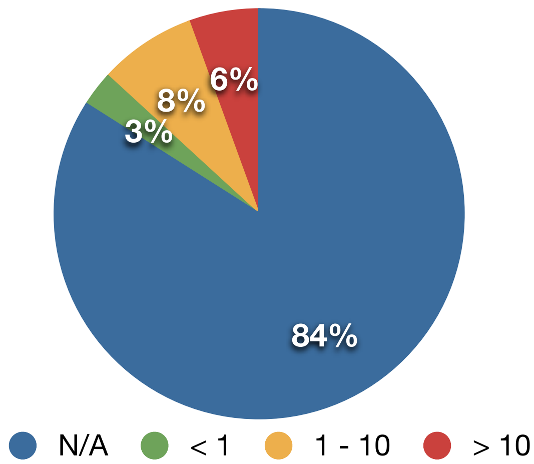
Target density of Extended sources (per Sufficient time)



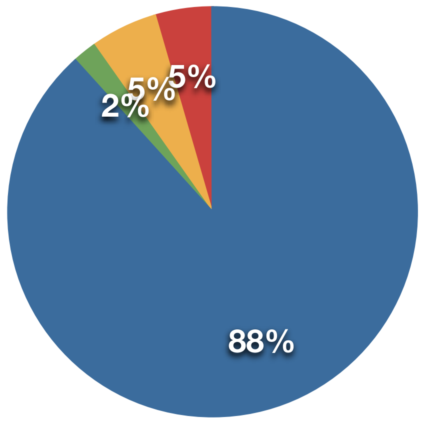
Target density of Extended sources (per # of DRSP cases)



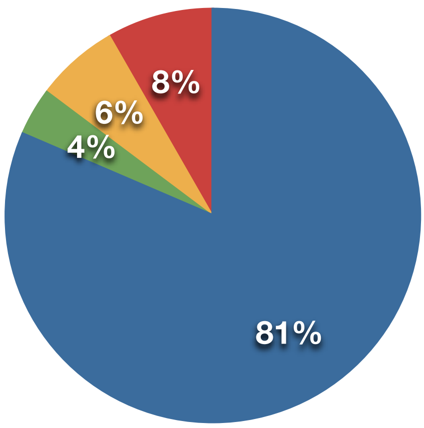
Target density of Point sources (per Total time)



Target density of Point sources (per Sufficient time)



Target density of Point sources (per # of DRSP cases)

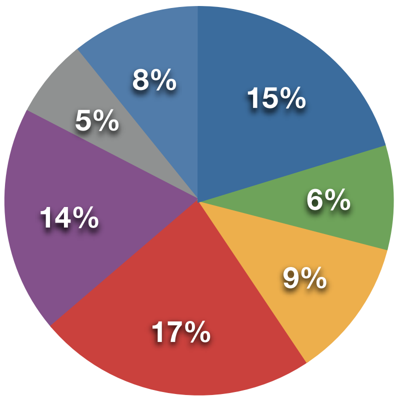


5.3.7 Target Coordinates

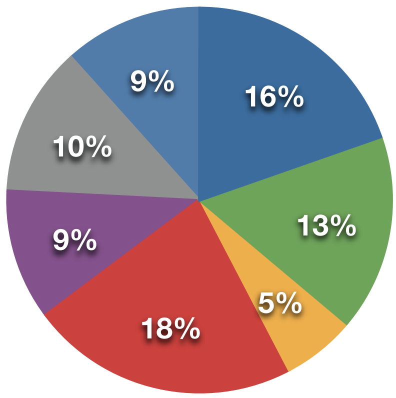
For 112 out of 187 (57% total time-wise and 54% sufficient time-wise) DRSP proposals do not know the coordinates of the targets they would like to observe. 17 out 187 (18% total and sufficient time-wise) DRSP proposals asked to observe targets all over the sky (RA between 0 and 24 hours and Dec between -90 and 90 or -70 and 70), thus, do not have any preference in RA or hemisphere. An additional 31 out 187 DRSP proposals do not have any preference for hemisphere when analysed with respect to the declination range they provide for their targets. The remaining 22 out of 187 DRSP proposals show a clear preference for the southern hemisphere (19 out of 22).

Declination range	# of DRSP proposals (percentage)	Total time (percentage)	Sufficient time (percentage)
-90 - -76	14.89	15.95	14.35
-75 - -47	6.38	13.34	17.11
-46 - 16	8.51	5.00	3.56
-15 - 15	17.02	18.25	22.67
16 - 46	13.83	8.90	10.59
47 - 75	4.79	10.20	14.27
79 - 90	7.98	9.45	5.66

Target Coordinates Distribution with # of DRSP cases

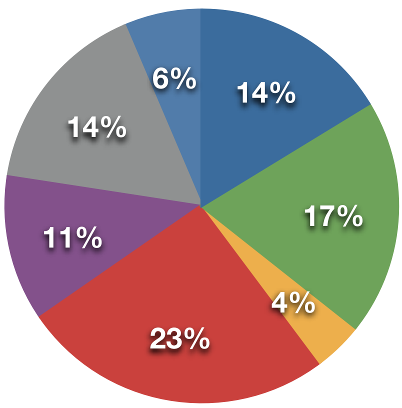


Target Coordinates Distribution with Total Time



-90 - -76   -75 - -47   -46 - 16   -15 - 15   16 - 46   47 - 75   79 - 90

Target Coordinates Distribution with Sufficient Time



For 32 out of 187 (more than 25% time-wise) DRSP proposals have targets all over the RA range. The remaining 38 DRSP proposals with known target coordinates show a preference for RA ranges 12–14 hours, 9–12 hours, 4–6 hours. The RA ranges 0–3 and 17–24 are much less populated.

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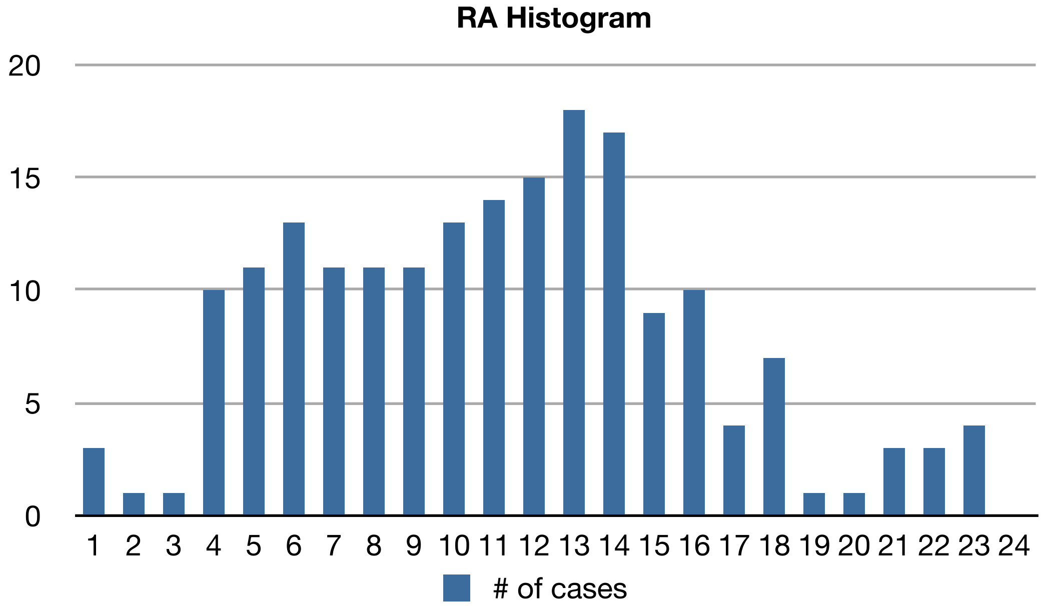
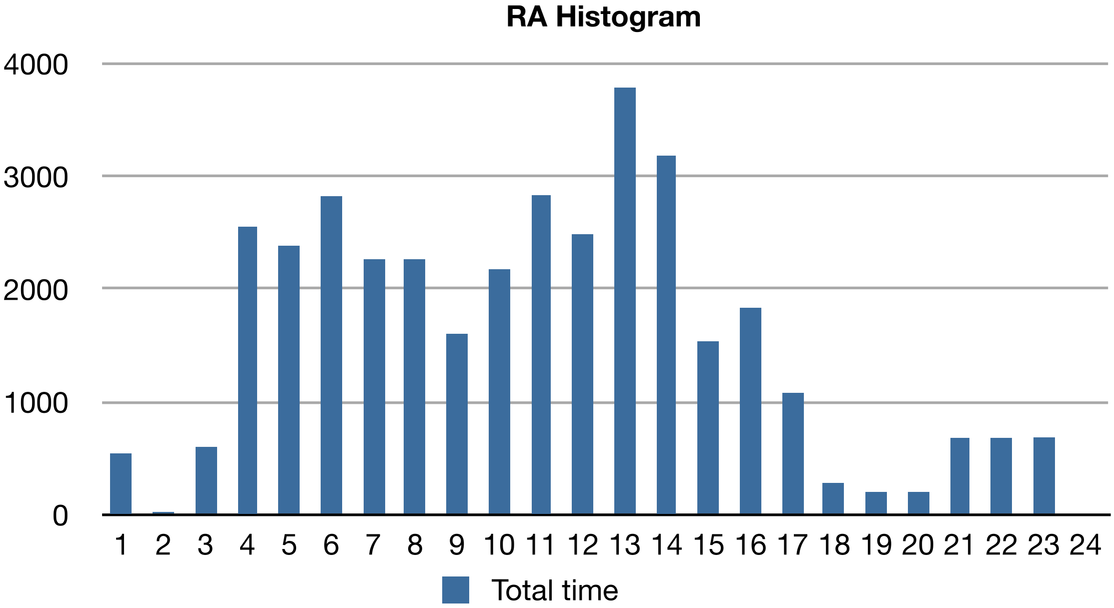
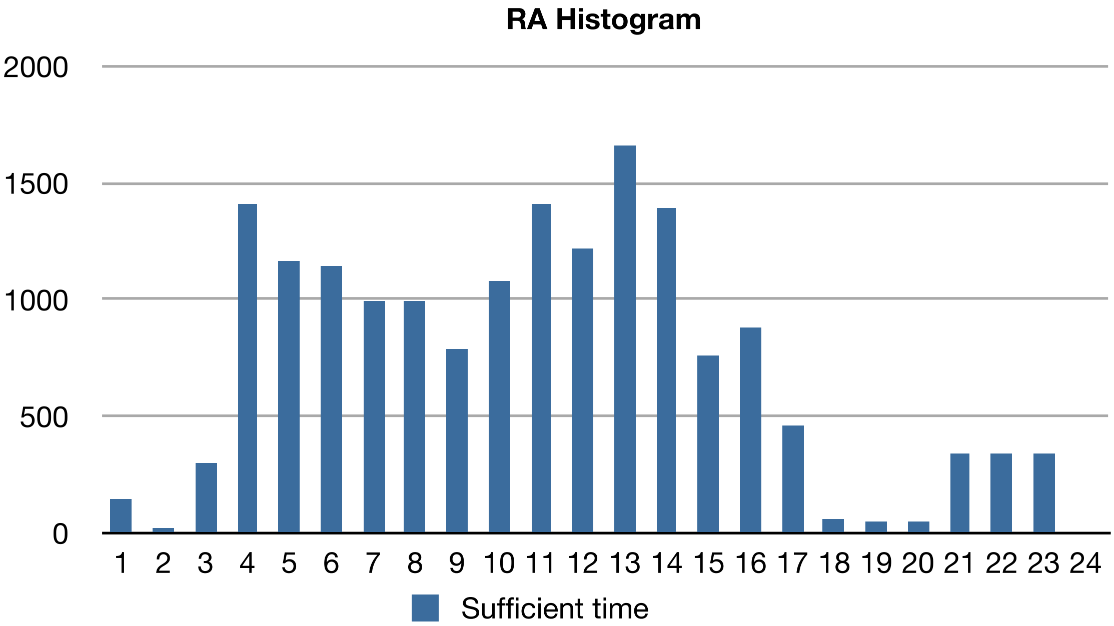
RA to *	# of cases	Total time (hr)	Sufficient time (hr)
1	3	545	145
2	1	22.5	22.5
3	1	600	300
4	10	2555	1410.5
5	11	2385	1165.5
6	13	2825	1143.5
7	11	2265	995.5
8	11	2265	995.5
9	11	1603	788.9
10	13	2174	1080
11	14	2835	1410.5
12	15	2485	1220.5
13	18	3785	1660.5
14	17	3185	1392.5
15	9	1535	760.5
16	10	1835	880.5
17	4	1080	460
18	7	280	61
19	1	200	50
20	1	200	50
21	3	680	340
22	3	680	340
23	4	684	342
24	0	0	0

* Excluding cases with no RA preference







5.3.8 Moving Targets

Majority of the DRSP proposals (176 out of 187, >95% time-wise) did not asked for observations of moving targets. Two of the remaining did not provide the movement speed of their targets. Only one DRSP proposal asked to observe targets moving with speeds from 10 arcsec/hour up to 2000 arcsec/hour where the latter is higher than the top-level requirements of E-ELT (of 1000 arcsec/hour).

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5.3.9 Variable Targets

DRSP submitters were asked whether any of their targets are variable and whether they require repeated observations. The majority of the DRSP proposals (131 out of 187, 60% time-wise) do not ask for observations of variable targets. Among the 57 proposals that asked for observations of variable targets, 7 of them do not require any multiple sampling. The sampling rates required by the remaining 50 DRSP proposals vary from as fast as 1000 per second to as sparse as 15 per century. The sampling rate distribution analysed in terms of the total time required by observations, is dominated by sparse sampling rates from once per 7-8 years and once per month to once per week. For the ease of viewing we grouped the sampling rates as per minute, per night, per week, per year and N/A in the pie-charts.

Variable target	# of DRSP cases	Total time (hr)	Sufficient time (hr)
no	131	31083	12680.65
yes, 0.13 per year	1	4000	2600
yes, 1 per hour	3	330	109
yes, 1 per millennium	1	400	80
yes, 1 per min	2	300	120
yes, 1 per month	3	2590	1445.5
yes, 1 per week	4	1650	792.5
yes, 1 per year	8	191	37.05
yes, 1-10 per sec	2	120	60
yes, 1-5 per week	1	1000	200
yes, 10 per day	1	50	5
yes, 10 per hour	1	300	150
yes, 1000 per sec	2	350	100.2
yes, 15 per century	1	22.5	22.5
yes, 15 per week	1	600	60
yes, 2 per hour	3	210	65.5
yes, 2 per month	1	81	16.2
yes, 2 per year	3	925	252.5
yes, 3 per day	1	1400	1120
yes, 3 per year	3	440	84
yes, 4 per hour	3	560	118
yes, 4 per year	2	700	350
yes, 6 per day	1	24	7.2
yes, 6 per min	1	18	9
yes, 9 per year	1	300	270
yes, N/A	6	2500	550
yes, see text per sec	1	24	5.76

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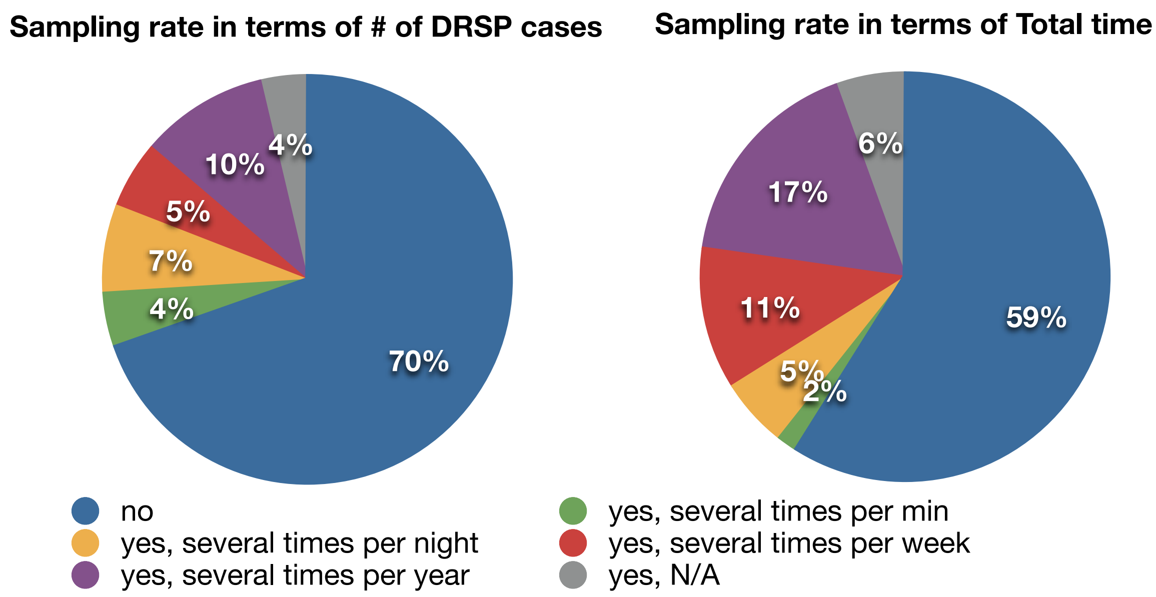
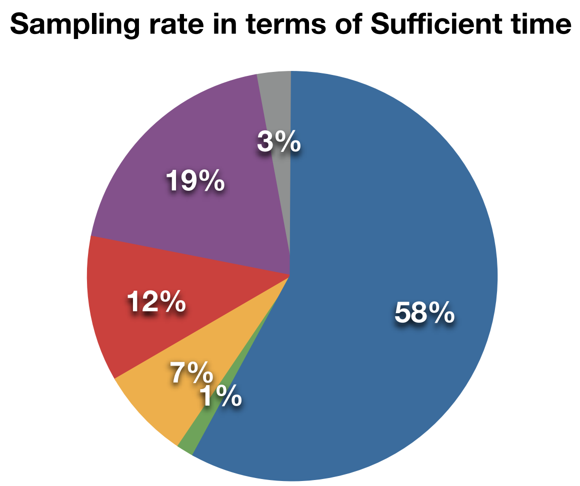




5.3.10 Target Type

DRSP submitters were asked what type of targets they want to observe with E-ELT. Note that this question was not compulsory and is only one of the measures of community's interests. 177 out of 187 DRSP proposals provided one or more type of objects. 77 DRSP proposals have star-like targets which is the majority also when analysed in terms of total and sufficient time required by observations. The next most popular targets are galaxies constituting targets of 41 DRSP proposals. Analyses in terms of total and sufficient time required by observations showed that AGNs, exoplanets and IGM are also very common targets.

5.4 Spatial Information

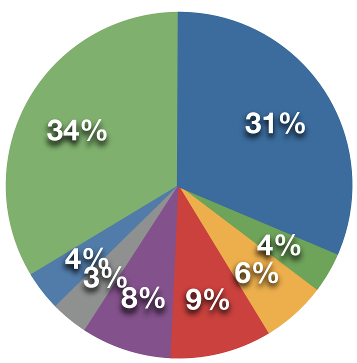
This section of DRSP contains information about the spatial requirements of the DRSP science cases including the spatial resolution, field-of-view, multiplexity and plate scale stability.

5.4.1 Spatial Resolution

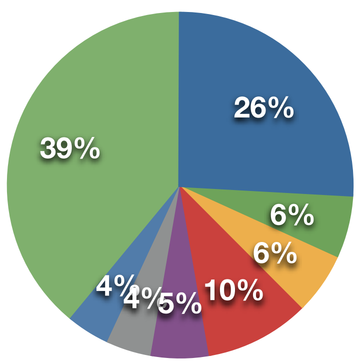
DRSP submitters were asked to provide the most stringent spatial resolution required for the observations they want to conduct with E-ELT. The spatial resolution is defined as "the smallest distance at which two point source can reliably be separated". DRSP submitters were also asked to provide the number of spatial elements (pixels or spaxels) for linear sampling.
The majority of the DRSP proposals (113 out of 187) asked for observation that require spatial resolution of ≤50 mas whereas 67 out of these asked for diffraction limited observations. On the other hand, 46 out of 187 proposals asked for seeing limited observations. Analyses in terms of total and sufficient time required by observations shows however a slightly different picture where seeing limited observations over take the diffraction limited observations by 39% to 26% and the rest is distributed almost equally between spatial resolution of 5 mas and 250 mas. Overall, time-wise the high spatial resolution (≤ 50 mas) observations and lower spatial resolution (≥75 mas and seeing limited) share the time equally.

Spatial resolution	Total time (hr)	Sufficient time (hr)	# of DRSP cases
diffraction limited	15774.5	5526.85	67
5 mas	1890	1233	5
10 mas	3011	1221.25	21
50 mas	4741	2083.35	20
75 mas	4226	1152.2	9
100 mas	1740	897	11
250 mas	1858	863	9
seeing limited	16923	8333.91	46

Total time per spatial resolution



Sufficient time per spatial resolution



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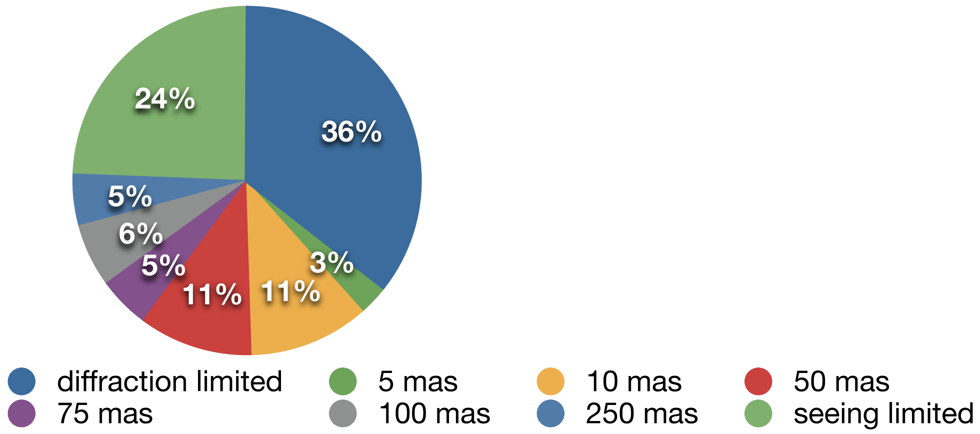
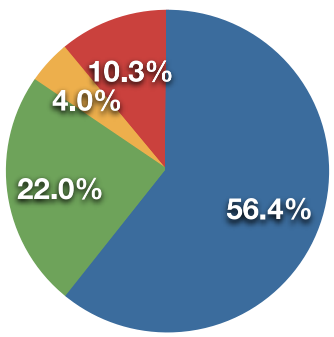
# of DRSP cases per spatial resolution



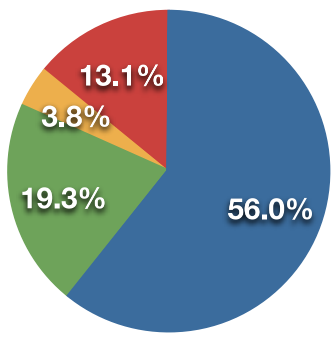
Nearly two thirds of the DRSP proposals require two or less elements to sample the spatial resolution they asked for, whereas only ~15% require more than 4 spatial elements.

Sampling	Total time (percentage)	Sufficient time (percentage)	# of cases (percentage)
<= 2	56.39	56.02	56.91
2.1 - 4	22.03	19.26	23.94
4.1 - 10	4.04	3.78	4.26
> 10	10.31	13.06	7.45

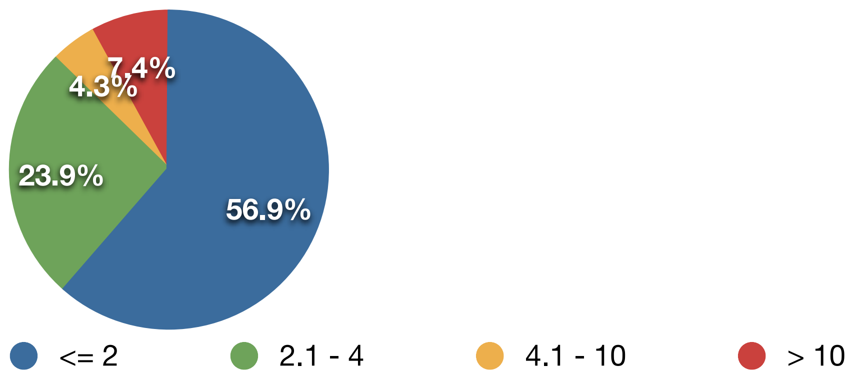
Sampling in terms of Total Time



Sampling in terms of Sufficient Time



Sampling in terms of # of DRSP cases



We also analysed the relation between spatial resolution and spectral resolution required by the observations. Most of the diffraction limited observations are for low resolution spectroscopy (R = 500 – 1000 and R = 100 – 300) and broad-band imaging. A significant portion is also asked for very high spectral resolution observations with R = 50000 – 100000. Observations requiring a spatial resolution of 5 mas are only for broad-band imaging and medium resolution (R= 3000 – 5000 and 10000 – 20000) spectroscopy, whereas 10 mas spatial resolution is asked by all kinds of imaging and spectroscopy observations with a slight domination of medium resolution spectroscopy. Similarly observations with 50 mas spatial resolution are asked by almost all kinds of observations equally, with a slight domination of narrow-band imaging and medium resolution spectroscopy. Observations with 75 mas spatial resolution are only required for medium (especially R=3000–5000) and very high resolution (R=50000–100000) spectroscopy.
100 mas spatial resolution observations are not asked for very high resolution spectroscopic observations but mostly for medium to high resolution spectroscopy and broad-band imaging observations. On the other hand, 250 mas spatial resolution is only demanded by spectroscopy with 3000–10000 resolution and to a lower extent by R=500–1000 and 50000–100000 resolution spectroscopic observations. Seeing limited observations are mostly asked for highest resolution (R>100000) spectroscopic observations, yet almost all other kinds of spectroscopy and imaging proposals also ask for seeing limited observations.

Spectral resolution	Sufficient time (hr)	Total time (hr)	# of DRSP cases	Spatial resolution
bbimaging	1133.5	4145	26	diffraction
nbimaging	251.55	1245	13	diffraction
100-300	1371	4730	7	diffraction
300-500	250	650	3	diffraction
500-1000	1646.4	2752	4	diffraction
1000-2000	51	120	5	diffraction
2000-3000	305	690	7	diffraction
3000-5000	405	1300	9	diffraction
5000-10000	310	1009	8	diffraction
10000-20000	560.7	1435.5	11	diffraction
20000-50000	167.2	824	4	diffraction
50000-100000	912.5	2299	11	diffraction
>100000	104	310	5	diffraction
bbimaging	758	990	3	5
nbimaging	0	0	0	5
100-300	0	0	0	5
300-500	0	0	0	5
500-1000	0	0	0	5
1000-2000	0	0	0	5
2000-3000	0	0	0	5
3000-5000	475	900	2	5
5000-10000	0	0	0	5
10000-20000	393	590	2	5
20000-50000	0	0	0	5

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Spectral resolution	Sufficient time (hr)	Total time (hr)	# of DRSP cases	Spatial resolution
50000-100000	0	0	0	5
>100000	0	0	0	5
bbimaging	232.1	442	6	10
nbimaging	130.5	210	3	10
100-300	130	200	2	10
300-500	160	500	3	10
500-1000	180	700	3	10
1000-2000	130	200	2	10
2000-3000	130	200	2	10
3000-5000	606.15	909	9	10
5000-10000	220	500	3	10
10000-20000	475	610	4	10
20000-50000	130	200	2	10
50000-100000	200	550	3	10
>100000	197.5	350	2	10
bbimaging	363.7	861	4	50
nbimaging	722.5	1445	5	50
100-300	32.5	130	1	50
300-500	0	0	0	50
500-1000	25	25	1	50
1000-2000	600.15	1230	3	50
2000-3000	600	1200	2	50
3000-5000	759.6	1430	6	50
5000-10000	500	1000	1	50
10000-20000	500.15	1030	2	50
20000-50000	0	0	0	50
50000-100000	100	600	2	50
>100000	212.5	550	2	50
bbimaging	0	0	0	75
nbimaging	0	0	0	75
100-300	0	0	0	75
300-500	0	0	0	75
500-1000	3.2	16	1	75
1000-2000	100	1000	1	75
2000-3000	0	0	0	75
3000-5000	550	1950	3	75
5000-10000	201	520	2	75
10000-20000	48	240	1	75
20000-50000	0	0	0	75
50000-100000	250	500	1	75
>100000	0	0	0	75
bbimaging	336	540	4	100
nbimaging	176	220	1	100
100-300	0	0	0	100
300-500	150	300	1	100

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Spectral resolution	Sufficient time (hr)	Total time (hr)	# of DRSP cases	Spatial resolution
500-1000	200	200	1	100
1000-2000	25	100	1	100
2000-3000	150	300	1	100
3000-5000	276	620	2	100
5000-10000	120	240	2	100
10000-20000	447	790	4	100
20000-50000	45	90	1	100
50000-100000	0	0	0	100
>100000	0	0	0	100
bbimaging	0	0	0	250
nbimaging	0	0	0	250
100-300	0	0	0	250
300-500	0	0	0	250
500-1000	50	500	1	250
1000-2000	0	0	0	250
2000-3000	0	0	0	250
3000-5000	300	300	1	250
5000-10000	500	1000	5	250
10000-20000	0	0	0	250
20000-50000	0	0	0	250
50000-100000	13	58	2	250
>100000	0	0	0	250
bbimaging	413.96	1154	5	seeing
nbimaging	607.5	1215	2	seeing
100-300	630	1500	2	seeing
300-500	600	1200	1	seeing
500-1000	62.5	70	2	seeing
1000-2000	113.5	255	4	seeing
2000-3000	245	555	4	seeing
3000-5000	760	1680	4	seeing
5000-10000	979.4	3027	8	seeing
10000-20000	0	0	0	seeing
20000-50000	280	1340	5	seeing
50000-100000	647.5	1389	9	seeing
>100000	4783.4	7128	10	seeing

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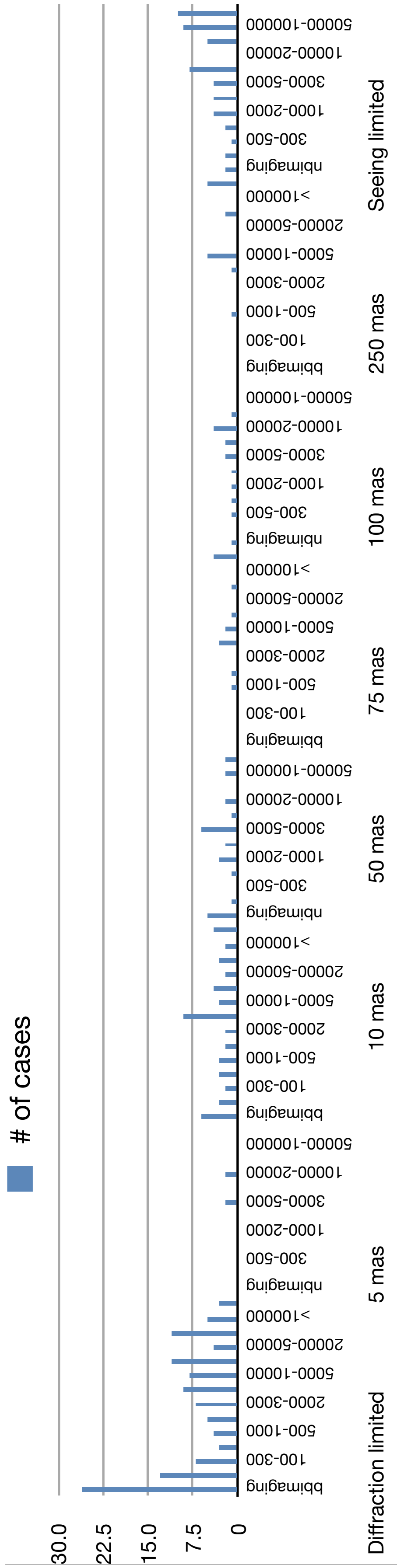

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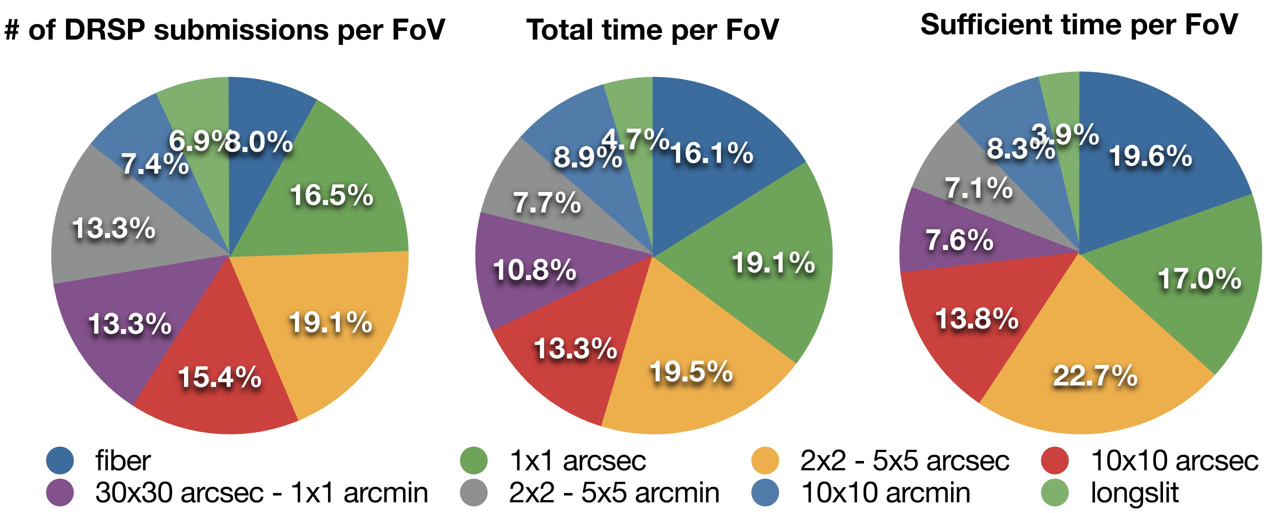
5.4.2 Total Field-of-View

The total field-of-view (FoV) required by DRSP proposals is dominated by small FoVs. The FoVs smaller than 10 arcsec ×10 arcsec make up two thirds of all DRSP cases. FoVs larger than 5 arcmin×5 arcmin make up only 8% of all DRSP cases. Similarly FoVs between 30 arcsec×30 arcsec and 1 arcmin×1 arcmin, and those between 2×2 and 5×5 arcmin-square each make up 13% (8% time-wise) of all DRSP cases. Less than 7% of the cases (4% time-wise) require long slit observations. The FoVs requested by DRSP submitters do not always correspond to the FoV provided by the selected instrument.

Field-of-view	# of DRSP submissions	Total time (hr)	Sufficient time (hr)
fiber	15	8062	4172.4
1x1 arcsec	31	9600	3631.5
2x2 - 5x5 arcsec	36	9763.5	4840.6
10x10 arcsec	29	6685	2948.4
30x30 arcsec - 1x1 arcmin	25	5416	1624.95
2x2 - 5x5 arcmin	25	3840	1503.86
10x10 arcmin	14	4440	1762.65
longslit	13	2362	826.2



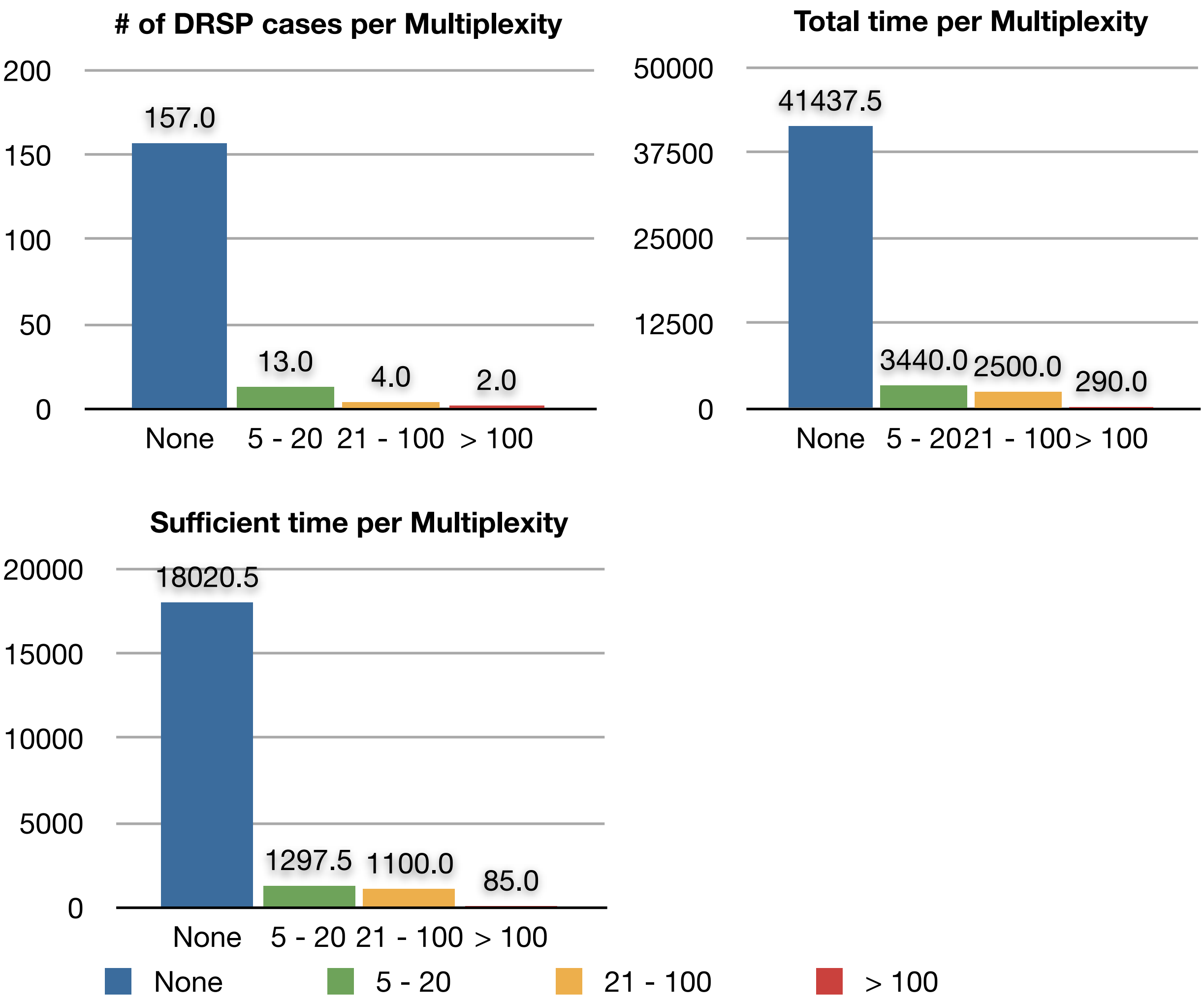
5.4.3 Multiplexity and Pick-off Field-of-View

The vast majority of all DRSP submissions (~84%) do not require multiplexity.
Only 13 out of 187 DRSP proposals require a multiplexity between 5 and 20 and another 4 proposals require a multiplexicity between 21 and 100. Only two DRSP proposals asked for multiplexities higher than 100. Analysed in terms of total and sufficient time required by

observations, the multiplexities of 5–20 and 21–100 are required each by about 6% of all DRSP proposals whereas >100 multiplexity is required by less than one percent of all DRSP proposals.

Multiplexity*	Total time (hr)	Sufficient time (hr)	# of DRSP cases
None	41437.5	18020.51	157
5 - 20	3440	1297.5	13
21 - 100	2500	1100	4
> 100	290	85	2

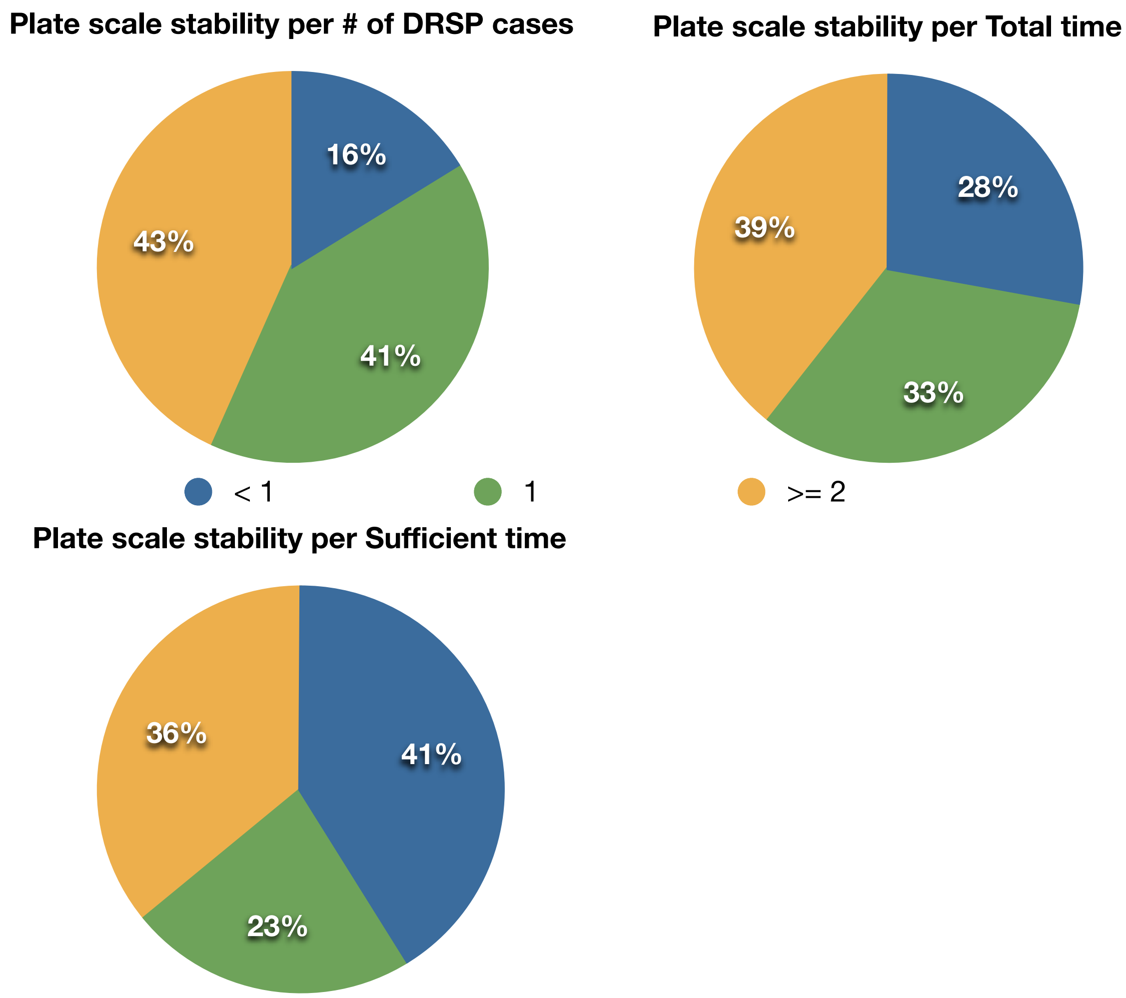
* Excluding the cases with fiber/slitlet as Pick-off FoV



5.4.4 Plate Scale Stability

DRSP submitters were asked whether their observations require plate scale stability and if so to what extent. 80% of the DRSP proposals do not require any plate scale stability. Among the remaining 37 proposals, more than half requires plate scale stability less than or equal to 1%, around 40% require stability equal to or larger than 2%, and 6 DRSP proposals require critical plate-scale stability, close to the top-level requirement of the E-ELT.

Plate Scale stability (percentage)	# of DRSP cases	Total time (hr)	Sufficient time (hr)
< 1	6	3000	1673
1	15	3526	928.45
>= 2	16	4225	1458.5
N/A	151	39417.5	17250.61



5.5 Spectral Information

This section of DRSP contains information about the spectral requirements of the DRSP science cases via collecting the wavelength range and spectral resolution of observations.

5.5.1 Wavelength Range

DRSP submitters were asked to provide the wavelength range they would like to observe with E-ELT. Most of the DRSP cases propose observations that cover a wide wavelength range and/or multi broad-band filters. We grouped these user defined wavelength ranges into five categories as optical (300–799 nm), near-infrared (800–2600 nm), mid-infrared (2,6–15,0 microns), far-infrared (15,0–30,0 microns) and more (>30 microns). Note that some proposals fall into more than one category but the percentages shown in the following table and pie-charts are the true values that are calculated via dividing by the total number of DRSP proposals, and the total time asked by all proposals, respectively.

Analysis showed that almost two thirds of the DRSP proposals would like to observe in the optical wavelengths whereas more than half would like to observe in the near-infrared. Another 19% is distributed among mid- and far-infrared where observations at >30 microns make up 1.6%. Mid-infrared observations are demanded by 14% of proposals but forms 7% in terms of total time required by observations.

Note that there are 17 out of 187 DRSP proposals asking for observations in wavelengths smaller than 350 nm, which make ~8% of all DRSP cases time-wise.

wavelength range	**# of DRSP submissions (percentage)**	**Total time (percentage)**
300 - 799 nm	64.90	81.79
800 - 2600 nm	56.90	61.45
2601 - 15000 nm	14.40	7.11
15001 - 30000 nm	4.30	4.38
> 30001 nm	1.60	1.65

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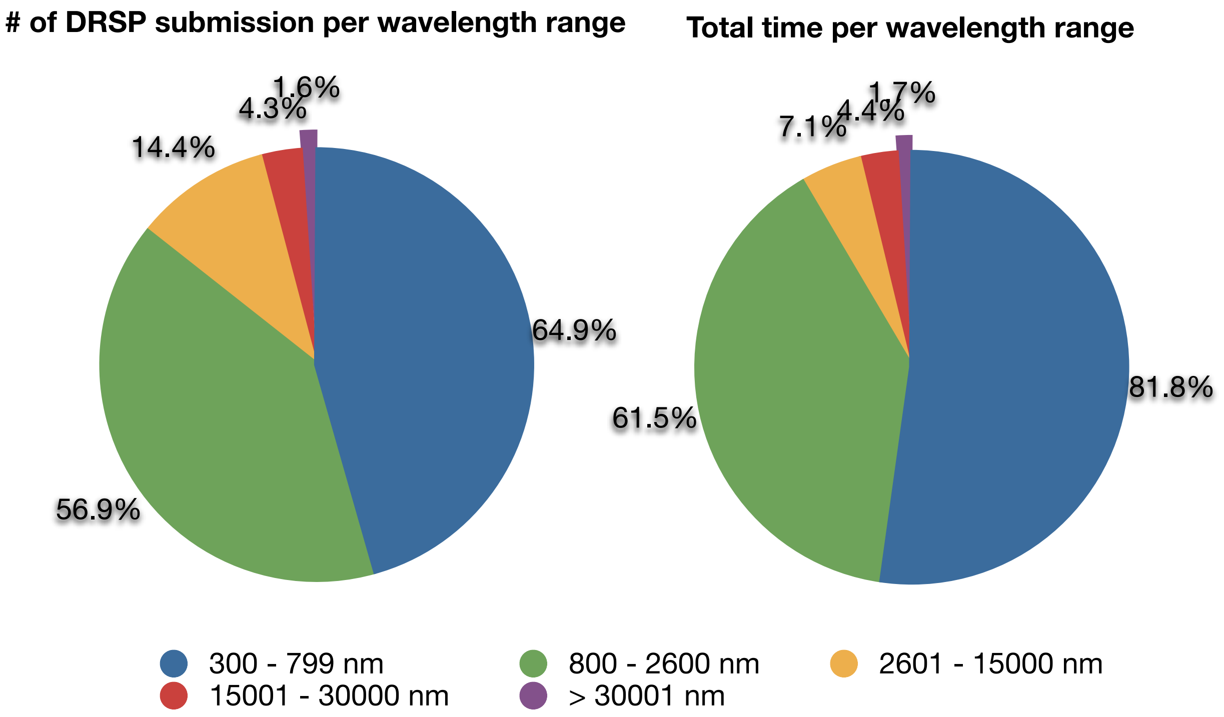


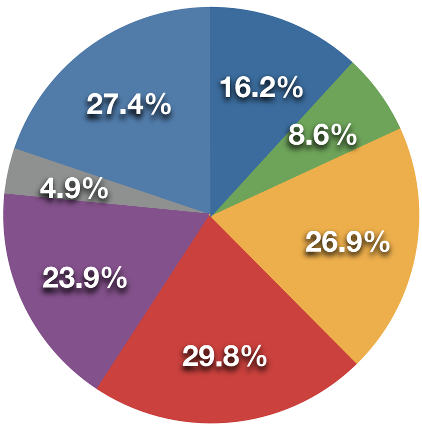
5.5.2 Spectral Resolution

The majority of DRSP proposals asked for spectroscopy, alone or together with imaging. Only one fifth of the DRSP proposals asked for solely broad-band and/or narrow-band imaging. Therefore several proposals fall into more than one category but the percentages shown in the following table and pie-charts are the true values that are calculated via dividing by the total number of DRSP proposals, and the total time asked by all proposals, respectively.
Overall, the type of observation most commonly asked for is broad-band imaging, followed by medium resolution (R=3000 – 5000) observations. Analyses in terms of total and sufficient time required by observations show that the highest spectral resolution (R>100.000) is also among the most commonly demanded spectral resolution.

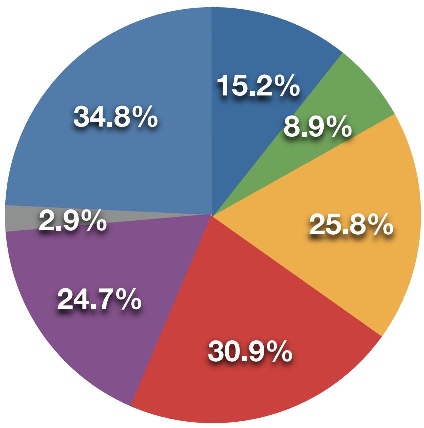
Spectral resolution	Total time (percentage)	Sufficient time (percentage)	# of cases (percentage)
broad-band imaging	16.21	15.19	25.53
narrow-band imaging	8.64	8.86	12.77
100-300	13.08	10.15	6.38
300-500	5.28	5.44	4.26
500-1000	8.50	10.17	6.91
1000-2000	5.79	4.78	8.51
2000-3000	5.87	6.71	8.51
3000-5000	18.12	19.39	19.15
5000-10000	14.54	13.28	15.43

Spectral resolution	Total time (percentage)	Sufficient time (percentage)	# of cases (percentage)
10000-20000	9.36	11.37	12.77
20000-50000	4.89	2.92	6.38
50000-100000	10.76	9.96	14.89
>100000	16.62	24.86	10.11

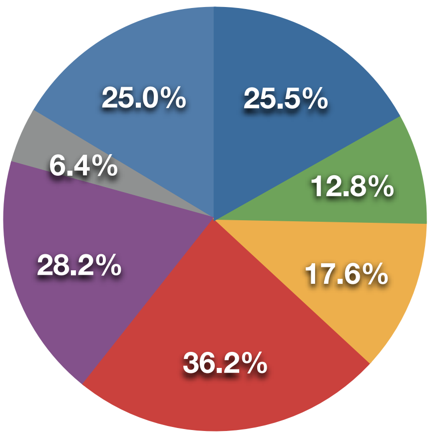
Total time per spectral resolution



Sufficient time per spectral resolution



# of DRSP cases per spectral resolution



broad-band imaging · narrow-band imaging · 100 - 1000 · 1000 - 5000 · 5000 - 20000 · 20000 - 50000 · > 50000

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5.6 Instrument Information

This section of DRSP contains information about the instrumentation requirements of the DRSP science cases including the instrument, desired special mode and desired adaptive optics mode.

5.6.1 Instrument

DRSP submitters were asked to state the instrument they require for the proposed observations. This instrument could either be chosen from the 8 instrument studies under consideration for E-ELT or could be any other instrument proposed and described by the submitter her/himself. Multiple instrument selection was also allowed.
All instruments that are studied in Phase A have been requested and almost all equally, with a slightly higher number of proposals for the only mid-infrared instrument (METIS), and a slightly lower one for the most specialised instrument: the planet-finder (EPICS). However, analysed in terms of total and sufficient time required by observations, CODEX takes of METIS, and the preference for EPICS increases, whereas the slightly less requested instrument is MICADO.

Instrument	# of DRSP submissions (percentage)	Total time (percentage)	Sufficient time (percentage)
METIS	22.87	15.91	11.85
SIMPLE	11.17	8.48	8.26
OPTIMOS	18.62	18.24	18.58
MICADO	18.09	9.13	6.60
HARMONI	17.55	13.54	14.37
EAGLE	13.83	13.49	12.40
CODEX	13.30	19.85	26.42
EPICS	5.85	15.13	16.50
OTHER	13.83	9.41	11.16

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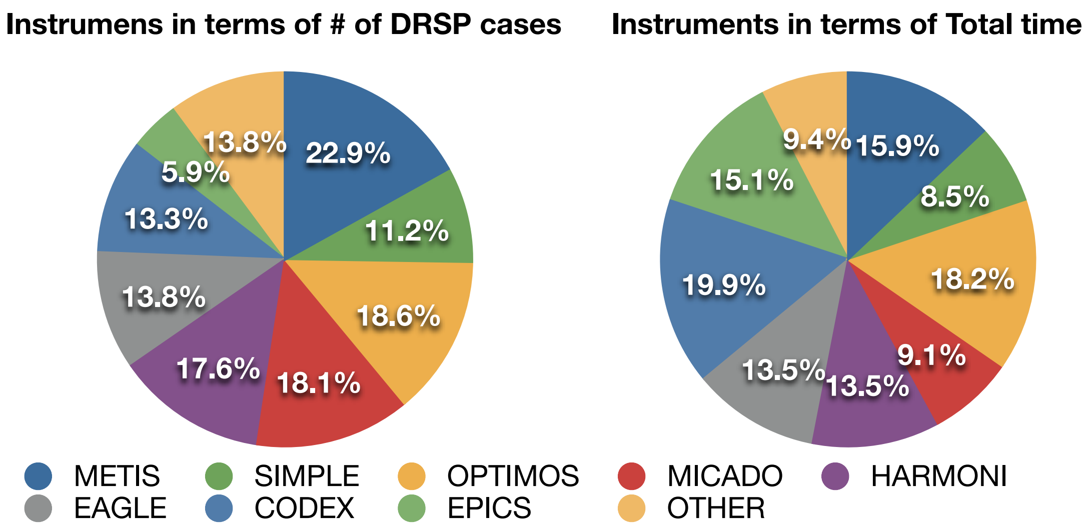

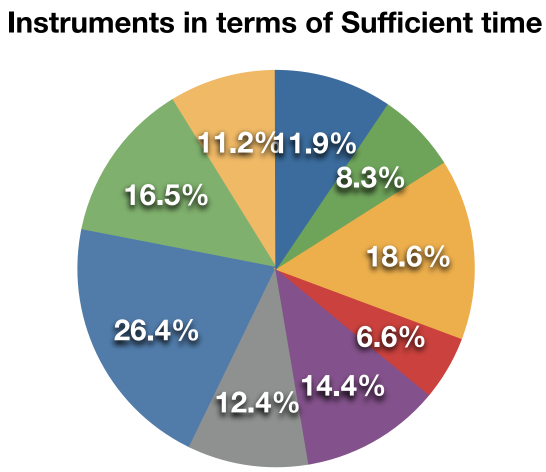

5.6.2 Desired Special Mode

DRSP submitters were asked if their observations require a special mode such as coronagraphy, high time resolution, polarimetry, precision astrometry, precision photometry, special calibration or any other user specified additional special mode. Submitters were allowed to select multiple special modes and/or define their own special mode requirements. 116 of 187 DRSP cases do not require any special mode. The remaining 72 cases requested mostly multiple special modes and almost all modes were requested equally, with a slightly higher number of proposals for precision photometry and lower one for special calibration.
The analysed in terms of total and sufficient time required by observations, coronagraphy requests makes up half of the total, whereas the other modes are almost equally distributed in the remaining half, with a slightly lower request for special calibration.

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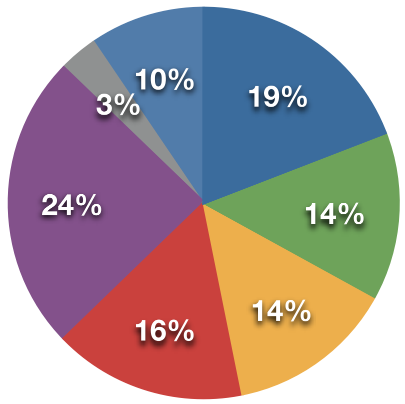
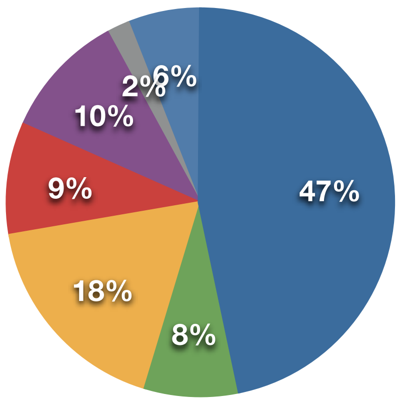
Desired Special Mode	# of DRSP cases	Total time (hr)	Sufficient time (hr)
N/A	116	32026	13946.85
coronagraphy	18	9660	4410.5
high time-resolution	13	1617	569.96
polarimetry	13	3649	1118.95
precision astrometry	15	1922.5	549
precision photometry	23	2153	924.26
special calibration	3	390	297
other	9	1255	437.5

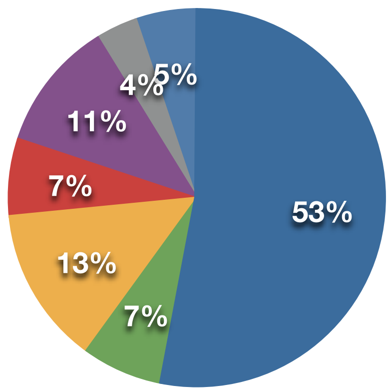
# of DRSP cases per special mode



Total time per special mode



Sufficient time per special mode



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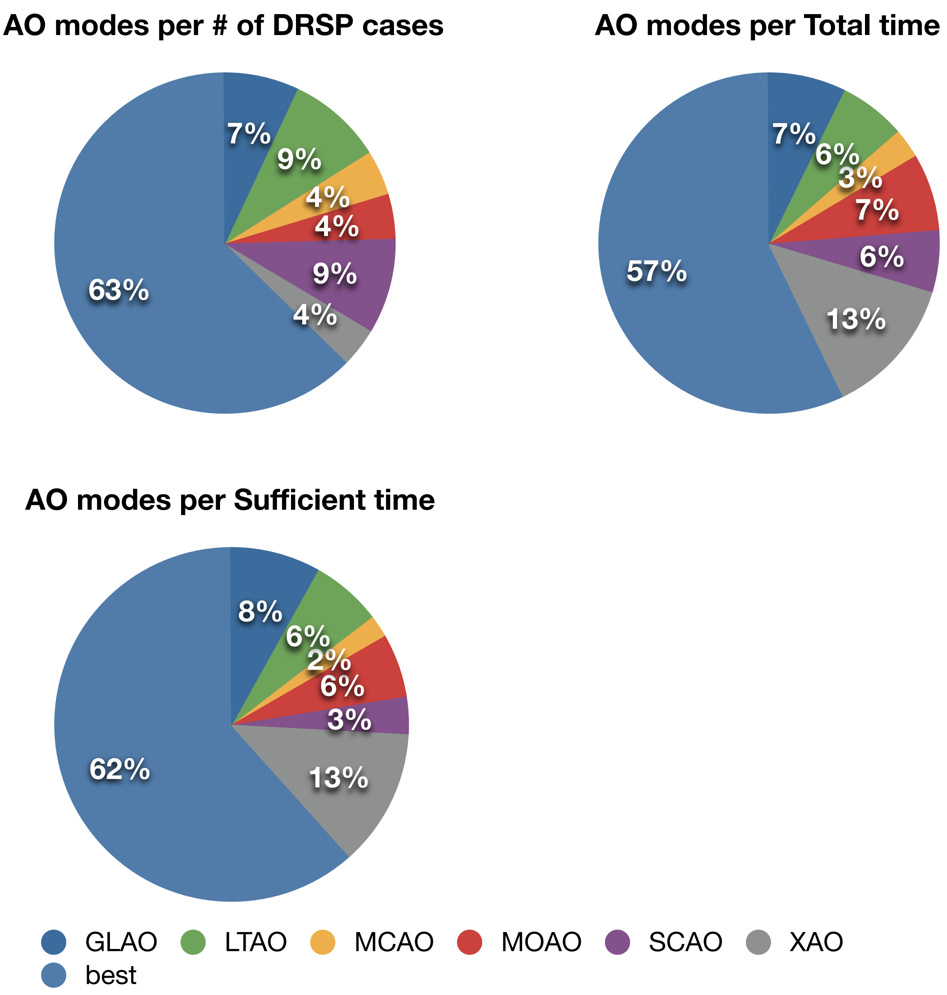
5.6.3 Desired Adaptive Optics Mode

DRSP asked for the desired adaptive optics mode among GLAO, LTAO, MCAO, MOAO, SCAO and XAO, providing also the option called "best for my needs" to overcome the requirement on the user to have an in-depth knowledge of the different AO modes. The majority of the DRSP submitters (>60%) chose the "best for my needs" option. The remaining 40% are distributed almost equally among the other specific AO modes. The situation is similar when analysed in terms of total and sufficient time required by observations, with a slightly higher preference for XAO and slightly lower preference for MCAO.



5.7 Time Requirements

This section of DRSP contains information about the time requirements of the science cases.

5.7.1 Longest Continuous Observation Time on a Target or Field

DRSP submitters were asked to provide the longest continuous observation time on a target or field for their observations. This question was optional yet 155 out of 187 DRSP proposals provided a reply.
One third of the DRSP proposals require observation times between 1–2 hours. There also a significant amount of DRSP proposals (10% number-wise, 17% time-wise) requiring continuous observations for 9–10 hours. Less than 2% of the observations asked for continuous observations longer than 10 hours.

Longest continuous observing time	# of DRSP cases	Total time (hr)	Sufficient time (hr)
None	33	6796	2830.35
< 1	27	7446	3377.8
1 - 2	65	15810	6494.15
2.1 - 3	10	1550	607
3.1 - 4	13	6077	1936
4.1 - 5	4	297.5	210
5.1 - 6	9	1624	530.26
6.1 - 8	4	2300	1080
8.1 - 9	2	418	109
9,1 - 10	19	7150	3661
> 10	2	700	475

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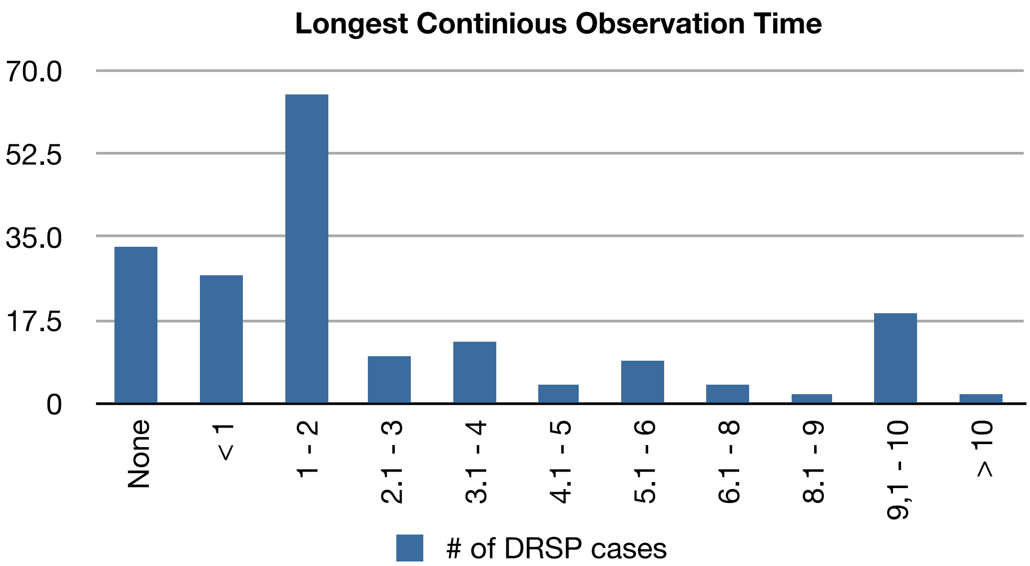
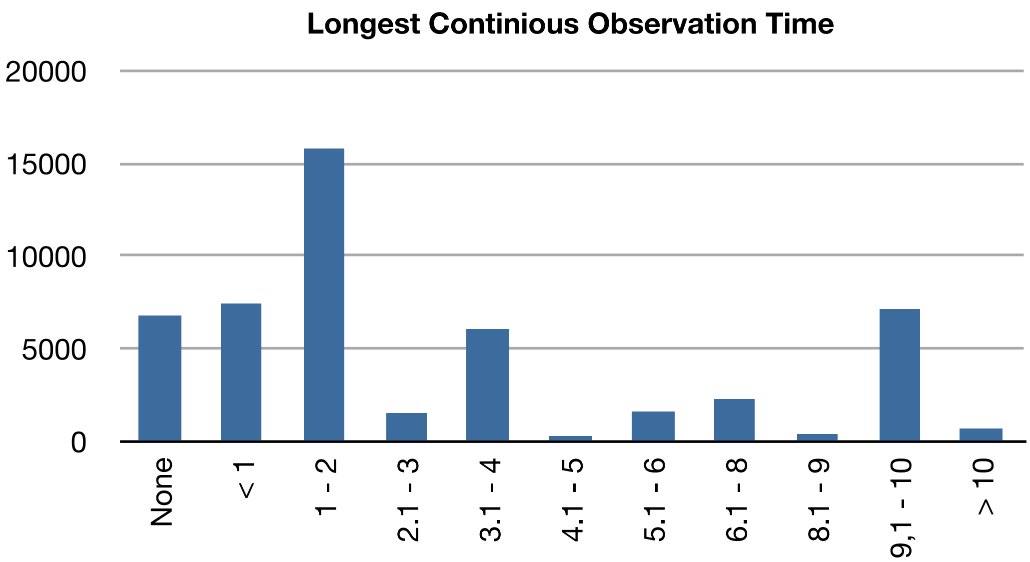
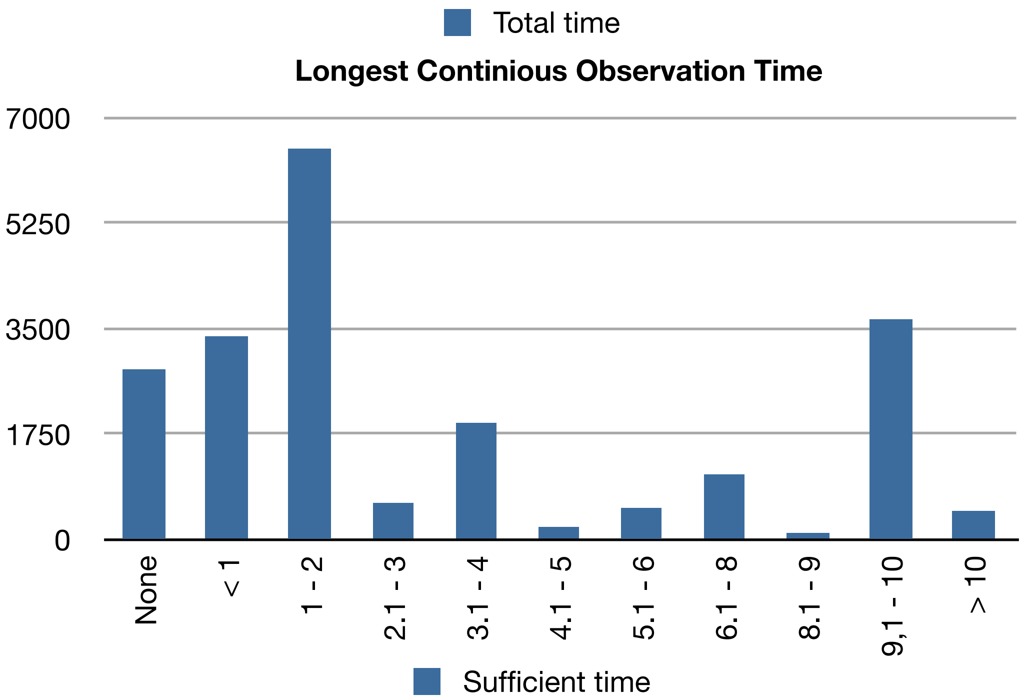

Longest Continious Observation Time
70.0
52.5
35.0
17.5
0
None
< 1
1 - 2
2.1 - 3
3.1 - 4
4.1 - 5
5.1 - 6
6.1 - 8
8.1 - 9
9,1 - 10
> 10
# of DRSP cases


Longest Continious Observation Time
20000
15000
10000
5000
0
None
< 1
1 - 2
2.1 - 3
3.1 - 4
4.1 - 5
5.1 - 6
6.1 - 8
8.1 - 9
9,1 - 10
> 10



5.7.2 Shortest Integration Time on a Target or Field

Another optional question was on the shortest integration time on a target or field, required by the observations proposed by DRSP submitters. 144 out of 187 DRSP proposals submitted a requirement ranging between less than 1 second and 1 hour. The shortest integration time is 1 ms, requested by 4 DRSP proposals. DRSP proposals asking for integration times of or shorter than 1 seconds are represent about 17% of the proposals having expressed a preference. Analysed in terms of total and sufficient time required by observations, one third of the DRSP proposals have shortest integration times between 300 and 1800 seconds, followed by one fifth requiring 1 second or shorter. Less than ten percent of the DRSP proposals require integration times of one hour as shortest.

Shortest integration time	# of DRSP cases	Total time (hr)	Sufficient time (hr)
None	44	9393	4318.85
< 1	10	1470	608.7
1	15	10322	4708.4
2 - 10	19	1859.5	926.96
30 - 300	42	9184	2614.65
301 -1800	47	14575	6703
1801 - 3600	11	3365	1430

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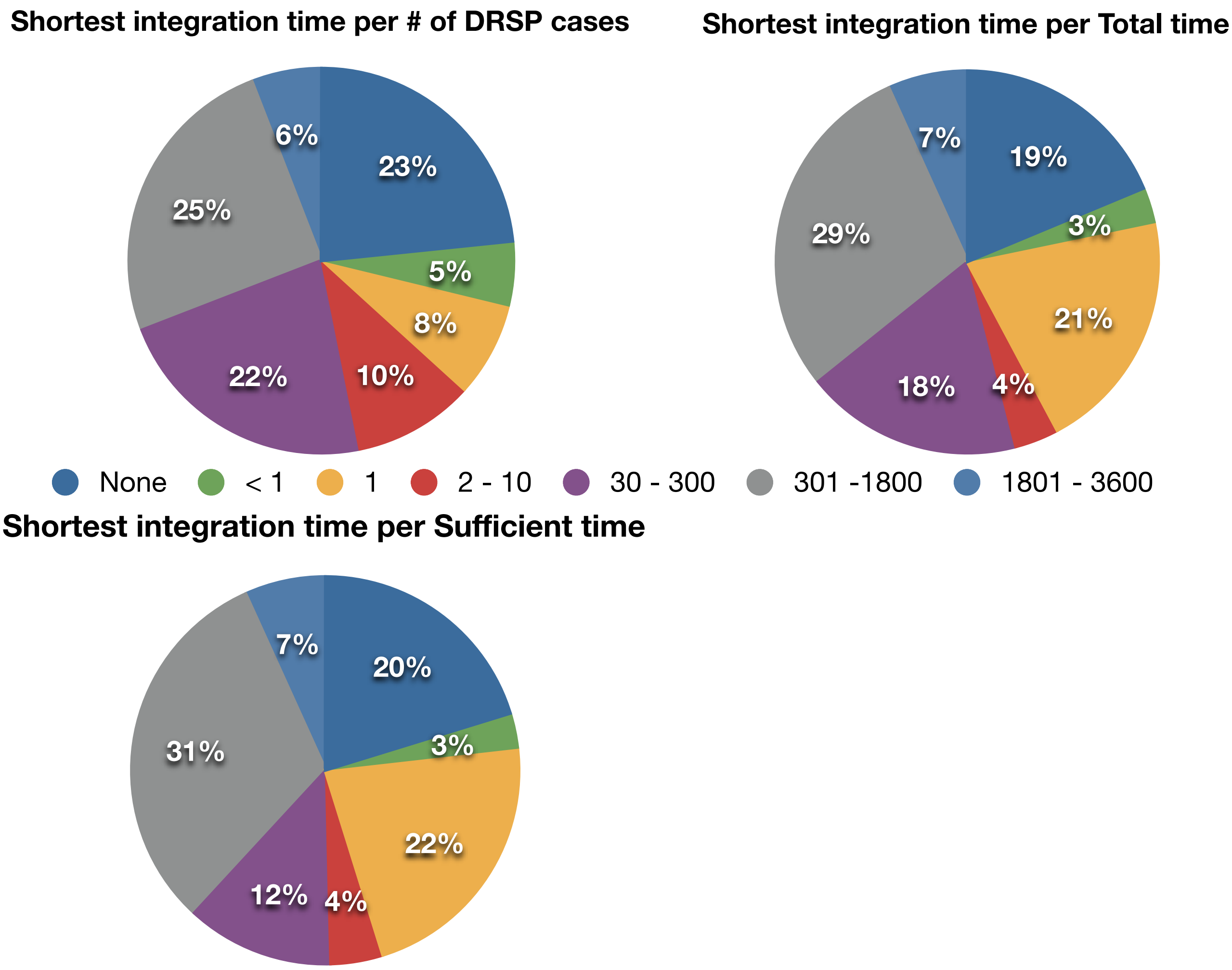


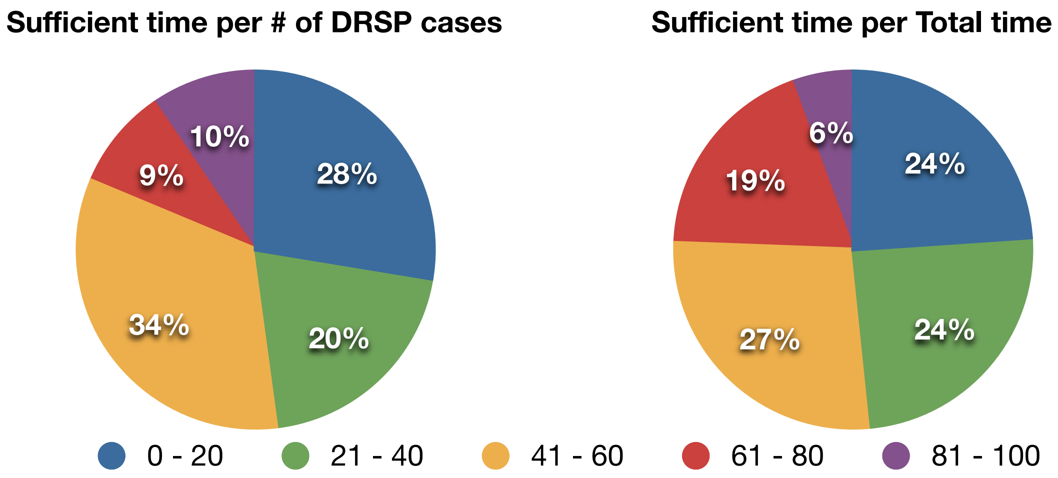
5.7.3 Total Time

The total integration time required by all DRSP observations, excluding the overheads, is 50168.5 hours which corresponds to 5016.85 nights (calculated as 10 hours nigh-time per day) (more than 13 years).

5.7.4 Sufficient Fraction of Time

DRSP submitters were asked to provide the fraction of the total time would suffice to obtain scientifically useful results. Less than 10% of the DRSP proposals require all or more than 80% of the total time they asked. For the majority of the DRSP proposals, less than 60% of the total time they asked is enough to obtain scientifically useful results. The sum of sufficient integration time of all DRSP proposals is 21310.56 seconds which corresponds to 2131.06 nights (calculated as 10 hours nigh-time per day).

Percentage of sufficient time	# of DRSP cases	Total time (hr)
0 - 20	52	12024
21 - 40	38	12259
41 - 60	63	13670
61 - 80	17	9424
81 - 100	18	2791.5



5.7.5 Time Critical Observations

DRSP submitters were asked whether their observations are time critical, i.e., whether there are specific timing requirements for their observations. 39 out of 187 DRSP submissions (20%) replied positively. Some require co-ordinated observations with other facilities and some need time critical observations due to the nature of the targets or science aimed for.

5.8 Operational Information

This section of DRSP contains information about the operational requirements of the DRSP science cases including remote observation capabilities, multiple instrument usage and target-of-opportunity requirements.

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5.8.1 Real Time Decision and Pipeline Requirements

DRSP submitters were asked to specify any automatic pipeline requirements when they propose observations that require real-time decisions.
The vast majority of the DRSP proposals do not require real-time decisions. Only 31 cases require real-time decisions mostly due to the movement or variable nature of their targets and thus mostly required quick-look data analysis capabilities.

5.8.2 Remote Observing and Additional Capabilities

DRSP submitters were asked whether they would welcome remote observing capabilities. If so, they were asked to list the capabilities that should be provided. 69 out of 187 DRSP proposals replied positively for the remote observing capabilities. Half of these did not specify any capabilities to be provided whereas the most common capability asked for is a quick-look access to the reduced data.

5.8.3 Multiple Instrument Usage

DRSP submitters were asked if their observing programme required the use of two or more different E-ELT instruments and if so, to provide the maximum time-lag in units of minutes between observations with different instruments.
The vast majority of the DRSP proposals did not request multiple instrument usage. Among the 27 cases that did require such observations, 19 did not provide any maximum time-lag between observations with different instruments. The lowest time-lag is zero minutes and the longest time-lag is almost half a year.

5.8.4 Target-of-Opportunity Requirements

16 out of 187 DRSP proposals require target-of-opportunity (ToO) observations, which make up less than 1% when analysed in terms of total and sufficient time required by observations. For the longest acceptable response time to a trigger, the shortest requirement is 10 minutes and the longest is 7 hours.

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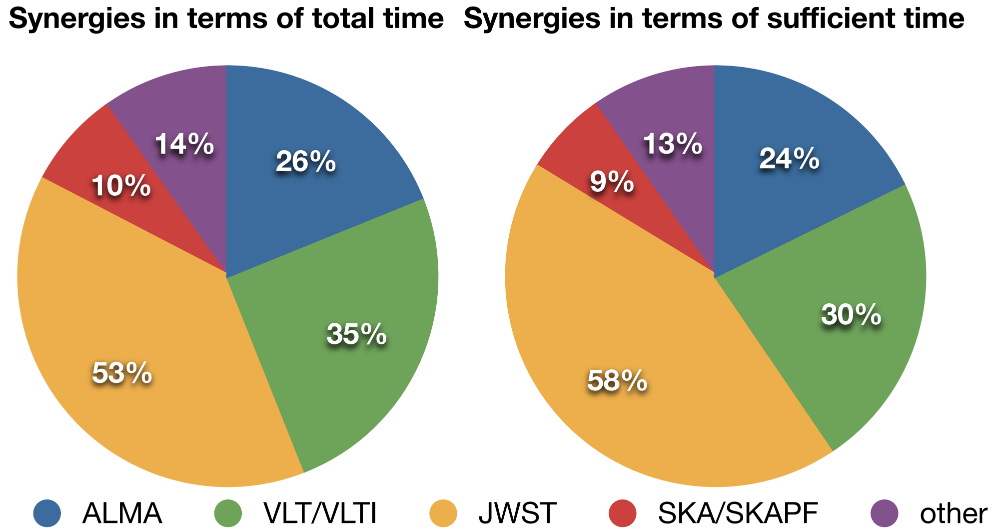
5.9 Synergies and Critical Aspects

This section of DRSP contains information regarding the synergies and critical aspects of the DRSP science cases.

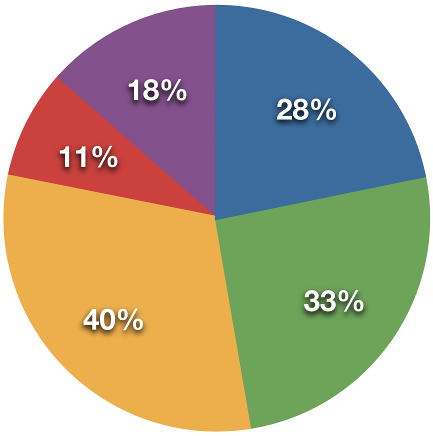
5.9.1 Synergies with Other Facilities

Only one fifth of all DRSP do not require synergies with other facilities.
The largest fraction (40% in numbers and more than 50% time-wise) point to synergy with the JWST. One third of the proposals link with VLT/VLTI, one forth with ALMA and around 10% with the SKA. About 15% of the DRSP proposals requested synergies with facilities other than these four.

Synergy facility	Total time (percentage)	Sufficient time (percentage)	# of DRSP cases (percentage)
ALMA	26.03	23.60	28.19
VLT/VLTI	34.61	30.30	32.98
JWST	53.34	57.64	39.89
SKA/SKAPF	10.24	8.58	10.64
other	13.60	12.99	17.55



Synergies in terms of # of DRSP cases



Synergy facility	Wavelength range (nm)	Sufficient time (hr)	# of DRSP cases	Total time (hr)
ALMA	300-799	2958	22	5590
VLT/VLTI	300-799	5393.05	75	12547
JWST	300-799	6971.25	40	13448
SKA/SKAPF	300-799	2341.75	22	4505
other	300-799	2607.5	21	4875
ALMA	800-2600	3544	32	7930
VLT/VLTI	800-2600	5445.55	79	14637
JWST	800-2600	9541.05	66	21188
SKA/SKAPF	800-2600	1542.75	19	3775
other	800-2600	2624.5	22	5315
ALMA	2601-15000	1555.25	27	4735
VLT/VLTI	2601-15000	3651.5	31	9230
JWST	2601-15000	3821.5	33	9340
SKA/SKAPF	2601-15000	3300	22	6600
other	2601-15000	3541.5	28	7140
ALMA	15001-30000	0	0	0
VLT/VLTI	15001-30000	0	0	0
JWST	15001-30000	30	1	300
SKA/SKAPF	15001-30000	0	0	0
other	15001-30000	22.5	3	45
ALMA	>30000	400	2	800
VLT/VLTI	>30000	0	0	0
JWST	>30000	400	2	800
SKA/SKAPF	>30000	0	0	0
other	>30000	400	2	800

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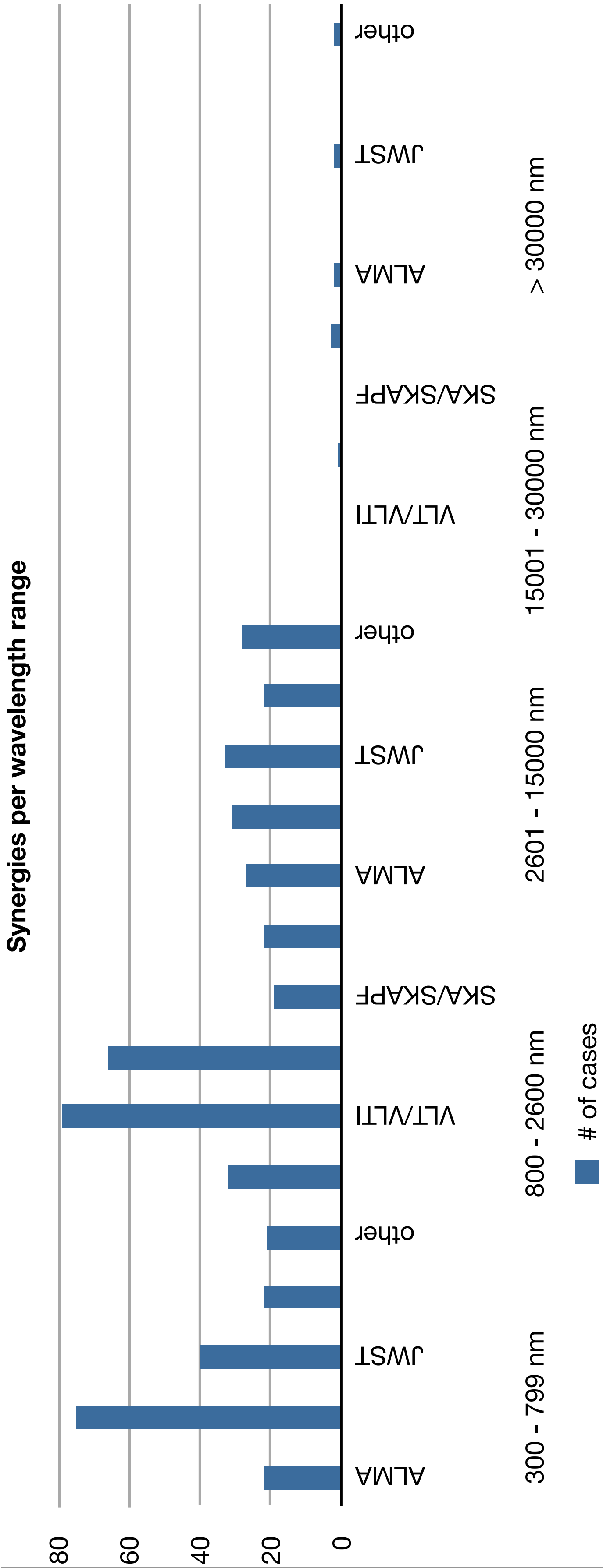

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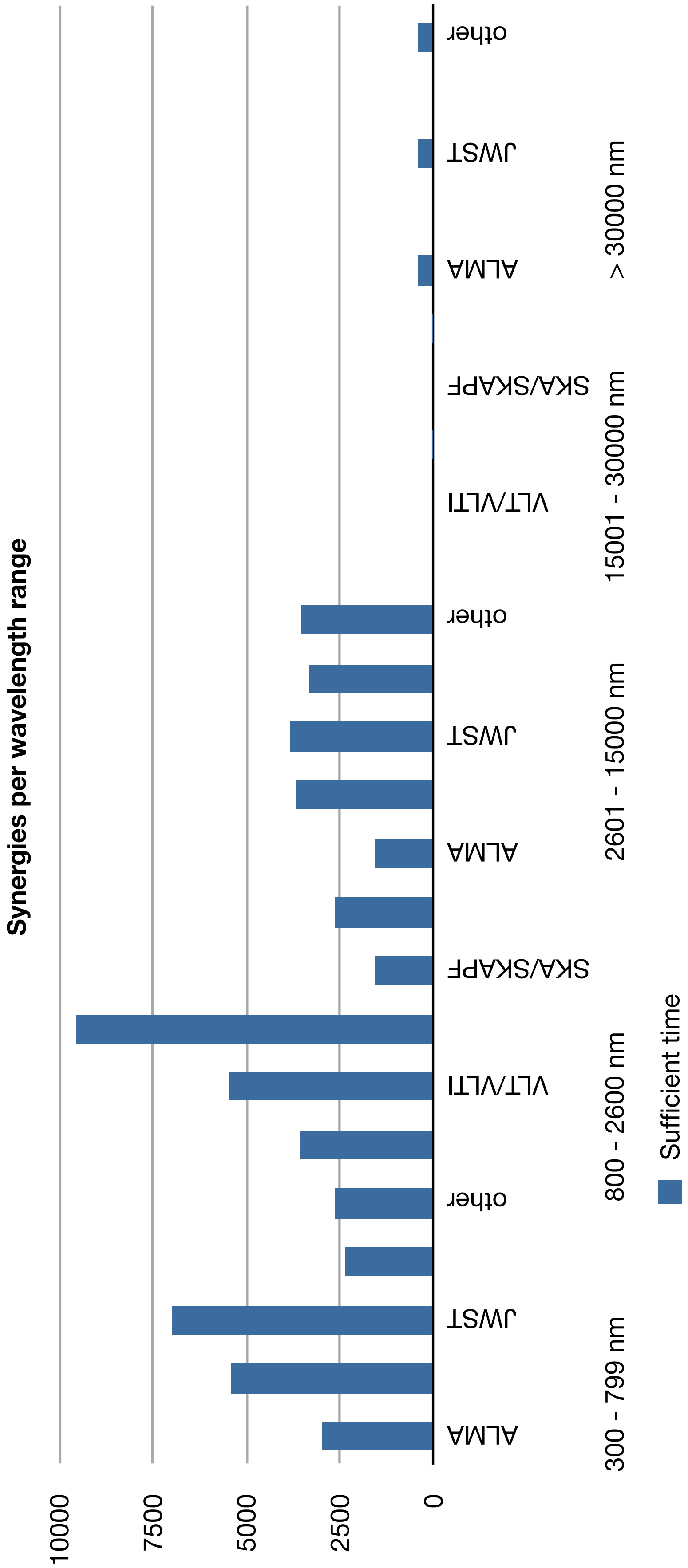
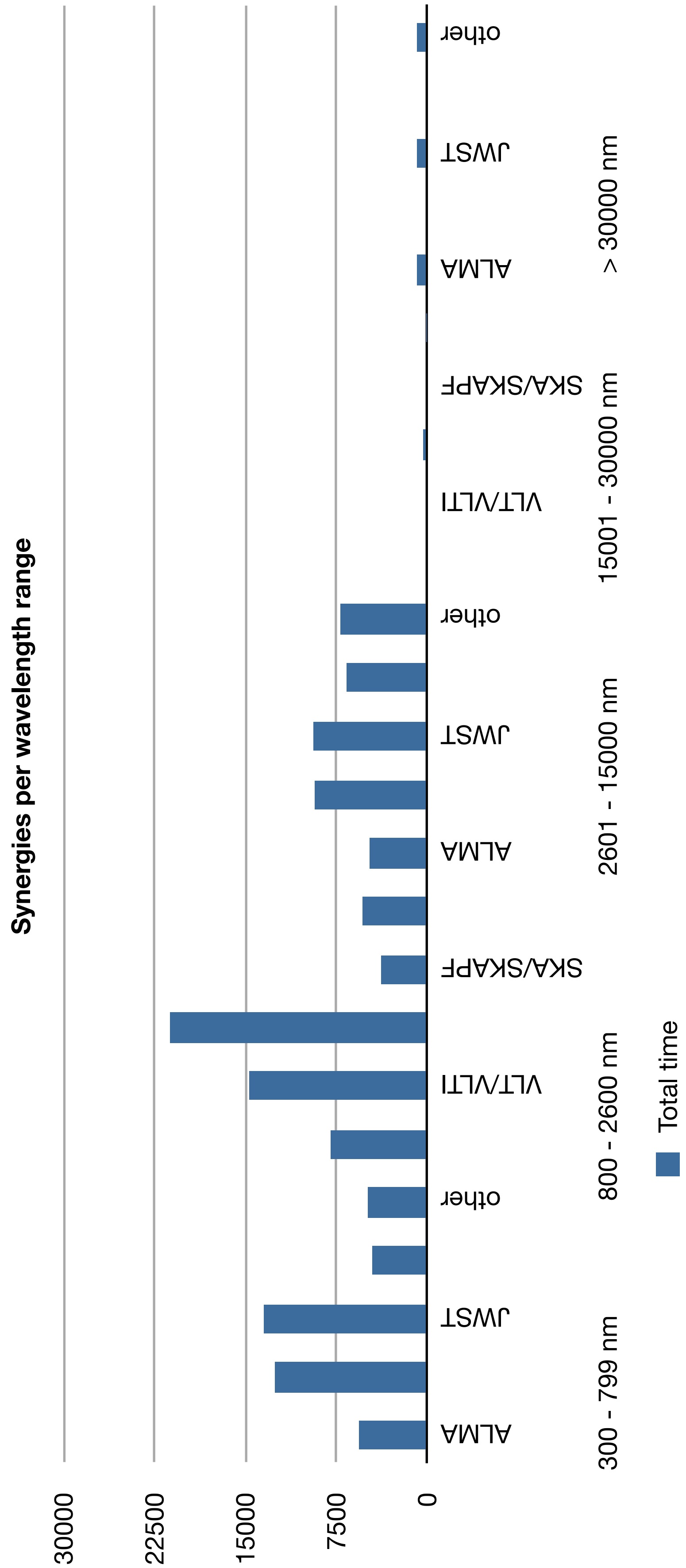

Synergies per wavelength range
10000
7500
5000
2500
0
ALMA
JWST
other
VLT/VLTI
SKA/SKAPF
300 - 799 nm
800 - 2600 nm
2601 - 15000 nm
15001 - 30000 nm
> 30000 nm
Sufficient time



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5.9.2 Critical Aspects and Limiting Factors for the Science Cases

The most commonly expressed critical aspect is the adaptive optics and spatial resolution/ diffraction limited observations, listed by 45 out of 187 DRSP proposals (20% time-wise). Integral field unit spectrography is stated by 20 out of 187 proposals (> 13% time-wise). The next common critical aspects are multiplexity and multi-object spectroscopy which is expressed by 11 DRSP proposals (9% time-wise), and high spectral resolution as mentioned in 10 DRSP proposals (> 4% time-wise).

6 Feedback to the E-ELT Project

The DRSP has provided some immediate feedback to the project. It will remain a database to be analysed in the future and will play a role in the consideration of advisory committees, but some immediate first conclusions are listed below.

6.1 Telescope Design

There are several areas of the DRSP that are related to the telescope design: the wavelength range, AO, target brightness, time critical observations, ToO and total FoV.

Most aspects requested in the DRSP proposals had been taken into account by the project. A few critical ones such as the wavelength range remained uncertain choices.
The DRSP analysis showed that wide wavelength ranges from ultra-violet to mid-infrared and sub-mm are demanded by the community. The major impact on the telescope design is the mirror coating which is to be one of the two open choices: a bare aluminium coating or a protected silver coating. The protected silver coating is clearly superior to the bare aluminium coating at all wavelengths > 370 nm. However, only the aluminium coating would provide access to the UV below 350 nm down to the atmospheric cut-off. The latter was demanded by only 17 out of 187 DRSP proposals (~8% of all DRSP cases time-wise). From a DRSP point of view, a protected silver coating would thus be preferred.

Another open point was the field-of-view and its vignetting. Somewhat surprisingly, only ~8% of the DRSP proposals asked for >5x5 arcmins FoV, i.e. larger than the current unvignetted FoV of the telescope.

Rapid response opportunities are still requested and will be accommodated by the telescope kinematics and instrument readiness times.

6.2 Instrument Selection

The DRSP included many questions related to the instrument properties such as the wavelength range, spectral resolution, spatial resolution, AO, multiplexity, field-of-view (FoV), desired special mode, shortest integration time, and the preferred instrument. The DRSP responses were fed to the E-ELT Science Working Group (SWG) and used as an input for the SWG's instrument recommendation.

All instruments are requested by similar number of proposals and also with similar percentage time-wise. Around 10% of the DRSP proposals (number and time-wise) requested an instrument other than the 8 under study.

The AO mode and shortest integration time required do not provide any conclusive constraints for instrument selection since most of the DRSP submitters selected the AO mode "best for their needs" and the rest is almost equally distributed among different AO modes. Similarly, the majority of the DRSP proposals do not require challenging short integration times, as only 13% of the proposals (~25% time-wise) asked for integration times of less than or equal to 1 second.

Most of the DRSP proposals require observations covering a wide wavelength range i.e., covering both optical and infrared wavelengths. Analysing the wavelength range in terms of optical (300–799 nm), near-infrared (800–2600 nm), mid-infrared (2601–15000 nm), far-infrared (15001–30000 nm) and more (>30001 nm), showed that optical observations are requested by 65%, near-infrared observations are requested by 57% and mid-infrared observations are requested by 14% of the DRSP proposals. This indicates that instruments covering a wide range from optical to near-infrared are needed to satisfy the needs of the community.

Around one third of the DRSP proposals asked for diffraction-limited observations. Among these, imaging and low spectral resolution (R < 1000) modes dominate the number of requests, while the different spectral resolutions have equal lower shares. When combined with the proposals asking for a spatial resolution equal to or less than 50 mas, the DRSP proposals requiring very high spatial resolution amount to half of the total.
Around one third of the proposals asked for seeing-limited observations, largely dominated by very high spectral resolution (R > 50.000) observations in the optical. Note that a single science case of the CODEX instrument makes up one fourth of the seeing-limited cases and 8% of all DRSP cases time-wise. Excluding this one case, the DRSP analysis in terms of spatial and spectral resolution indicate that the majority of the community demands instruments that provide very high spatial resolution, and both imaging and at least medium resolution spectroscopic capabilities.

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DRSP submitters were asked whether their science case requires an instrumental special mode not yet foreseen, such as coronagraphy, high-time resolution, precision photometry, etc. or any user-defined special mode. The majority of the DRSP proposals (> 60%) did not require any additional mode, indicating that the instruments under study fulfilled their needs.

Another aspect of instrumentation covered by the DRSP questionnaire were the FoV and the multiplexity.
The total field-of-view (FoV) required by DRSP proposals was dominated by small FoVs (<10”). FoVs smaller than 10 arcsec × 10 arcsec make up two thirds of all DRSP cases. FoVs larger than 5 arcmin×5 arcmin only 8% of all DRSP cases. Multiplexity was only requested by ~15% of DRSP proposals.
This indicates that the majority of the first generation proposals can be satisfied with small FoV, single object instruments which would satisfy the needs of the majority of the community.

6.3 Site Selection

The DRSP prompted questions such as target coordinates, target selection facilities, AO, wavelength range and synergies, whose replies are related to the site of the E-ELT. By the time the DRSP was conducted the site of the E-ELT was not yet decided. Therefore the DRSP stands as an impartial measure of the community’s preference regarding the site of the E-ELT.

About 60% of the DRSP submissions did not provide any coordinates for their targets. Among the remaining 70 cases, 48 had no preference for the hemisphere whereas 22 out of 70 DRSP proposals show a clear preference for the southern hemisphere (19 out of 22).
The facilities with which the targets of the DRSP submissions are chosen also showed a preference for the southern hemisphere. The most common source of targets is the VLT as listed in more than a third (more than half time-wise) of the DRSP proposals. Other southern hemisphere facilities like ALMA and VISTA are also among the prominent sources for targets, mentioned by 52 out of 187 DRSP proposals. The majority of the rest will be using satellite missions such as HST, Spitzer and JWST.

The wavelength range demanded by the DRSP submitters covers a wide range, mostly optical and/ or near-infrared but with a non-negligible percentage of submitters (20% of DRSP cases making 12% time-wise) asking for mid-IR and sub-mm observations. This indicates that the community has a non-negligible preference for an infrared-friendly site.
In terms of the adaptive optics, only 8% of the DRSP submitters demanded the telescope provided GLAO whereas the rest opted for more complex AO systems, indicating that the site should also be AO-friendly.
Synergy with other facilities is another area over which the site plays a great role. The DRSP submitters have a clear preference (> 80%) for synergies with facilities in the southern hemisphere like VLT/VLTI, ALMA and SKA.

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6.4 Operations

The E-ELT Operations Project Office has prepared a separate document on the operational requirements of the E-ELT based on the DRSP responses (see E-TRE-ESO-725-0639).

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Appendices

A. Title of All DRSP Submissions

1. Planets of brown dwarfs
2. Measuring Cosmic Magnetic Fields with the E-ELT
3. Black holes in nuclear star clusters
4. The accretion history of outer halo of giant galaxies
5. Understanding Accretion and Outflow in star and planet formation
6. Center of the Milky Way in the NIR/MIR
7. Search and characterization of small mass planets around nearby stars
8. Planets Discovered by Radial Velocity Searches
9. Young self-luminous gas planets in star forming regions
10. Imaging hot-star surfaces at short wavelengths
11. Resolving natural laser emission from Eta Carinae
12. Corrugated stellar surfaces
13. Wavelength shifts of intergalactic absorption lines
14. Probing galaxy evolution with long-period variables
15. The star formation history of the most metal poor galaxies. A case of near-field cosmology.
16. Exploring the Era of Planetesimal Formation in the Solar System - The Ice Phase
17. Exploring the Era of Planetesimal Formation in the Solar System - The Dust Phase
18. The internal structure of asteroids and comets - body formation and evolution in the planetary disk
19. The inner 10 pc of M31, M32 and M33: what drives the formation of supermassive
20. A dynamical measurement of the expansion history of the Universe
21. The impact of the host galaxy environment to trigger SNe and GRBs: probing the SN factory NGC2770.
22. The Galactic Center: I: Star Formation near a MBH - a test case for evolution in galaxy nuclei
23. The Galactic Center: II: The central cusp - a laboratory for stellar dynamics and a probe of the gravitational potential

24. The Galactic Center: III: The Accretion Flow onto the massive black hole - an archetype of low-efficiency AGN
25. The evolution of metallicity in the intergalactic medium from high redshift.
26. 3D reconstruction of the Intergalactic Medium
27. Searching for the variability of fundamental physical constants with QSO absorption spectra
28. Probing the interplay of galaxies and the intergalactic medium from which they form
29. Young Massive Star Clusters in M31 and M33
30. Extragalactic black holes: are ULXs intermediate mass black holes?
31. The growth of supermassive black holes in obscured galactic nuclei
32. SCUBA2 on E-ELT
33. Transiting exomoons
34. Formation and Evolution of the two giant elliptical of the Coma cluster
35. Stellar populations in NGC 5128
36. The architecture of planetary systems - including Earth-mass planets in the habitable zones - with age
37. Characterizing the atmospheres of transiting rocky planets within the habitable zone of M stars
38. Galactic Archaeology: Unravelling the assembly history of the Milky Way with nucleochronometry
39. Taxonomy of the formation of Low Mass Objects: from the Local Bubble to the Perseus Arm
40. Earth twins in the habitable zone of Solar-type stars
41. Protocluster formation, clusters discovered by ALMA through the Sunyaev-Zeldovich effect
42. Observing Titan's surface and atmosphere activity
43. Detailed characterization of the galaxies with the most intense star formation at z=1-4
44. Stellar kinematics of z~1-2 star forming and active galaxies
45. Measuring black hole and neutron star masses in Galactic sources
46. Proto-planetary disks with aperture masking: bridging the gap to VLTI
47. Planets in the Galactic Bulge and external dwarf galaxies
48. TNO, icy relics of the early Solar System
49. Testing planetary pollution and stellar models using precise abundaces in twin binaries
50. Mg Isotopes in Very Metal-Poor K Dwarfs
51. The evolution of the black-hole mass - Bulge Luminosity - Sigma relationship using QSOs
52. Determining the upper stellar mass limit from resolved starburst clusters
53. Evolution of the mass-luminosity relationship for brown dwarfs and superJupiters
54. Taxonomy of the formation of Low Mass Objects: from the Local Bubble to the Perseus Arm
55. Resolved Stellar Populations

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56. A Spectroscopic Survey of Globular Clusters in Coma: Early Galaxy Formation and Dark Matter Content.
57. Constraining reionisation with Lyman-alpha emitters in the young Universe
58. The dark nature of ultra-compact dwarf galaxies
59. Globular clusters as key tracers of dark matter around giant ellipticals and their formation history
60. Dwarf spheroidal galaxies in the Perseus Cluster
61. Tracking the First galaxies and cosmic reionisation from redshift 5 to 13
62. Survey for Companions of Jupiter Trojan Asteroids
63. Rapid Reponse Observation of Gamma-Ray Bursts
64. Direct imaging of exoplanets around nearby main-sequence stars
65. Dwarf Galaxies in the Coma Cluster: probing the faint end of the luminosity function in dense environments.
66. AGB stars in Local Group Galaxies
67. Exploring Atmospheric Phenomena on the Giant Planets from E-ELT
68. Star formation history in late type galaxies in Virgo
69. Detecting Earth-like planets around very nearby stars
70. The central structure and supermassive black holes in nearby galaxies
71. Imaging the circumstellar environment of massive protostars
72. Fast cadence, high-resolution spectroscopy of stellar activity phenomena
73. The redshift z = 2 Universe
74. The Physics of Galaxy Evolution from Stellar Archaeology
75. Nuclear activity in nearby galaxies
76. Young Jupiters in Nearby Associations
77. Multiplicity of very low luminosity objects
78. Luminous and Ultraluminous Infrared Galaxies up to z=3
79. Star formation by submm large area continuum mapping
80. Census of the Galaxy plane: submm continuum survey
81. MID-IR Characterization of exoplanet atmospheres in the solar neighbourhood
82. The cosmic history of super-massive Black hole growth
83. Kinematics of isolated dwarf galaxies of the Local Group: probing the structure of Dark Matter haloes in their pristine status
84. A survey for giant planets in the Large Magellanic Cloud
85. Research for exo-planets in open clusters
86. Activity and magnetic fields in young low-mass stars and brown dwarfs
87. Spatially resolved properties of the galaxies with the most intense star formation at z=1-4

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88. Metallicities of M dwarfs: with and without planets
89. High Time Resolution Astrophysics
90. Signatures of planets and of their formation in circumstellar disks
91. Pristine C and N abundances in Local Group galaxies
92. Lithium abundance in Local Group galaxies
93. The physics of exo-planets atmospheres
94. The metallicity evolution at high redshift
95. Extragalactic X-ray binaries
96. a METIS study of brown dwarf disks
97. Resolving the chemistry of planet formation with E-ELT METIS
98. Unravelling the formation of massive galaxies: ELT studies of high-redshift ULIRGs
99. Peculiar erruptive variable(s)
100. Extended Planetary nebulae
101. Dark Matter and Dark Energy with Gravitational Lensing and the E-ELT
102. A SIMPLE view of the world of cool stars
103. Unveiling the physical and chemical properties of Extragalactic Star Clusters systems
104. Probing the inner region of proto-planetary disks
105. Mass decomposition of disk galaxies at z~1
106. Resolving the molecular envelope around evolved stars
107. Unraveling the gas producing agents in galaxies
108. Infrared magnetic field studies of cool stars and exoplanets
109. High Precision Dark Matter Mapping
110. Dusty structures around evolved stars
111. Star formation history, stellar population content and dynamics of the outer halos of giant elliptical galaxies within 100 Mpc distance
112. White dwarfs in globular clusters
113. GRBs as a tool to explore the high-z universe
114. Testing the universality of the IMF in extragalactic stellar clusters
115. Kinematics of ionised gas in the accretion phase of young massive stars
116. Cosmology with gravitational arc statistics
117. Imaging exozodiacal dust around nearby stars with E-ELT/METIS.
118. Accretion processes in the Galactic Center at the parsec scale
119. Characterizing ULIRGs, and their influence and relationship to the inter-galactic medium
120. Transmission spectroscopy of transiting exoplanets
121. Cosmology with Distant Type Ia Supernovae

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122. Tracing the velocity field of intra-cluster stars in the most X-ray-luminous galaxy cluster RX J1347.5-1145 with EAGLE
123. Characterisation of old planets at white dwarfs with the E-ELT
124. Morphology and Surface Profile X-ray Bright Optically Normal Galaxies
125. Galactic Population of SNIa progenitors
126. Mapping the ionised gas at large scales: galactic haloes and IGM
127. Gamma-ray bursts as cosmological probes
128. Sizing Up Asteroids
129. Observing the Extremes of the Core-Collapse Supernova Explosion Mechanism
130. Disk evolution and planet formation around evolved binary stars
131. PROBING THE JOINT FORMATION OF AGNs AND MASSIVE SPHEROIDS
132. Studying Galaxy Evolution in situ
133. LISA binaries and Type Ia Supernovae
134. Masses and stellar velocity dispersions of submillimetre galaxies
135. Intermediate mass black holes
136. Constraining the formation and the evolution of early-type galaxies
137. The mass and fueling of the most massive black holes
138. The formation and evolution of stars and planets with the E-ELT: synergies with ALMA, JWST & SKA
139. The brightest supernovae in the Universe - high redshift pair-instability SNe
140. Resolved morphologies of $z \sim 2$ galaxies: unique views on mass assembly at early epochs
141. High-redshift baryons toward quasars and gamma-ray bursts.
142. Pulsars - An Exemplar of Extreme Physics
143. Exozodiacal discs: characterising the inner parts of planetary systems
144. GRBs as tracers of massive star formation - spatially resolved GRB host spectroscopy
145. Very distant galaxies observed through gravitational telescopes
146. Spectroscopy of massive stars at extremely low metallicity
147. The Role of Active Galactic Nuclei in the Growth of Galaxies
148. A direct meassure of the pc-scale dusty torus structure in AGN centres.
149. Probing jet formation near the event horizons of black holes
150. Spectro-polarimetry with the E-ELT: Magnetic fields in late-type stars & brown dwarfs
151. Compact binaries in large-scale surveys
152. The evolution of the mass-luminosity relationship for planetary mass objects
153. Testing the rotational mixing theory for massive stars
154. Understanding early phases of Star Formation

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155. An ELT study of dusty debris disks around M dwarves, Hyades members and field stars
156. Extragalactic Stellar Science with Blue Supergiants
157. Imaging the birth of relativistic jets
158. Searching for debris discs in terrestrial planet regions.
159. Resolving the known debris disc population
160. Spectroscopic study of primitive near-Earth asteroids: how did water get to Earth?
161. Search for very active comets and other transient phenomena in extrasolar planetary systems
162. Optical/IR pulse profiles of magnetars
163. Evolution of the Cosmological Metric and of Fundamental Structural parameters of Galaxies
164. The merging phase in the evolution of compact groups since z~1
165. A rapid-response mode to study the transient Universe
166. Sizes of asteroids potentially hazardous for our planet
167. The inner workings of late-type stars, as revealed by systematic abundance studies of globular-cluster stars
168. A CO imaging survey of protoplanetary disks: Resolving the planet-forming region with the E-ELT
169. An E-ELT METIS search for Keplerian disks around proto-planets using IR molecular emission lines
170. Resolving Solar System Minor Bodies with AO Imaging
171. Seeking the Progenitors of Type Ia SNe
172. Probing the Properties of the First Galaxies In the Universe with ELT
173. Constraining the progenitor models of long-duration gamma-ray bursts
174. Star formation with ALMA and the EELT
175. Galaxy agglomeration by clusters of galaxies
176. Mid-IR observations of brown dwarfs down to a few Jupiter masses
177. The Enigmatic Martian Atmosphere
178. From first Light to the earliest galaxies: Approaching the end of reionisation with E-ELT/HARMONI
179. HARMONI spectroscopic follow-up of exoplanets detected with future planet finding instrument.
180. Giant-planet-mass objects in the Large Magellanic Clouds
181. Characterizing the lowest mass freely floating objects in star forming regions
182. The centers of Massive Dense Young Clusters: deep ELT infrared imaging and 3D spectroscopy
183. Is the low-density IGM at z~2-3 metal enriched?
184. Colour-magnitude diagrams of resolved stellar populations of elliptical galaxies

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185. First Stars relics in the Milky-Way and satellites
186. ELT integrated spectroscopy of early-type galaxies at z>1
187. A Survey of Black Holes in Different Environments

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B. The DRSP Web Form

The DRSP web form consists of 9 sections, each with multiple questions and form fields. Each question has a help text that pops up in the screen when the mouse is over that item. Below we put a screenshot showing how the form looks like and some examples of the help texts.

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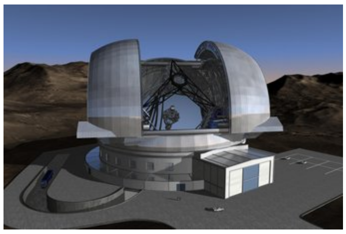
European
Southern
Observatory

E-ELT DRSP

E-ELT DESIGN REFERENCE SCIENCE PLAN: SUBMISSION FORM

The purpose of the form below is to allow members of the E-ELT user community to provide their input to the E-ELT Design Reference Science Plan (DRSP). All members of the community are invited and encouraged to participate in this survey. Please note that the form below will only be available until **30 June 2009** at which point the DRSP submission process will close.

The information you provide will be used by the E-ELT Science Office at ESO (EScO) to compile a statistical analysis of the community's requirements which will be published in a report. **If you do not wish your response to be published then please answer 'No' to the *Publication agreement* item below**. In that case the information you provide will enter the statistical analysis but it will be treated confidentially by EScO and no details will be published.



All observations serving a common scientific purpose should be grouped together into a single programme (i.e. into a single submission) even if that programme requires multiple (types of) observations. Multiple observations can be defined in a single submission by making appropriate multiple selections below. Feel free to submit as many different "observing programmes" as you like, multiple submissions are most welcome.

DRSP FORM

Fields marked with * are mandatory. All other fields are optional. Note that for all mandatory fields, "place holder" options exist.
Help text: Hovering above items displays some additional explanations concerning that item.
Note that multiple selections are possible in many cases (by clicking the options while pressing the Ctrl key).

General Information

Project title *

Project category * — Please select
see ASTRONET for details

Abstract (max 100 words) *

Publication agreement * — Yes / No

Author Information

Principal Investigator *

CoIs (if any) — add >> — remove

Institute of PI

Country of employment of PI * — Please select

Career stage of PI * — Please select

E-mail *

Target Information

Which facility or existing survey or catalogue or resource will be the source of the target(s)? * — e.g. VLT, VISTA, ALMA, SDSS, VizieR, NED, etc.

Is any preparatory work required prior to these observations? — (•) No ( ) Yes: e.g. pre-imaging, wide survey, precise astrometry, radial velocity surv

Target brightness * — from [ ] to [ ] in units of [Vega mag] in [U] band

Target size * — ( ) point source ( ) extended source with half-light radius from [ ] mas to [ ] mas

Number of targets * — [ ] targets and (where applicable) target density of [ ] per arcmin^2

Target coordinates (if known)

( ) Equatorial [0] hours < RA < [24] hours
[-90] degrees < Dec< [+90] degrees [add >>] [remove]

( ) Galactic [0] degrees < l < [360] degrees
[-90] degrees < b < [+90] degrees [add >>] [remove]

Moving target? — (•) No ( ) Yes, with rate [ ] arcsec/hour

Are any of the targets variable? Do they require repeated observations? — (•) No ( ) Yes and requires sampling rate of [ ] observations per [second]

Target type — N/A; Solar System body; Exoplanet; Star

Spatial Information

Spatial resolution * — [Please select] with a linear sampling of [ ] spatial elements (pixel or spaxel)

Field-of-view * — Total FoV of [Please select]

Multiplexity — [1] with pick-off FoV of [N/A]

Plate scale stability — [ ] % over [ ] seconds

Spectral Information

Wavelength range * — from [ ] nm to [ ] nm [add >>] [remove]
and/or [U] [add >>]

Spectral resolution *	broad-band imaging narrow-band imaging R = 100-300 R = 300-500 R = 500-1000

Instrument Information

Instrument * Please see E-ELT instrumentation web page for descriptions of the instruments under consideration.	EAGLE CODEX MICADO EPICS
Desired special mode	N/A Precision photometry Precision astrometry Polarimetry and required precison/comments
Desired AO mode (if known)	Best for my needs

Time Requirements

Integration time per target or field and per setup * Please consult the imaging and spectroscopic E-ELT Exposure Time Calculators (and their documentation).	from ___ to ___ hours assuming i.e. seeing, airmass, lunar phase, thermal background...
Longest continuous observation time on a target or field	___ hours
Shortest integration time on a target or field	___ seconds
Total time required to complete your programme *	___ hours
What fraction of the total time would suffice to obtain scientifically useful results? *	___ %
Are the observations time critical?	No / Yes, because ___

Operational Information

Does the execution of the observations require real-time decisions?	No / Yes, because ___ with the following automatic pipeline requirements:
Would you welcome remote observing capabilities?	No / Yes, the following capabilities should be provided:
Does the programme require the use of two or more different E-ELT instruments?	No / Yes, and the maximum time-lag between observations with different instruments should be ___ min
Is it Target-of-Opportunity like?	No / Yes, and the longest acceptable response time to a trigger is ___ min

Additional Information

Synergy with other facilities	N/A ALMA JWST VLT/VLTI and any further comments

Critical aspects / limiting factors for the science case *

e.g. which capability should not be compromised because it is critical for the success of your programme.

Detailed description of the science case and/or any other comments or remarks (max 1000 words):

Submit form Reset form

A few examples of pup-up help texts:

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European
Southern
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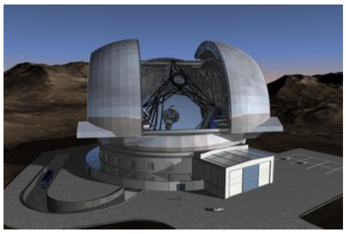
E-ELT DRSP

E-ELT DESIGN REFERENCE SCIENCE PLAN: SUBMISSION FORM

The purpose of the form below is to allow members of the E-ELT user community to provide their input to the E-ELT Design Reference Science Plan (DRSP). All members of the community are invited and encouraged to participate in this survey. Please note that the form below will only be available until **30 June 2009** at which point the DRSP submission process will close.



The information you provide will be used by the E-ELT Science Office at ESO (EScO) to compile a statistical analysis of the community's requirements which will be published in a report. **If you do not wish your response to be published then please answer 'No' to the *Publication agreement* item below**. In that case the information you provide will enter the statistical analysis but it will be treated confidentially by EScO and no details will be published.

All observations serving a common scientific purpose should be grouped together into a single programme (i.e. into a single submission) even if that programme requires multiple (types of) observations. Multiple observations can be defined in a single submission by making appropriate multiple selections below. Feel free to submit as many different "observing programmes" as you like, multiple submissions are most welcome.

DRSP FORM

Fields marked with * are mandatory. All other fields are optional. Note that for all mandatory fields, "place holder" options exist.
Help text: Hovering above items displays some additional explanations concerning that item.
Note that multiple selections are possible in many cases (by clicking the options while pressing the Ctrl key).

General Information

Project title *

Project category * — Please select
see ASTRONET for details

Abstract (max 100 words) *

Publication agreement * — ◉ Yes ◯ No

Do you agree that the information you provide may be published in full in the final DRSP report? If you do not agree your case will only be used for the statistical analysis, but no details will be published.

Auth

Princ

Cols — add >> — remove

Institute of PI

Country of employment of PI * — Please select

Career stage of PI * — Please select

E-mail *

Target Information

Which facility or existing survey or catalogue or resource will be the source of the target(s)? * — e.g. VLT, VISTA, ALMA, SDSS, VizieR, NED, etc.

Is any preparatory work required prior to th... — No / Yes: e.g. pre-imaging, wide survey, precise astrometry, radial velocity surv

Please detail any preparatory work – either on the E-ELT or any other facility – that may be required on your targets prior to this observing programme, and give reasons.

Targ... — from ___ to ___ in units of Vega mag in U band

Targ... — point source / extended source with half-light radius from ___ mas to ___ mas

Number of targets * — ___ targets and (where applicable) target density of ___ per arcmin^2

Target coordinates (if known)

Equatorial — 0 hours < RA < 24 hours
-90 degrees < Dec< +90 degrees — add >> — remove

Galactic — 0 degrees < l < 360 degrees
-90 degrees < b < +90 degrees — add >> — remove

Moving target? — No / Yes, with rate ___ arcsec/hour

Are any of the targets variable? Do they require repeated observations? — No / Yes and requires sampling rate of ___ observations per second

Target type — N/A, Solar System body, Exoplanet, Star

Spatial Information

Spatial resolution * — Please select — with a linear sampling of ___ spatial elements (pixel or spaxel)

Field-of-view * — Total FoV of Please select

Multiplexity — 1 — with pick-off FoV of N/A

Plate scale stability — ___ % over ___ seconds

Spectral Information

Wavelength range * — from ___ nm to ___ nm — add >> — remove
and/or U — add >>

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Target Information

Which facility or existing survey or catalogue or resource will be the source of the target(s)? * — e.g. VLT, VISTA, ALMA, SDSS, VizieR, NED, etc.

Is any preparatory work required prior to these observations? — (•) No ( ) Yes: e.g. pre-imaging, wide survey, precise astrometry, radial velocity surv

Target brightness * — from [ ] to [ ] in units of [Vega mag] in [U] band

Target size * — ( ) point source ( ) extended source with half-light radius from [ ] mas to [ ] mas

Number of targets * — [ ] targets and (where applicable) target density of [ ] per arcmin^2

Targ

Please either fill in the number of individual targets that your programme consists of, or fill in the target density on the sky and the minimum number of targets required to reach your science goals.

( ) Equatorial — 0 hours < RA < 24 hours; -90 degrees < Dec< +90 degrees — add >> — remove

( ) Galactic — 0 degrees < l < 360 degrees; -90 degrees < b < +90 degrees — add >> — remove

Moving target? — (•) No ( ) Yes, with rate [ ] arcsec/hour

Are any of the targets variable? Do they require repeated observations? — (•) No ( ) Yes and requires sampling rate of [ ] observations per [second]

Target type — N/A; Solar System body; Exoplanet; Star

Spatial Information

Spatial resolution * — [Please select] with a linear sampling of [ ] spatial elements (pixel or spaxel)

Field-of-view * — Total FoV of [Please select]

Multiplexity — [1] with pick-off FoV of [N/A]

Plate scale stability — [ ] % over [ ] seconds

Spectral Information

Wavelength range * — from [ ] nm to [ ] nm — add >> — remove

and/or [U] — add >>

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Target Information

Which facility or existing survey or catalogue or resource will be the source of the target(s)? *
e.g. VLT, VISTA, ALMA, SDSS, VizieR, NED, etc.

Is any preparatory work required prior to these observations?
No Yes: e.g. pre-imaging, wide survey, precise astrometry, radial velocity surv

Target brightness *
from to in units of Vega mag in U band

Target size *
point source extended source with half-light radius from mas to mas

Number of targets *
targets and (where applicable) target density of per arcmin^2

Target coordinates (if known)

Please supply the approximate coordinates of your targets, if known. Multiple ranges may be specified. Enter one range at a time and then hit 'add'. The coordinates of individual targets can be specified by giving the same start and end values to the range. Eg: 22 hours < RA < 22 hours. Specifying an entire hemisphere or even the whole sky is also valid.

Equatorial 0 hours < RA < 24 hours
-90 degrees < Dec< +90 degrees add >> remove

Galactic 0 degrees < l < 360 degrees
-90 degrees < b < +90 degrees add >> remove

Moving target?
No Yes, with rate arcsec/hour

Are any of the targets variable? Do they require repeated observations?
No Yes and requires sampling rate of observations per second

Target type
N/A
Solar System body
Exoplanet
Star

Spatial Information

Spatial resolution *
Please select with a linear sampling of spatial elements (pixel or spaxel)

Field-of-view *
Total FoV of Please select

Multiplexity
1 with pick-off FoV of N/A

Plate scale stability
% over seconds

Spectral Information

Wavelength range *
from nm to nm add >> remove
and/or U add >>

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Target Information

Which facility or existing survey or catalogue or resource will be the source of the target(s)? * — e.g. VLT, VISTA, ALMA, SDSS, VizieR, NED, etc.

Is any preparatory work required prior to these observations? — (•) No ( ) Yes: e.g. pre-imaging, wide survey, precise astrometry, radial velocity surv

Target brightness * — from ___ to ___ in units of [Vega mag] in [U] band

Target size * — ( ) point source ( ) extended source with half-light radius from ___ mas to ___ mas

Number of targets * — ___ targets and (where applicable) target density of ___ per arcmin^2

Target coordinates (if known)

( ) Equatorial — 0 hours < RA < 24 hours
-90 degrees < Dec< +90 degrees — add >> — remove

( ) Galactic — 0 degrees < l < 360 degrees
-90 degrees < b < +90 degrees — add >> — remove

Moving target? — (•) No ( ) Yes, with rate ___ arcsec/hour

Are any of the targets variable? Do they... — (•) No ( ) Yes and requires sampling rate of ___ observations per [second]

Please tick and fill in ONLY if the target's variability affects your programme.

Targ... — N/A / Solar System body / Exoplanet / Star

Spatial Information

Spatial resolution * — [Please select] with a linear sampling of ___ spatial elements (pixel or spaxel)

Field-of-view * — Total FoV of [Please select]

Multiplexity — 1 with pick-off FoV of [N/A]

Plate scale stability — ___ % over ___ seconds

Spectral Information

Wavelength range * — from ___ nm to ___ nm — add >> — remove
and/or [U] — add >>

Target Information

Which facility or existing survey or catalogue or resource will be the source of the target(s)? *	e.g. VLT, VISTA, ALMA, SDSS, VizieR, NED, etc.
Is any preparatory work required prior to these observations?	◉ No ○ Yes: e.g. pre-imaging, wide survey, precise astrometry, radial velocity surv
Target brightness *	from [ ] to [ ] in units of [Vega mag] in [U] band
Target size *	○ point source ○ extended source with half-light radius from [ ] mas to [ ] mas
Number of targets *	[ ] targets and (where applicable) target density of [ ] per arcmin^2
Target coordinates (if known)	○ Equatorial [0] hours < RA < [24] hours [-90] degrees < Dec< [+90] degrees add >> remove ○ Galactic [0] degrees < l < [360] degrees [-90] degrees < b < [+90] degrees add >> remove
Moving target?	◉ No ○ Yes, with rate [ ] arcsec/hour
Are any of the targets variable? Do they require repeated observations?	◉ No ○ Yes and requires sampling rate of [ ] observations per [second]
Target type	N/A Solar System body Exoplanet Star

Spatial Information

Spatial resolution *	[Please select] with a linear sampling of [ ] spatial elements (pixel or spaxel)
Fielc	Total FoV of [Please select]
Multi	[1] with pick-off FoV of [N/A]
Plate	[ ] % over [ ] seconds
Spec	
Wavelength range *	from [ ] nm to [ ] nm add >> remove and/or [U] add >>

Please select the spatial resolution value closest to the most stringent value required by your programme. By 'spatial resolution' we mean the smallest distance at which two point sources can reliably be separated. Please also provide the required number of spatial elements (pixel or spaxel) per resolution element. Nyquist sampling requires at least 2 spatial elements per resolution element.

C. Full DRSP Submissions (with authors agreement)

1.1- Project Title: Planets of brown dwarfs

1.2- Project Category: 3

1.3- Abstract:
The detection of free-floating objects of planetary mass implies planets can not only form via core-accretion but also via fragmentation of molecular clouds, like stars. The question, however, is whether planets can form also in orbit around a fusor in this way. Since the formation of massive planets via core-accretion in the disk of brown dwarfs is impossible, the hypothesis can be tested by searching for planets of brown dwarfs. Since it is expected that most such systems have short orbital periods, a radial-velocity survey is preferred over an imaging survey. Using a HR- infrared spectrograph on the E-ELT it will not only be possible to detect Jupiter-like planets but to extend the work down to planet with the mass of the earth. By studying their properties it will be possible to conclude how they formed.

1.4- Publication agreement: yes

2.1- PI: Eike W. Guenther

2.2- CoIs: N/A

2.3- Institute: Thueringer Landessternwarte Tautenburg

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: guenther@tls-tautenburg.de

3.1- Source of targets: VLT

3.2- Preparatory work on targets required?: yes, Some objects will be identified in VISTA survey, most of them area already known.

3.3- Target brightness: 12, 16, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: 0.000001

3.7- Target coordinates: l:0 - 360;b:-90 - +90

3.8- Moving target?: no

3.9- Variable target?: yes, 3 per year

3.10- Target type: exoplanet

4.1- Spatial resolution: 250, 2

4.2- Field-of-view: longslit

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 10, 200

5.1- Wavelength range: 1000 - 2400

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: SIMPLE

6.2- Desired special mode: other, high precision RV measurements

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.06, 0.2, full moon, seeing < 0.8 arcsec, assuming that LG-AO works

7.2- Longest continuous observation time on a target or field: 0.2

7.3- Shortest integration time on a target or field: 200

7.4- Total time: 40

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

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8.2- Would you welcome remote observing capabilities?: yes, It would be important to receive the spectra directly after they have been taken in order to select the best targets for the next observing run.

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
The objects are bright in the IR (12-16 mag in K) but faint in the optical (>> 18 mag in V). In the case of CRIRES on the VLT this is a problem, as the current AO-system does not work for these objects. As mentioned in the ESO Messenger, using a LASER-guide star does improve very significantly the image quality, but without a star to do the tip-tit correction, the image will not be diffraction limited. Thus, the HR-IR spectrograph of the E-ELT has to be built in such a way that it would work efficiently also if there is no bright star close to the target.

9.3- Detailed description or other comments:
The detection of free-floating objects of planetary mass implies planets can not only form via core-accretion but also via
fragmentation of molecular clouds, like stars. The question, however, is whether planets can form also in orbit around a fusor in this way.
Since the formation of massive planets via core-accretion in the disk of brown dwarfs and very low-mass stars is impossible, the hypothesis can
be tested by searching for planets of these objects. Because a system consisting of a brown dwarf and a planet resembles more a binary rather
then a planetary system, and because binary systems are common, such systems might be common too. It is thus better to carry out a
radial-velocity survey in order to detect planets of brown dwarfs. Since it is expected that most such systems have
short orbital periods, a radial-velocity survey is preferred over an imaging survey.

The crucial question thus is, whether really all planets of stars form via core-accretion, or whether some are just planemos in orbit around stars.
There are two possibilities to answer this question: One is to find a transit planet that does not have a core, the other is to find
Jupiter-like planets of BDs. The first idea is almost impossible to carry out, because the mass of the core is typically only 5\\% of a
Jupiter-like planet. The idea of this project is simply that disks of BDs are not massive enough to form Jupiter-like planets, and thus any
massive planet of a BDs must have formed like a planemo. The detection of the famous 2M1207 is already encouraging, as this object is a young

BD with a mass between 25 and 45 MJupiter which is orbited by 5+/-2 MJupiter companion at a distance of 55~AU (Chauvin et
al. 2004). As pointed out by Lodato et al. (2005 the companion could not have formed via core-accretion. Since the
mass-ratio of the primary to secondary resembles more a binary system, it is plausible that this system formed like a wide binary star.
Another interesting object is Oph 162225-240515, which is a 14 MJupiter BD, orbited by a 7 MJupiter planemo (Jayawardhana \\&
Ivanov; 2006). Again the formation of this ``planet\'\' via core-accretion is highly unlikely.

The thrilling perspective of the observations with the ELT is that it will be possible to detect planets with the mass of the earth orbiting BDs. Again there are two possibilities what kind of properties they might have, from which we can conclude how such objects form: one possibility is that are like the terrestrial planets of our solar-system. That is, the angular momentum is in the orbits of the planets, not in the central object. Alternatively, they may be like the moons of Jupiter. That is, the angular momentum is in the central object. By know what the properties of these planets are, we will learn how they formed.

1.1- Project Title: Measuring Cosmic Magnetif Fields with the E-ELT

1.2- Project Category: 4

1.3- Abstract:
Magnetic fields affect the evolution of structure in the universe and drive solar and stellar activity which is a key to lifeâs origin and survival. However, our understanding of how cosmic magnetic fields form and evolve is currently very limited. I discuss the case of high spectral-resolution Stokes vectorpolarimetry with the proposed European ELT. R=105 spectrografs in polarized light are photon starving even for relatively bright stars. The optical design and the large aperture of an E-ELT shall enable future high-precision spectropolarimetry even in linearly polarized light and even for targets as distant as the nearest quasars. This shall enable the direct measurements of cosmic magnetic fields based on the Zeeman effect from stars to quasars.

1.4- Publication agreement: yes

2.1- PI: Klaus G. Strassmeier

2.2- CoIs: W.-R.Hamann, R. NeuhÃ¤user, I. Ilyin, C. Denker, C. Cunningham, R. Eberhardt, E. Beckert

2.3- Institute: AIP

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: kstrassmeier@aip.de

3.1- Source of targets: entire literature

3.2- Preparatory work on targets required?: yes, built a spectropolarimeter in a smart-focal plane

3.3- Target brightness: 0, 23, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 100000

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 4 per hour

3.10- Target type: exoplanet

4.1- Spatial resolution: seeing, 2

4.2- Field-of-view: fiber

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 360 - 2500

5.2- Spectral Resolution: 50000-100000, >100000

6.1- Instrument: other, CODEX and SIMPLE

6.2- Desired special mode: polarimetry, dP/P between 10-2 and 10-6

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.1, 10, N/A

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 10

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 85

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, quick-look data quality

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, 0

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: other, Simulatneous photometry

9.2- Critical aspects / limiting factors for the science case:
A hi-res spectropolarimeter for solar-physics quality dP/P requires a symmetric telescope beam. Currently this is only possible in the intermediate f/4.6 focus.

9.3- Detailed description or other comments:
We propose to undertake a design study for a spectropolarimetric light feed for the E-ELT\'s proposed high-resolution optical and near-IR (echelle) spectrographs. Our aim is to detect a differential polarimetric precision of 10-6 in selected spectral lines. The polarimeter shall be part of a smart focal plane for the symmetric beam of the telescope in its intermediate f/4.6 focus. Our concept shall allow at least two spectrographs to receive (polarized) light at the same time. Among the future scientific applications is a search for the linearly-polarized signal (or the lack thereof) from light reflected off a close-by planet in the
combined Stokes spectra as well as mapping the magnetic seed field in the intergalactic space by using background quasars. We stress the importance of measuring stellar and planetary magnetic fields because these are prerequisites for planet habitability with life as we know it.

1.1- Project Title: Black holes in nuclear star clusters

1.2- Project Category: 2

1.3- Abstract:
Nuclear star clusters (NCs) appear to follow the same scaling relation as supermassive black holes in that their mass is proportional to the mass of their host galaxy. It has therefore been proposed that NCs are an alternative incarnation of \central massive objects" in lower mass galaxies. However, unlike black holes, NCs provide a visible record of the accretion of stars and gas into the nucleus. We propose to make the highest spectral and angular resolution study to date of five nearby (D<5 Mpc) galaxies in order to quantitatively probe their stellar populations and kinematics. These observations will (1) provide important information on the formation mechanism of nuclear star clusters, and (2) allow us
to estimate nuclear star cluster and potential black hole masses and examine scaling relations with their host galaxies.

1.4- Publication agreement: yes

2.1- PI: Nadine Neumayer

2.2- CoIs: C.J. Walcher, T. Boeker, H.-W. Rix

2.3- Institute: ESO, Garching

2.4- Country of Employment: DE

2.5- Career Stage: postdoc

2.6- E-mail: nneumaye@eso.org

3.1- Source of targets: NED, published surveys

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 13, 18, Vegamag/arcsec2, R

3.4- Target size: extended source, 180, 300

3.5- Number of targets: 5

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star cluster, galaxy

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: K, B

5.2- Spectral Resolution: 5000-10000, 10000-20000

6.1- Instrument: EAGLE, OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 4, Seeing: 0.80 arcsecs, Airmass: 1.15, target brightness (V): 14-18mag/sqarcsec, S/N~50/(2spaxel)

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 15

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

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9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
The most important aspects for the success of the proposed science case are high spatial resolution and high sensitivity of the instrument.

9.3- Detailed description or other comments:
N/A

1.1- Project Title: The accretion history of outer halo of giant galaxies

1.2- Project Category: 2

1.3- Abstract:
There is a growing evidence that the outer halos of giant galaxies are composed of chemically inhomogeneous streams, indicating their accretion origin. These evidences are until now primarily based on photometric observations of red giant branch stars. Only in two nearest giant galaxies, the Milky Way, and Andromeda, the spectroscopy of the halo stars is possible. We propose to observe a statistically significant sample of red giant branch stars in the outer halo of NGC 5128, in order to derive abundances of several elements and hence detect possible accreted groups of stars.

1.4- Publication agreement: yes

2.1- PI: Marina Rejkuba

2.2- CoIs: N/A

2.3- Institute: ESO

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: mrejkuba@eso.org

3.1- Source of targets: HST ACS existing data, with possibly some additional VLT data.

3.2- Preparatory work on targets required?: yes, precise astrometry and photometric selection of targets

3.3- Target brightness: 24, 25, Vegamag, I

3.4- Target size: point source

3.5- Number of targets: 120

3.6- Density of targets: 120

3.7- Target coordinates: RA:13 - 14;Dec:-44 - -41

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 75, 4096

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 650 - 920

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 45, 50, 42m telescope, 0.8

7.2- Longest continuous observation time on a target or field: 1.5

7.3- Shortest integration time on a target or field: 3600

7.4- Total time: 150

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7.5- Percentage of the total time sufficient to obtain scientifically useful results: 60

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
Multiplex of at least 30 is necessary. Otherwise the time necessary for the science goal is becoming very long. Spectral resolution of at least 5000 (better ~6000-7000) in the I-band wavelength range. The exposure time assumed LTAO, because with GLAO time necessary was longer than 12 years, according to the ETC.

9.3- Detailed description or other comments:
Centaurus A is the nearest easily observable giant elliptical galaxy. While in the inner regions clear evidences of a recent merger are present, the outer halo of this galaxy shows a smooth stellar density profile. From the photometrically derived metallicities, there is evidence of significant structure in the outer halo. Is this the evidence that the outer halo is built entirely from the accreted satellites? The spectroscopic survey of the large number of red giant branch stars will provide detailed abundances of several elements and address the question whether the outer halo is chemically homogeneous, or if it is built from accreted satellites.

The observational goals are to obtain spectra of S/N=20-30 in the CaII triplet region. CaII triplet has been proven to be a good tracer of [Fe/H] for red giant branch stars. Recently Kirby et al. (2008) showed that with R=6000 spectra, with S/N~20 or better, in the wavelength region around CaII triplet, it is possible to derive also abundances of alpha elements and iron with precision of the order of 0.05 dex. The spectra of red giant branch stars in NGC 5128 will provide therefore the first indication of the chemical enrichment history of this galaxy. Combined with the existing deep images from ACS on HST, we can derive detailed star formation history.

The main goal of the proposal is however to detect groups of stars with similar chemical signatures in the outer halo. The Milky Way halo has been shown to be composed of a huge number of stellar streams, indicating its assembly through hierarchical accretion. The minimum number of targets necessary to detect chemical inhomogeneities is about 60. Stars will be selected from the astrophotometric catalogues obtained with the VLT and HST imaging.

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The detection of stellar streams in the smooth outer halo of NGC 5128 would provide important clues to whether the stellar halo formation is similar in different galaxy types and in different environments. This project will in the future be extended to include also other types of galaxies.

1.1- Project Title: Understanding Accretion and Outflow in star and planet formation

1.2- Project Category: 3

1.3- Abstract:
Over the last two decades, work on protostellar jets has largely focused on intermediate-scale studies of the interaction between jets and the ambient medium, and on statistical studies (surveys) as a means of mapping star formation across large clouds. HST and Spectro-astrometric observations of the central engine hint at the complex interplay between accretion and outflow occurring within 100AU of the protostar. If we are to understand these processes, milli-arcsecond-scale imaging and spectroscopy at near-to-mid-IR wavelengths will be needed to resolve the inner regions of the disk (and disk hole), accretion flows, jet width and collimation/acceleration zone.

1.4- Publication agreement: yes

2.1- PI: Chris Davis

2.2- CoIs: N/A

2.3- Institute: N/A

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: c.davis@jach.hawaii.edu

3.1- Source of targets: VLT, UKIRT, UKIDSS

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 10, 16, Vegamag, K

3.4- Target size: extended source, 10, 1000

3.5- Number of targets: 20

3.6- Density of targets: 2

3.7- Target coordinates: RA:0 - 24;Dec:-60 - +60

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per year

3.10- Target type: star

4.1- Spatial resolution: 10, 2

4.2- Field-of-view: 2x2arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 1000 - 10000

5.2- Spectral Resolution: 10000-20000

6.1- Instrument: SIMPLE

6.2- Desired special mode: precision astrometry, N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.2, 1, N/A

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 10

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

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8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, N/A

9.2- Critical aspects / limiting factors for the science case:
Accretion and outflow velocities are typically 10s of km/s; spectral resolution should not be compromised to increase spectral range for this project.

9.3- Detailed description or other comments:
N/A

1.1- Project Title: Center of the Milky Way in the NIR/MIR

1.2- Project Category: 1

1.3- Abstract:
Star formation and accretion physics close to SgrA*
in the central stellar cluster of the Milky Way:
(1) The IRS13N sources as candidates for young (recently formed)
stellar objects in the central cluster ;
(2) Proper motions of dust filaments tracing wind interaction ;
(3) Bow-shock embedded stars ;
(4) The identification (longward of 8 microns), variability,
and polarization of SgrA*;
Highest angular resolution imaging and/or diagnostic spectral line tracers
available in the MIR can ideally be measured with
the E-ELT in the NIR/MIR.

1.4- Publication agreement: yes

2.1- PI: Andreas Eckart

2.2- CoIs: Christian Straubmeier

2.3- Institute: I Physikalisches Institut, Uni. Koeln

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: eckart@ph1.uni-koeln.de

3.1- Source of targets: VLT

3.2- Preparatory work on targets required?: yes, continuation of VLT studies of the central parsec

3.3- Target brightness: 6, 18, Vegamag, K

3.4- Target size: extended source, few, 1000

3.5- Number of targets: 1

3.6- Density of targets: N/A

3.7- Target coordinates: RA:17 - 18;Dec:-30 - -28

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: other, Galactic Center

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 30x30arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: L, M, N

5.2- Spectral Resolution: 1000-2000

6.1- Instrument: METIS

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6.2- Desired special mode: precision astrometry, imaging and spectroscopy plus polarimetry (optional)

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: 0.2, 1, moderate seeing, AO approaching diffraction limit, clear ky

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 60

7.4- Total time: 20

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 5

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: yes, object selaction within the crowded central stellar cluster, possible triggering of supplementary observations (mm/sub-mm/radio), N/A

8.2- Would you welcome remote observing capabilities?: yes, execution of observing blocks; possibly remote checking of pipeline/prelook/pointing results

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, ALMA and MIRI on JWST

9.2- Critical aspects / limiting factors for the science case:
none - given the high density of point sources and extended source and the great wealth of information already collected - observations are always scientifically useful (using deconvolution, bootstrapping of calibration etc.)

9.3- Detailed description or other comments:
The center of our galaxy (GC) is the closest galactic nucleus that
can be studied.
The region comprises gas and dust filaments (the mini-spiral),
the central stellar cluster and 3-4 million solar masses super-massive
(SMBH) massive black hole
at the position of the compact radio source SgrA*.

The central half parsec of the
Milky Way hosts a surprisingly high number of massive young stars
organized in at least one disk-like structure of clockwise
rotating stars.
The mechanism responsible for the presence of young stars in the
strong tidal field of the SMBH is not clear.
Several stellar sources are embedded in the mini-spiral material or
in their own dust shells.
there are several key projects that can
ideally be followed up on -- or even tackled for the first time
using METIS in the MIR on the E-ELT:
(1) The IRS13N sources as candidates for young (recently formed)
stellar objects in the central cluster ;
(2) Proper motions of dust filaments tracing wind interaction ;
(3) Bow-shock embedded stars ;
(4) The identification (longward of 8 microns), variability,
and polarization of SgrA*;
Highest angular resolution imaging and/or diagnostic spectral line tracers
available in the MIR are essential to make further progress in this
field (e.g. through absorption features from ices H_2O, CH_4,
CO, NH_3 etc.; or through emission features from gaseous molecules
like H_2, CO, H_2O, CH_4, C_2H_2, HCN, OH, SiO etc.).
In most cases the emission is extended on the angular resolution scale
achievable with the E-ELT in the NIR/MIR domain. High angular resolution
studies with a large full aperture telescope therefore are the optimum choice.

1.1- Project Title: Search and characterization of small mass planets around nearby stars

1.2- Project Category: 3

1.3- Abstract:
E-ELT equipped with a high contrast imager at optical/NIR wavelengths (e.g. EPICS) may offer opportunities to search and characterize planets shining by reflected light around nearby stars, that cannot be equalled by any other currently planned instruments. According to our simulations, a well designed high contrast imager should be able to detect some dozens Neptune-like planets and even some super-Earths, possibly in the habitable zones. This program will likely require a substantial

investment of observing time: however, an appropriate optimization of the target sample might allow to reach the main science goals even on a multi-purpose telescope serving a wide community.

1.4- Publication agreement: yes

2.1- PI: Markus Kasper

2.2- CoIs: Raffaele Gratton, Jean Luc Beuzit, Florian Kerber

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: mkasper@eso.org

3.1- Source of targets: VLT, SDSS, VizieR, etc.

3.2- Preparatory work on targets required?: yes, pre-imaging, precise astrometry, radial velocity survey.

3.3- Target brightness: -1, 10, Vegamag, I

3.4- Target size: point source

3.5- Number of targets: 300

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: exoplanet

4.1- Spatial resolution: diffraction, 0.005

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: 1, 1x1arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: 600 - 1700

5.2- Spectral Resolution: 100-300

6.1- Instrument: EPICS

6.2- Desired special mode: coronography, N/A

6.3- Desired AO mode: XAO

7.1- Integration time per target or field and per setup: 0.5, 8, N/A

7.2- Longest continuous observation time on a target or field: 4

7.3- Shortest integration time on a target or field: 1

7.4- Total time: 2000

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, VLT/VLTI, Target Selection

9.2- Critical aspects / limiting factors for the science case:
High contrast imaging is crucial.

9.3- Detailed description or other comments:
Observations of samples of planets in the solar neighbourhood is very important for various reasons:

• Frequency and mass distribution of giant planets at old ages, once dynamic evolution have cleaned systems from planets in unstable orbits, can be compared with the results obtained in star forming regions.

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• These systems may be studied in more detail, even in regions much closer to the central star with respect to the snowline, allowing to explore the HZ and even inner regions.
• These observations are important forerunner for Darwin and TPF, clarifying which systems are most likely to host rocky planets in the HZ.
Even more interesting would be detection of small mass planets (Neptunes and Super-Earths). This is the current frontier of extra-solar planet studies. Detection of a statistical significant number of Neptune-like and Super Earths would be crucial for various reasons:
• The expected frequency of low-mass planets at various separation from the central star is a basic parameter for models of planet formation.
• Even low resolution and low S/N spectra of such objects would allow a first characterization of their atmosphere. This is extremely important because little is known about the range of possible variations for the atmospheres of low-mass planets, and moreover about the incidence of Earth-like (O2-dominated) atmospheres.

To examine the potentialities of EPICS for these scientific goals, we considered the properties of the planet expected to be detected on a survey covering a sample of 512 stars within 20 pc from the Sun and brighter than I<9.. For each star we randomly choose 5 planets (characterized by pairs of mass-semi-major axes) from the planetary population predicted by the Bern formation models (see Mordasini et al. 2008) for an host star of 1 MSun. All the orbits are assumed to be circular and no planet-planet dynamical interaction is taken into account. Luminosity of each planet is estimated taking into account both intrinsic luminosity and reflected light contribution. The intrinsic luminosity of the planet is obtained by interpolation from the models by Baraffe et al. (2003), while the reflected contribution is obtained assuming mass-radius relation and the albedo's consistent with data from Solar System planets and transiting exo-planets, and the fraction of the planet surface s een from the Earth which is actually illuminated by the star. We then compared the expected contrasts with the curves for limiting detections appropriate for EPICS (these are computed for typical observing conditions, and 4 hr exposure time, but only include photon noise; they are then somewhat optimistic): a planet is detected if it is above the 5σ detection threshold.

We distinguished different planet mass ranges:
• all the objects with MP>40 MEarth are considered as Jupiter-like planets (red/orange filled dots)
• those with 10 MEarth < MP <40 MEarth are the Neptune-like planets (blue filled dots)
• those with 1.2 MEarth < MP < 10 MEarth are the Super Earths (green dots)
• and finally the ones with MP ≤ 1.2 MEarth are marked as Earth-like planets (cyan filled dots)

The main results of these simulations are as follows:
• Essentially all giant planets at projected separation beyond the EPICS IWA will be detected, making up a potential sample of several hundred objects.
• A similar survey will also be quite effective in detecting Neptune like planets, with several tens of them detected, in the range of projected separation from the IWA up to about 0.1 arcsec. This will be fully adequate for a statistical discussion of their properties.
• On the other hand, in our simulations only a few Earths and super-Earth are detected (around very close and bright stars), making the success rate heavily dependent on random fluctuations.

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Inspection of the results of our simulations indicates that the most critical parameter for detection of Super-Earths in this sample of stars is the best limiting contrast that could be achieved by EPICS for very bright stars: out of the EPICS IWA (0.02 arcsec at best), all mature Super-Earths have a contrast worst than 10-9.5, making them difficult objects at these
small separations. Summarizing, the most critical requirement for this science goal concerns the limiting contrast achievable with EPICS, which is determined by photon and calibration noise. Limiting contrast should be 10-9 (Neptunes), ideally 10-10 (Super-Earths), at a separation of 0.1 arcsec. Longer exposure times can be considered, but of course a high instrument efficiency and small calibration errors are critical.

We finally note that using a noise model which includes photon and read-out noise (but not calibration of flat field errors), our simulations show that many detections are done at rather high S/N. At a spectral resolution of R=100, S/N exceed 100 for ~85% of the warm Jupiters, ~40% of the cold Jupiters, and about 30% of the Neptunes detected in a similar survey. This implies that rather accurate spectral information could be gathered from t

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1.1- Project Title: Planets Discovered by Radial Velocity Searches

1.2- Project Category: 3

1.3- Abstract:

Imaging of Extrasolar Giant Planets already detected by RV and/or astrometry would represent a major breakthrough thanks to the availability of dynamical constraints (or even full orbit determination) on the planet masses and on the orbital elements. In most cases, stellar ages are or can be determined rather well exploiting suitable indicators (isochrones, magnetic activity and rotation, kinematics, etc.). Therefore, these objects will represent the ideal benchmarks for the calibration of models for substellar objects Spectroscopic and polarimetric observation of these planets (for which most important parameters are known) is also crucial for testing models of their atmospheres.

1.4- Publication agreement: yes

2.1- PI: Markus Kasper

2.2- CoIs: Raffaele Gratton, Jean Luc Beuzit, Florian Kerber

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: mkasper@eso.org

3.1- Source of targets: VLT, SDSS, VizieR, etc.

3.2- Preparatory work on targets required?: yes, pre-imaging, precise astrometry, radial velocity survey.

3.3- Target brightness: -1, 10, Vegamag, I

3.4- Target size: point source

3.5- Number of targets: 200

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: exoplanet

4.1- Spatial resolution: diffraction, 0.005

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: 1, 1x1arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: 600 - 1700

5.2- Spectral Resolution: 100-300

6.1- Instrument: EPICS

6.2- Desired special mode: coronography, N/A

6.3- Desired AO mode: XAO

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7.1- Integration time per target or field and per setup: 0.5, 8, N/A

7.2- Longest continuous observation time on a target or field: 4

7.3- Shortest integration time on a target or field: 1

7.4- Total time: 1000

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, VLT/VLTI, Target Selection

9.2- Critical aspects / limiting factors for the science case:
High contrast imaging is crucial.

9.3- Detailed description or other comments:
In most cases masses for planets detected by EPICS cannot be determined independently of ages. Imaging of EGP already detected by RV and/or astrometry would represent a major breakthrough thanks to the availability of dynamical constraints (or even full orbit determination) on the planet masses and on the orbital elements. In most cases, stellar ages are or can be determined rather well exploiting suitable indicators (isochrones, magnetic activity and rotation, kinematics, etc.).
Therefore, these objects will represent the ideal benchmarks for the calibration of models for substellar objects. They would represent the bridge between the rather different detection space of direct imaging and radial velocity techniques. This is relevant for a proper interpretation of the statistical results on planet frequency resulting from the two techniques in their different separation ranges.
Spectroscopic and polarimetric observation of these planets (for which most important parameters are known) is also crucial for testing models of their atmospheres. Given the distribution of separations for planets known from radial velocities, imaging of planets detected by RVs put constrains on both the Inner Working Angle and on the contrast at very small separations. While planets at larger distances from the star are expected from RV surveys in the next years (stars that have clear trends of radial velocities being obvious candidates), it is clear that accessibility to planets at angular separations of <0.05 arcsec and with monochromatic contrasts of at least 108 is

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required in order to obtain images of a large sample of planets already discovered by radial velocities (see Figure 18: the number of known planets
detectable using EPICS is 43 for an IWA=0.05 arcsec, 63 for an IWA=0.03 arcsec, and 80 for an IWA=0.02 arcsec). In addition, minimum semi-major axis decrease from ~1.5 AU for IWA=0.05 arcsec
to ~0.8 AU for IWA=0.02 arcsec: this should allow to obtain spectra of objects in the Habitable Zone,
where significant variations of atmospheric composition are expected. On this respect, EPICS should
represent a major step forward with respect to SPHERE and JWST, that should be able to detect only
very few of these planets. It should also be noticed that a few of these planets are several order of magnitude above the EPICS limiting contrast: very accurate characterization should be possible for such objects.
Summarizing, most critical requirements for this science goal concern EPICS Inner Working Angle (0.03 arcsec, and possibly 0.02 arcsec) and contrast at small separation (a contrast better than 10-8 and as good as 10-9 at separation in the range 0.05-0.1 arcsec is required). With expected contrasts in the range 10-7-10-8, spectra at reasonable high S/N (>30) can be obtained for several tens of these planets in a few hour of observations each with the IFS. Coupled with the polarization information that can be derived using EPOL, a detailed characterization of the planetary atmospheres at different position angles will be possible with EPICS.

1.1- Project Title: Young self-luminous gas planets in star forming regions

1.2- Project Category: 3

1.3- Abstract:
Detection of young self-luminous giants in star forming regions and young associations is basic in order to determine the initial frequency and distribution with mass and separation of giant planets. This will allow extensive comparisons with models of planetary system formation and evolution.

1.4- Publication agreement: yes

2.1- PI: Markus Kasper

2.2- CoIs: Raffaele Gratton, Jean Luc Beuzit, Florian Kerber

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: mkasper@eso.org

3.1- Source of targets: VLT, SDSS, VizieR, etc.

3.2- Preparatory work on targets required?: yes, pre-imaging, precise astrometry, radial velocity survey.

3.3- Target brightness: -1, 10, Vegamag, I

3.4- Target size: point source

3.5- Number of targets: 200

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: exoplanet

4.1- Spatial resolution: diffraction, 0.005

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: 1, 1x1arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: 600 - 1700

5.2- Spectral Resolution: 100-300

6.1- Instrument: EPICS

6.2- Desired special mode: coronography, N/A

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6.3- Desired AO mode: XAO

7.1- Integration time per target or field and per setup: 0.5, 8, N/A

7.2- Longest continuous observation time on a target or field: 4

7.3- Shortest integration time on a target or field: 1

7.4- Total time: 1000

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, VLT/VLTI, Target Selection

9.2- Critical aspects / limiting factors for the science case:
High contrast imaging is crucial.

9.3- Detailed description or other comments:
Detection of young self-luminous giants in star forming regions and young associations is basic in order to determine the initial frequency and distribution with mass and separation of giant planets. This will allow extensive comparisons with models of planetary system formation and evolution. This is crucial, because these mechanisms are still far from being properly understood, mainly because available data are strongly biased toward short period systems. In particular the peak of the distribution of giant planets with separation is expected to lie slightly out of the so-called snow-line, where ices can survive, providing a wealth of material for the formation of large planetary cores: for solar type stars, the snow-line is expected to be at ~3-5 AU.

Explorations of regions even further out (at >10 AU) is also crucial in order to understand the possible impact of neighbours on the dynamical evolution of the orbits of already formed planets. These regions are difficult to explore or even inaccessible with indirect methods like radial velocities and transits. While astrometric signal from such systems would be detectable with PRIMA or GAIA, the typical long periods involved would require long time coverage in order to provide enough data. Finally, microlensing data, while statistically very useful, provide only a photogram of the planet orbits, so that important parameters like real separation or orbital eccentricity cannot be determined.

Direct detection may be very helpful for several reasons:
• A single image is enough for describing main characteristics of the whole system
• Repeated visits may allow determination or at least constraints on the main orbital parameters (semi-major axis, eccentricity, inclination)
• Possibly coupled with indirect methods (see below), planetary masses can be derived, fully constraining system parameters

For this goal, best data are obtained for star forming regions, because very young planets are expected to be bright (although there is a considerable uncertainty in the mass-luminosity relation at these very young ages). These regions are typically at distances between 100 and 150 AU, although TW Hya is closer. Note that only a handful of stars in these star forming regions are bright enough to be observable with EPICS.

Instruments on 8-10 m class telescope (SPHERE and GPI) should allow detection of a few tens planets (essentially Giant Planets) around a few of the closest young objects, while JWST can observe fainter stars and has a sensitivity to much smaller planet masses but only in the very outer regions of the systems. While this would be by itself of very high interest, the much higher sensitivity of EPICS should allow to observe much fainter planets, that is both less massive and/or older, and moreover to explore with high sensitivity much inner regions, close to the snowline. Neptune-like planets should be detectable by EPICS down to a few (2-3) AU even if the limiting contrast is only 10-6. EPICS should then allow a complete census of the gaseous planets that form outer of the snowline. This is very important in order to better constrain the mechanism of formation of giant planets in the outer parts of the system.
The presence of disks, while providing very important information on their relation with the very young
planets, may prevent planet detection. This may occur either because the disk is optically thick (depending on its density, presence of gas, and typical grain size) or because the disk is so luminous to overcome planet emission. Optically thick disks are observed around very young objects (age ~ 1 Myr or less) in the Orion nebula and elsewhere (see e.g. O'Dell & Wen 1994). Observation of planets
should then be easier around older objects, preferably seen pole-on (it is anyhow dubious that planets
can form on such short timescale). Competition with planet emission is very critical for mid-IR instruments on 8-10 m or smaller class telescopes; it is less a problem with EPICS at E-ELT because
observations are in the NIR (where disk thermal emission is negligible), the diffraction peak (where most planet light is concentrated) covers only a small sky area (~1.5x10-5 arcsec2 in the J-band), and
planet detection is made exploiting molecular bands in the planet spectrum, which are absent in the disk spectrum. Still, stellar light scattered by the disk may be a not negligible contribution to the local

background, contributing to statistical noise. For instance, in the case of AU Mic (a ~12 Myr old M1V
star), the disk (which is observed near edge-on) is ~9 mag/arcsec2 fainter than the star (in the J, H and K band) at 10 AU from the star (Fitzgerald et al. 2007). Over the area subtended by a diffraction
peak, the disk should then produce a flux equivalent to that of a planet with a contrast of 3E-9, that is
the emission of a 4 MEarth, 10 Myr old planet, according to an extrapolation from Baraffe models. This is close to the limiting mass. More luminous disks might then be an important limitation to planet detection, the concern being more serious for edge-on disks.

Summarizing, the most critical requirements for this science goal concern EPICS limiting magnitude (I=9 and possibly even fainter) and inner working angle (0.03 arcsec, and possibly 0.02 arcsec), while limiting contrast is less critical, very useful data being obtained even if only a rather conservative value of 10-6 is achieved (although of course this program will gain significantly from achievement of a better contrast).
It should be noticed that young massive planets will be detected at quite high S/N with EPICS. This means that they can be targets of follow-up observations with higher spectral resolution.

1.1- Project Title: Imaging hot-star surfaces at short wavelengths

1.2- Project Category: 3

1.3- Abstract:
Aim: Diffraction-limited imaging at short optical wavelengths to study surface features of nearby hot, B- and O-type, stars and to map their rotation-induced oblateness, circumstellar disks, and obscuring dust structures. An optomechanically extremely small and simple (but software-wise complex) used-supplied visitor instrument for intensity interferometry will be used. An angular resolution three times that possible with adaptive optics in the (near-)infrared implies ten times more surface-resolution pixels, transforming several nearby stars into surface objects.

1.4- Publication agreement: yes

2.1- PI: Dainis DRAVINS

2.2- CoIs: et al.

2.3- Institute: Lund Observatory

2.4- Country of Employment: SE

2.5- Career Stage: faculty

2.6- E-mail: dainis@astro.lu.se

3.1- Source of targets: Bright Star Catalogue

3.2- Preparatory work on targets required?: no

3.3- Target brightness: -1.4, 6, Vegamag, V

3.4- Target size: extended source, 3, 20

3.5- Number of targets: 10

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A, N/A

5.1- Wavelength range: 320 - 800

5.2- Spectral Resolution: bbimaging, nbimaging

6.1- Instrument: other, Visitor instrument for intensity interferometry

6.2- Desired special mode: high time-resolution, Visitor instrument, nanosecond time resolution

6.3- Desired AO mode: best

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7.1- Integration time per target or field and per setup: 5, 10, Estimate: about one night per star

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 1000

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: yes, Visitor instrument requires presence of at least some group members, N/A

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, SKA/SKAPF, Imaging stellar surfaces at longer (near-)infrared wavelengths is a task for VLTI. The numerical methods for analyzing intensity interferometry data have much in common with low-frequency radio interferometers, e.g., LOFAR, MeerKAT, and SKA Pathfinder.

9.2- Critical aspects / limiting factors for the science case:
Requires availability of visitor instrument for intensity interferometry - see detailed description below.

9.3- Detailed description or other comments:
Intensity interferometry:

Already back in the 1960's, Hanbury Brown et al. developed the method of intensity interferometry for then measuring stellar diameters. At the time of its design, its functioning was the source of considerable confusion, whose eventual solution led to the development of the quantum theory of optical coherence, acknowledged with the 2005 Nobel prize in physics to Roy Glauber. Today it is seen as the first quantum-optical experiment; although its concept has found other applications, there have been no further uses in astronomy.

It involves measuring the second-order coherence of light (quite different from ordinary amplitude/phase interferometry of the Michelson type, such as in VLTI). The great advantage is lack of sensitivity to either atmospheric disturbances or to imperfections in telescopic optical quality. This

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comes about from an electronic (rather than optical) connection of telescopes: the noise budget relates to electronic timescales of nanoseconds (and light-travel distances of centimeters or meters) rather than those of the light wave itself. Observing at short wavelengths or near the horizon adds no complexity, and in principle diffraction-limited imaging can be reached. However, since a second-order quantity is measured, the method is expensive in requiring a large photon flux and very high time resolution, even to observe brighter stars.

The main resource required is a number of large optical telescopes distributed over some area. The recent availability of such large optical flux collectors (built for studying atmospheric Cherenkov light from energetic gamma-ray sources) now enables a digital revival of this method, applying high-speed detectors and fast computing. The most ambitious plans concern using CTA, the planned Cherenkov Telescope Array, to achieve sub-milliarcsecond optical imaging of the surfaces of brighter stars. Also, an IAU working group for intensity interferometry has now been set up.

Although the 42-m aperture of E-ELT is much smaller than CTA's kilometric baselines, its performance may permit unique measurements. The main differences are its better point-spread function (greatly reducing sky background compared to Cherenkov telescopes, reaching fainter sources) and the shorter but much more numerous baselines between all pairs of mirror segments. Comparable imaging would be impossible with either the standard E-ELT (diffraction-limited only in the infrared), by Cherenkov telescope groups (incapable in imaging over only tens of meters), or by foreseen space telescopes (too small apertures), thus offering a niche of unique science. The feasibility was already studied in ESO's 2005 conceptual design study of the QuantEYE instrument for the then OWL but the field has evolved significantly since.

Current timelines suggest that CTA may be completed some years ahead of E-ELT. Assuming that techniques for intensity interferometry will then have been developed, it would appear to be only a small marginal effort to make a visitor instrument for any focus position on the E-ELT. Such an instrument could, hardware-wise, be an extremely small and simple "photometer": just imaging the telescope entrance pupil onto a photon-counting detector array, with starlight from each one mirror segment hitting one particular detector pixel. No adjustments to any telescope optics are required, and the concept would work with either a sparsely or completely filled main mirror, be insensitive to either atmospheric seeing or to optical imperfections, and be feasible during full-Moon conditions. The complexity comes later, in the analysis of the tera- (or even petabyte) datasets, but that is "only" an off-line effort, not interfering with E-ELT operations.

1.1- Project Title: Resolving natural laser emission from Eta Carinae

1.2- Project Category: 1

1.3- Abstract:
Optical laser emission is a diagnostic of spatially inhomogeneous conditions far from thermodynamic equilibrium. Its presence has been identified in objects such as Eta Carinae but its spectral line components have not been spectrally resolved. Theoretically expected widths are on order 50 MHz (< 0.1 pm), requiring spectral resolutions around 100 million, far beyond classical spectroscopy. Such are to be realized with a small quantum-optical visitor instrument for intensity-correlation spectroscopy, measuring photon statistics for deducing the coherence time of light and realizing the highest spectral resolution in optical astronomy.

1.4- Publication agreement: yes

2.1- PI: Dainis DRAVINS

2.2- CoIs: et al.

2.3- Institute: Lund Observatory

2.4- Country of Employment: SE

2.5- Career Stage: faculty

2.6- E-mail: dainis@astro.lu.se

3.1- Source of targets: N/A

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 6.2, 6.2, Vegamag, V

3.4- Target size: extended source, 30, 500

3.5- Number of targets: 1

3.6- Density of targets: N/A

3.7- Target coordinates: RA:11 - 11;Dec:-59 - -59

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per year

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3.10- Target type: star

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: 5, fiber

4.4- Plate scale stability: N/A, N/A

5.1- Wavelength range: 450 - 1000

5.2- Spectral Resolution: >100000

6.1- Instrument: other, Visitor instrument for intensity-correlation spectroscopy

6.2- Desired special mode: high time-resolution, Visitor instrument, nanosecond time resolution

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 10, 10, One night per measurement run

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 1000

7.4- Total time: 50

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: yes, Eta Carinae varies with a 5.5 year cycle, during which there are periods when laser emission is absent

8.1- Does the execution of observations require real-time decisions?: yes, Visitor instrument requires presence of at least some group members, N/A

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

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9.1- Synergy with other programmes: VLT/VLTI, Eta Carinae is an extreme stellar object with a complex spatial structure that already has been studied with VLTI, while the precise locations of laser emission have been pinpointed with speckle interferometry.

9.2- Critical aspects / limiting factors for the science case:
Requires availability of visitor instrument for intensity-correlation spectroscopy - see detailed description below.

9.3- Detailed description or other comments:
Intensity-correlation spectroscopy reaching R=100,000,000

Natural laser emission may be produced whenever radiative mechanisms overpopulate suitable atomic energy levels. Strong evidence for optical laser emission exists in sources such as the extremely luminous star Eta Carinae (in particular Fe II emission lines from its gas ejecta condensations), while other suggested sources include symbiotic stars such as RR Tel or V1016 Cyg, and hot Be stars in general (e.g., the just published monograph: Letokhov & Johansson: Astrophysical Lasers, Oxford UP, 2009).

Laser emission is a diagnostic of spatially inhomogeneous conditions far from thermodynamic equilibrium, but it is very demanding to spectrally resolve the optical line components. The lines are theoretically estimated to be extremely narrow, with linewidths in Eta Carinae expected to be on order 50 MHz (< 0.1 pm), requiring spectral resolutions around 100 million, much higher than reachable with classical spectroscopy.

However, such resolutions are feasible with photon-correlation spectroscopy on nanosecond timescales, measuring the autocorrelation function of photon arrival times to obtain the coherence time of light, and thus the spectral linewidth. A particular advantage is the insensitivity to spectral, spatial, and temporal shifts of emission-line components due to local velocities and probable variability of "hot-spots" in the source. A 50 MHz wide emission line, say, is self-beating on a timescale equal to its coherence time (its inverse linewidth: 20 ns), generating such a timescale in the autocorrelation function. The method constitutes a quantum-optical measurement of the second-order optical coherence function, somewhat analogous to stellar intensity interferometry, although this is now temporal (not spatial) "interferometry ". The feasibility was already studied in ESO"s 2005 conceptual design study of the QuantEYE instrument for the then OWL but the concept has evolve
d significantly since. The signal increases with the square of the telescope collecting area (not diameter!) and for Eta Carinae (probably) requires to isolate light from selected, subarcsecond-scale gas condensations (e.g. so-called Weigelt blobs) in the immediate vicinity of the Eta Carinae central object, hence the need for E-ELT.

For these measurements, a very small and hardware-wise very simple, visitor instrument will be needed: basically an extremely-high-speed (nanosecond) photon-counting photometer with interference filters to isolate the relevant spectral line to be measured.

1.1- Project Title: Corrugated stellar surfaces

1.2- Project Category: 3

1.3- Abstract:
Aim: Spatially resolved spectroscopy across resolved stellar disks. Wavelengths of stellar spectral lines do not exactly equal laboratory values plus Doppler shift due to stellar radial motion. Convective blueshifts arise from greater photon contributions from hot, bright and rising (thus blueshifted) convective surface features. These shifts vary between stellar disk center and limb, depending on stellar surface corrugation. On a smooth star, convective blueshift decreases towards the limb, but increases on corrugated and "mountainous" ones since gas flows are mainly observed approaching the observer on the near-side of the "mountain" slopes.

1.4- Publication agreement: yes

2.1- PI: Dainis DRAVINS

2.2- CoIs: et al.

2.3- Institute: Lund Observatory

2.4- Country of Employment: SE

2.5- Career Stage: faculty

2.6- E-mail: dainis@astro.lu.se

3.1- Source of targets: Bright Star Catalogue

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 0, 6, Vegamag, V

3.4- Target size: extended source, 10, 20

3.5- Number of targets: 10

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +10

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per hour

3.10- Target type: star

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: 10, fiber

4.4- Plate scale stability: N/A, N/A

5.1- Wavelength range: 320 - 1000

5.2- Spectral Resolution: >100000

6.1- Instrument: CODEX

6.2- Desired special mode: special calibration, Spatially resolved spectroscopy across stellar disks; sampling at different center-limb positions.

6.3- Desired AO mode: XAO

7.1- Integration time per target or field and per setup: 1, 1, Integration time not limited by photon flux but by AO performance in resolving stellar disks.

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 100

7.4- Total time: 30

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: no

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8.1- Does the execution of observations require real-time decisions?: yes, Depend on AO system resolving the stellar disks, and requires placement of pick-off fibers or slits across the stellar disk image., N/A

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
Integral-field fiber unit, adjustable spectrometer entrance slitlets or other devices to sample different portions of stellar disks required. Expected size of the effects (besides stellar rotation) is on order 100-500 m/s across a stellar disk, requiring a matching wavelength calibration.

9.3- Detailed description or other comments:
Wavelength shifts across corrugated stellar surfaces

Absorption lines in stellar spectra do not have the wavelengths "naively" expected from their laboratory values, merely Doppler-shifted due to stellar radial motion. Subtle deviations are caused by gravitational redshift and convective blueshift, the latter an important tool for testing models of 3-dimensional stellar hydrodynamics. Convective shifts of photospheric absorption lines originate from correlated velocity and brightness patterns on stellar surfaces (granulation): rising (blueshifted) elements are hot (bright), and convective blueshifts normally result from a larger contribution of such blueshifted photons than of redshifted ones from the sinking and cooler (darker) gas.

So far, the Sun is the only star where it has been possible to study spectral-line variations across a spatially resolved stellar disk, e.g., center-to-limb changes along its equatorial and polar diameters, and their spatially resolved time variability. E-ELT will (at least marginally) resolve some stars as surface objects, and studying stellar disks with high-resolution spectroscopy opens up stellar fine structure to detailed study.

Hydrodynamic models of stellar surface convection already hint at observable phenomena. Lineshifts vary between different spectral types, and changes across the disk (for the Sun, known as "limb effect") may differ in both size and sign, depending on the detailed stellar surface structure.

In stars with "smooth" photospheric surfaces (in the optical-depth sense), one expects the convective blueshift to decrease near the limb, since the vertical convective velocities are then perpendicular to the line of sight, and the horizontal velocities which contribute Doppler shifts appear symmetric. However, stars with "corrugated" surfaces, i.e., with "hills" and "valleys" should show an increased blueshift toward the limb. Although the velocities on the star are horizontally

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symmetric, one will predominantly see the horizontal velocities on the slopes of those "hills" that are facing the observer. These velocities are approaching the observer and thus appear blueshifted. The equivalent redshifted components remain invisible behind these "hills", and an enhanced blueshift results. The effect is somewhat analogous to the asymmetric lines observed from the expanding envelopes of P Cygni stars.

Further effects appear in the time variability of lineshifts across spatially resolved stellar disks: On a "smooth" star, the temporal fluctuations are caused by the random evolution of granular features, all of which are reached by the observer''s line of sight. On a "corrugated" star, observed near its limb, there enters another element of variability since the changing "corrugations" of the swaying stellar surface sometimes hide some granules from direct view. The result is an enhanced temporal variability of line wavelengths and shapes which permits to further constrain the hydrodynamics of stellar atmospheres.

1.1- Project Title: Wavelength shifts of intergalactic absorption lines

1.2- Project Category: 2

1.3- Abstract:

Aim: Measure differential wavelength shifts between various types of intergalactic absorption lines in spectra of brighter quasars, to deduce physical properties of the intergalactic medium. Although one could "naively" expect lines from different species, of varying strength, excitation potential, or ionization level to have similar wavelength shifts if they form in the same intergalactic volume, small differences will result due to large scale convective motions (driven by hot AGN outflows near cluster centers) and by lines formed differently deep into the gravitational potential of galaxy clusters.

1.4- Publication agreement: yes

2.1- PI: Dainis DRAVINS

2.2- CoIs: et al.

2.3- Institute: Lund Observatory

2.4- Country of Employment: SE

2.5- Career Stage: faculty

2.6- E-mail: dainis@astro.lu.se

3.1- Source of targets: Well-known bright quasars

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 13, 17, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 10

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +20

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy cluster, IGM, AGN

4.1- Spatial resolution: seeing, 1

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A, N/A

5.1- Wavelength range: 320 - 1000

5.2- Spectral Resolution: >100000

6.1- Instrument: CODEX

6.2- Desired special mode: special calibration, Accurate wavelength calibration.

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 3, Several integrations per target foreseen; integration times limited to avoid spectral smearing due to Earth''s rotation.

7.2- Longest continuous observation time on a target or field: 3

7.3- Shortest integration time on a target or field: 3600

7.4- Total time: 60

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
Highly accurate and stable wavelength calibration required over the full wavelength range to measue lineshifts on a level of 50 m/s. If at all possible, spectral resolution well in excess of 100,000 is desired.

9.3- Detailed description or other comments:
Wavelength shifts of intergalactic absorption lines

The aim is to study various wavelength displacements (other than those due to the Universe expansion) that occur in the spectra of distant quasars. Such absorption lines arise in gas clouds that happen to be between us and the quasar (where the latter just acts as a backlight), most often in intervening clusters of galaxies. Measurements of the exact line wavelengths may be used in the search for possible modifications of fundamental physical constants of the earliest and most distant Universe, but probably carries more information about the internal motions in the intervening galaxy clusters. Large-scale convection-type motions are driven by the emission of hot particles from AGNs near the cluster centers. Since different types of spectral lines (of diverse strength, say) are formed differently far from the massive centers of the galaxy clusters, they are subject to various degrees of gravitational redshift. Other lines are preferentially formed at certain temperatures (
of diverse excitation potential, ionization level, etc.) and will be characterized by the velocity patterns in the corresponding structures. Further effects enter from isotopic lineshifts since, in the younger universe, the isotopic composition was somewhat different from the present.

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Related types of wavelength shifts of solar and stellar absorption lines have been studied in detail, can be theoretically modeled, and do place important constraints on three-dimensional and time-dependent model atmospheres. E.g., stellar surface convection (hot gases rising, cooler sinking) imply a greater photon contribution from the brighter (hotter) areas; since their spectral lines are blueshifted (gas rising towards the observer), the average stellar spectral line obtains a net convective blueshift. The precise amount depends on exactly where and how the lines are formed but for solar-type stars amounts to typically 300 m/s (reflecting convective motions an order of magnitude higher).

Also lines in quasar spectra must be influenced by somewhat similar effects. Gas motions in galaxy clusters are not random but are driven by large-scale convection. Although timescales are much greater than for stellar phenomena (100 million years rather than 10 minutes, say), the basic physical principles are similar, and analogous types of wavelength shifts must be expected. Convection in galaxy clusters is driven by gases heated by the energetic particle radiation emitted by AGNs, normally located near the centers of galaxy clusters, with simulations suggesting systematic flow velocities on order 100 km/s. Since the absorption lines to some extent hide the gas clouds behind, their signatures are biased with respect to the part of a galaxy cluster closer or further away from us. Those velocity patterns must be reflected in convective wavelength shifts which should have some analogies with those who are studied in the Sun and other stars.

Other effects that might affect the wavelengths of intergalactic absorption lines include suggested variable fundamental constants in the very early and very distant universe, and several searches for such effects have been made. However, systematic gas velocities expected in the intergalactic medium may reach 100 km/s, while wavelength shifts suggested to represent variable fundamental constants correspond to three orders of magnitude smaller effects, some 100 m/s. Although detailed modeling of expected intergalactic lineshifts has not yet been performed, an extrapolation from stellar physics suggests that already a modest asymmetry in the intergalactic velocity patterns would suffice to produce such differential lineshifts (and such effects from known physical processes must reasonably first be accounted for, before observations are interpreted in terms of new physical laws). The present observational project thus aims at mapping out differential wavelength shifts of as

many different atomic species that can be identified in quasar spectra, observed at the highest possible spectral resolution (ideally well above the R = 120,000 CODEX nominal specification).

1.1- Project Title: Probing galaxy evolution with long-period variables

1.2- Project Category: 2

1.3- Abstract:
The status of the Milky Way bulge is still unclear: either it is a classical bulge formed from infall, or a pseudo bulge formed by secular evolution of the disk. Observational evidence is partly contradicting on these two scenarios. We aim at studying the spatial distribution of long-period (AGB) variables in a handful of nearby barred spiral galaxies, analogues to our MW galaxy, in order to understand the formation and evolution of bulges in such galaxies, and to draw conclusions on the galactic Bulge itself.

1.4- Publication agreement: yes

2.1- PI: Stefan Uttenthaler

2.2- CoIs: Joris Blommaert, Martin Groenewegen

2.3- Institute: Instituut voor Sterrenkunde, K.U. Leuven

2.4- Country of Employment: BE

2.5- Career Stage: postdoc

2.6- E-mail: stefan@ster.kuleuven.be

3.1- Source of targets: Simbad, NED

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 19.0, 24.8, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: 10000

3.6- Density of targets: 3000

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 2 per month

3.10- Target type: N/A

4.1- Spatial resolution: 50, 3

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4.2- Field-of-view: 2x2arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 1, 3600

5.1- Wavelength range: J, H, K

5.2- Spectral Resolution: bbimaging

6.1- Instrument: MICADO

6.2- Desired special mode: precision photometry, ±0.05mag

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.2, 0.5, X=1.15, 10mas/pixel, laser tomography AO, S/N>=20, observation in the K band

7.2- Longest continuous observation time on a target or field: 0.5

7.3- Shortest integration time on a target or field: 600

7.4- Total time: 81

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, JWST cound also provide important information

9.2- Critical aspects / limiting factors for the science case:
The programme requires a (time consuming) photometric time series, which makes scheduling complex. An optimal time sampling strategy has to be developed.

9.3- Detailed description or other comments:

Due to our special position inside the Milky Way (MW) galaxy, the study of the MW bulge is difficult. As a consequence, its origin is still not understood. On the one hand, it could be a "classical" bulge formed from infall, and on the other hand it could be a "pseudo" bulge formed by secular evolution of the disk. Observational evidence from velocity dispersion, proper motion measurements, abundance analysis, age determination, etc., is partly contradicting on these two scenarios. In order to understand the formation of our MW bulge in more detail, we aim at observing the bulges of half a dozen MW analogues, i.e. spiral galaxies with a not too pronounced central bar, located in the cosmic neighbourhood. In particular, we aim at studying the spatial distribution of long-period variables (LPVs, mainly believed to be in the AGB stage of evolution) in these galaxies. AGB variables brighter than the RGB tip (K~24 at the distance of the Virgo cluster) are the bright tracers of sta
r formation about 1 - 5 Gyrs ago. This will make possible a distinction between "classical" and "pseudo" bulges. In the case of a "pseudo" bulge, the spatial distribution of LPVs will not follow the distribution of other (younger) components of the bulge. The inclination angle of the bar inside the MW bulge, as found from AGB variables, is different from the inclination angle of other bar components/tracers, indicating that the bar inside the MW bulge originates in secular evolution.

1.1- Project Title: The star formation history of the most metal poor galaxies. A case of near-field cosmology.

1.2- Project Category: 2

1.3- Abstract:

In the hierarchical picture of galaxy formation, large galaxies arise through the assembly of smaller aggregates. Extremely metal-deficient dwarf galaxies are the closest examples one could find of the elementary primordial units from which galaxies assembled. Their study can be (and has been) used in numerous cosmological studies, from the determination of primordial abundances (big bang nucleosynthesis and/or Pop III stars), to understanding star formation in pristine gas. Obviously, these targets are too faint to be available at high redshift, and they have to be studied locally. The record braking low metallicity dwarfs represent a sub-class among the Blue Compact Dwarfs (BCDs), and there are only a handful of them available. These systems are presently undergoing a major starburst which makes it easy detecting their interstellar medium.

However, studying the properties of the faint underlying galaxy requires 50-m class telescopes. We propose determining the star formation history of a (fairly) complete set of these low metallicity BCDs.

1.4- Publication agreement: yes

2.1- PI: J. Sanchez Almeida

2.2- CoIs: J.A.L. Aguerri,, C. Muñoz-Tuñon, P. Vilchez, R. Sanchez-Janssen, R. Amorin

2.3- Institute: Instituto de Astrofisica de Canarias

2.4- Country of Employment: ES

2.5- Career Stage: faculty

2.6- E-mail: jos@iac.es

3.1- Source of targets: SDSS, LAMOST, LSST, ...

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 21, 26, ABmag, V

3.4- Target size: extended source, 1500, 5000

3.5- Number of targets: 10

3.6- Density of targets: 1

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy, ISM

4.1- Spatial resolution: 100, 50 mas

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 500 - 1000, U, R, K

5.2- Spectral Resolution: bbimaging, nbimaging, 3000-5000, 10000-20000

6.1- Instrument: MICADO, HARMONI, other, Narrow band imaging facility. Fast seeging frozing camera

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.1, 10, N/A

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 0.1

7.4- Total time: 220

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 80

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
R 15000 visible spectrograph

9.3- Detailed description or other comments:
Scientific Rationale:

In the hierarchical picture of galaxy formation, large galaxies arise through the assembly of smaller aggregates. Large galaxies form metals early on, but some chemically unevolved dwarf galaxies should maintain a fossil record of the pristine Inter-Stellar Medium (ISM). Consequently, the study of extremely metal-deficient dwarf galaxies provides a vehicle to understand and characterize the elementary primordial units from which galaxies assembled. The record breaking low metallicities in the local universe correspond to a subclass among the Blue Compact Dwarf galaxies (BCDs, e.g., Kunth & Oslin, 2000, A&ARev). They may probe early phases of the Universe and, consequently, they can be (and have been) used in a large number of studies with cosmological implications. A few examples to illustrate the possibilities are:

- Set constraints on the Big-Bang nucleosynthesis (e.g., primordial He abundance).

- Set constraints on the Pop III stars. (Provide a threshold for the minimum metallicity of the gas from which the first galaxies where formed.)

- Understanding star-formation at low metallicity. Is IMF top-heavy? Feedback: is it controlled by SN explosions? Search for signs of inflows and outflows in BCDs.

- Do BCDs have AGNs (and so super massive BHs)? (Does the lack of BHs explain the primitive character of BCDs?)

- Why the most metal poor galaxies are much more metal rich than the metal poor stars of the gallactic halo? Why metallicities derived from DLAS are one order of magnitude smaller than that of BCDs? Self-contamination of all HII-region derived metallicities?

- Are there Pop III stars in BCDs? Why not? (Is metallicity not low enough?)

- Origin of the mass-metallicity relationship. Are BCDs outlayers? Why?

- What triggers a galaxy wide starburst, which is expected to be common phenomenon at high redshift? (Having oversized starbursts is one of the main properties of the BCDs.)

- Origin of the faint blue galaxies detected in deep space surveys, but absent in the local population.

BCDs are systems presently undergoing a major starburst. This makes it relatively easy studying their ISM, but it makes extremely complicated studying the properties low surface brightness host galaxy where the starburst takes place. Actually, the study of the stellar component of this underlaying galaxy demands 50-m class telescopes (see below).

There is only a handfull of galaxies of low metallicities (say, metallicities smaller than 1/20 solar; see, e.g., Kunth and Oslin, 2000). We plan to characterize the star formation history (SFH) of a representative number of them (10, including those to be discovered before EELT is operating). By modeling their (emission and absorption) spectra, one can determine starformation histories, abundances, dynamical masses, etc.

Why 50m class, R = 20000 , and 100 marcsec pixels?

The center of BCD host galaxies are outshined by the starburst. The underlying galaxy is only observable in the outskirts of the system, where it turns out to be 5 magnitudes fainter than the BCD peak luminosity. SFH studies of BCD starbursts are now feasible using 4m-class telescopes. One needs 40m-class telescopes to overcome the two orders-of-magnitude luminosity dim of the host galaxy.

One of the important observables is the dynamical mass of the systems. Rotation curve determination of dwarf galaxies requires R ~ 15000. In addition, one needs a few thousands Angstroms of spectra to determine HFSs. R~5000 suffices in this case.

The effective diameters of the systems are only a few arcsecs. In order to properly separate the starburst from the host galaxy, one needs an angular resolution one order of magnitude better than the galaxy size, i.e., some 100 marcsec. (One cannot go much further in angular resolution because we of the need to use the photon gathering power of a 40m mirror.)

1.1- Project Title: Exploring the Era of Planetesimal Formation in the Solar System - The Ice Phase

1.2- Project Category: 4

1.3- Abstract:
Comets are the ""living memories"" from the formation era of planetesimals in the outer solar system. They contain the original ices and release them as sublimated gas when getting close to the Sun. Measurements of the icy supervolatiles like H2O, NH3, CH4, C2H2, C2H6, CH3OH and others: (a) establishing a composition and temperature profile of the planetary formation disk; (b) determining isotope ratios in cometary volatiles, namely the D/H ratio of cometary water and how it relates to that of terrestrial H2O; (c) constraining the large-scale radial mixing of material in the disk.

1.4- Publication agreement: yes

2.1- PI: Hermann Boehnhardt

2.2- CoIs: N/A

2.3- Institute: Max-Planck Institute for Solar System Research

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: boehnhardt@mps.mpg.de

3.1- Source of targets: orbital information from IAU Central Bureau and JPL ephemeris

3.2- Preparatory work on targets required?: no

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3.3- Target brightness: 5, 1000, mJy, L

3.4- Target size: extended source, 200, 2000

3.5- Number of targets: 50

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +90

3.8- Moving target?: yes, 2 arcmin/h (average max.), some may be (much) faster when getting close to Earth

3.9- Variable target?: yes, N/A

3.10- Target type: solar system body

4.1- Spatial resolution: 50, 3

4.2- Field-of-view: longslit

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 1, 300

5.1- Wavelength range: 2800 - 5000

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: 1, 10, N/A

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 500

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: yes, of visibility constraints (moving targets) and intrinsic variability

8.1- Does the execution of observations require real-time decisions?: yes, objects are variable in time on time scales of hours, reduced (wavelength/flatfielded) spectrum should be available

8.2- Would you welcome remote observing capabilities?: yes, Immediate contact to operator, immediate frame transfer

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: yes, 700

9.1- Synergy with other programmes: ALMA, VLT/VLTI, Alma, VLT, Keck

9.2- Critical aspects / limiting factors for the science case:
In terms of priority: (0) moving target capability, (1) high dispersion 50000-100000, (2) wide simultaneous wavelength coverage 2.9-5.0 micron (3) longslit capability

9.3- Detailed description or other comments:
The bodies in the planetary system were formed 4.6 billion years ago in an extended disk and the formation took only a few ten million years. The physical conditions and the chemical composition of the planetary formation disk at that time is hardly constraint except that strong radial gradients in temperature and density are suggested from the inner edge close to the Sun, where the terrestrial planets originated, to the region of the gas giants, where the icy bodies like comets and Kuiper Belt objects were accreted. The physical processing of that formation disk material is at least partially reflected in properties of the most primordial bodies in the solar system that are accessible to observations today , i.e. comets and other minor bodies. Of particular interest is how they connect to the Earth, i.e. to the existence of water and the formation of life. Here, recent observational results in the 3 to 5 μm wavelength region performed at existing 4 to 10m class telescopes have demonstrated the principle capability to provide major progress in determining the composition of volatile ices in comets, the overall temperature conditions in cometary nuclei, and the isotopic mixing (for instance D/H in water). Comets are considered building stones of the larger planets in the respective distance range of the proto-planetary disk around the Sun. The composition and physical properties of comets trace directly back to their origin in the formation disk and to the physical conditions therein. It is thus of outmost scientific interest to explore them in order to enable a better and more comprehensive understanding of the conditions and the processes that have led to the formation of our own planetary system and that are still at work in formation disks around other stars in our galaxy.

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These scientific goals for the exploration of the era of planetesimal formation in our planetary system can be accomplished by
(a) establishing a composition and temperature profile of the planetary formation disk
(b) determining isotope ratios in cometary volatiles, namely the D/H ratio of cometary water and how it relates to that of terrestrial H2O
(c) constraining the large-scale radial mixing of material in the disk

These scientific goals require the measurement of volatile parent ices in cometary nuclei, e.g. H2O, NH3, CH4, C2H2, C2H6, CH3OH and others, which sublimate when the comet is close to the Sun. They can best be measured in the 3-5micron range at high dispersion (50000-100000). The science case needs an analysis of a larger sample of objects (30-50) including comets from the different dynamical families (Jupiter family, Halley-type, Oort Cloud). Although the measurements are in principle possible already at existing facilities like the ESO VLT, it will not be possible to achieve the required sample size and comet-type coverage within a reasonable lifetime of these observatories. An ELT with adequate instrumentation would overcome this situation and enable a significant progress and success for the characterization of the early icy phase in the solar system formation disk. Moreover, it should be noted that each measured comet will present its individual story of formation for
exploration by an ELT equipped with a high-dispersion 3-5 micron spectrograph like METIS.

1.1- Project Title: Exploring the Era of Planetesimal Formation in the Solar System - The Dust Phase

1.2- Project Category: 4

1.3- Abstract:
Comets are the ""living memories"" from the formation era of planetesimals in the outer solar system. They contain the original dust and release it when getting close to the Sun. N-band spectroscopy of less than a handful of comets, believed to have formed in the cold outer solar system, have revealed the existence of crystalline silicates, originating from a hot environment, aside with the amorphous components. Distribution, origin and mixing process of the crystalline dust are unclear. It can be explored by N-band spectroscopy of a larger (30-50 objects) of comets of from different dynamical families

1.4- Publication agreement: yes

2.1- PI: Hermann Boehnhardt

2.2- CoIs: N/A

2.3- Institute: Max-Planck Institute for Solar System Research

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: boehnhardt@mps.mpg.de

3.1- Source of targets: orbital information from IAU Central Bureau and JPL ephemeris

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 25, 2500, mJy, N

3.4- Target size: extended source, 200, 2000

3.5- Number of targets: 50

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +90

3.8- Moving target?: yes, 2 arcmin/h (average max.), some may be (much) faster when getting close to Earth

3.9- Variable target?: yes, N/A

3.10- Target type: solar system body

4.1- Spatial resolution: 250, 3

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 1, 300

5.1- Wavelength range: N

5.2- Spectral Resolution: 500-1000

6.1- Instrument: METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: 1, 10, N/A

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 500

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: yes, of visibility constraints (moving targets) and intrinsic variability

8.1- Does the execution of observations require real-time decisions?: yes, objects are variable in time on time scales of hours, reduced (wavelength/flatfielded) spectrum should be available

8.2- Would you welcome remote observing capabilities?: yes, Immediate contact to operator, immediate frame transfer

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: yes, 700

9.1- Synergy with other programmes: JWST, VLT/VLTI, VLT, Keck, JWST

9.2- Critical aspects / limiting factors for the science case:
In terms of priority: (0) moving target capability, (1) wide simultaneous wavelength coverage N band (2) low dispersion 500-1000, (3) field coverage capability

9.3- Detailed description or other comments:
The bodies in the planetary system were formed 4.6 billion years ago in an extended disk and the formation took only a few ten million years. The physical conditions and the chemical composition of the planetary formation disk at that time is hardly constraint except that strong radial gradients in temperature and density are suggested from the inner edge close to the Sun, where the terrestrial planets originated, to the region of the gas giants, where the icy bodies like comets and Kuiper Belt objects were accreted. The physical processing of that formation disk material is at least partially reflected in properties of the most primordial bodies in the solar system that are accessible to observations today , i.e. comets and other minor bodies. Of particular interest is how the mineral

phase is represented and whether and to which extend a second principle silicate component of crystalline character was present in the outer formation disk (intermixed with the amorphous silica tes of interstellar origin). The existence of crystalline silicates as an original ingredient in comets is suggested by N band spectroscopy of - up to now - three cases, i.e. comets Hale-Bopp, Hyakutake, and 9P/Tempel 1. The distribution, origin and mixing processes of the crystalline component in the original dust of the outer solar system (where comets were formed) remain unclear. It is thus of outmost scientific interest to explore the cometary dust in order to enable a better and more comprehensive understanding of the conditions and the processes that have led to the formation of our own planetary system and that are still at work in formation disks around other stars in our galaxy.

These scientific goals for the exploration of the era of planetesimal formation in our planetary system can be accomplished by constraining the large-scale radial mixing of dust material in the disk through silicate components in comets.

These scientific goals require the N band measurement of the dust in cometary comae at low (500-1000) dispersion when the comet is close to the Sun. The science case needs an analysis of a larger sample of objects (30-50) including comets from the different dynamical families (Jupiter family, Halley-type, Oort Cloud). Although the measurements are in principle possible already at existing facilities like the ESO VLT, it will not be possible to achieve the required sample size and comet-type coverage within a reasonable lifetime of these observatories. An ELT with adequate instrumentation would overcome this situation and enable a significant progress and success for the characterization of the early silicate dust in the solar system formation disk. Moreover, it should be noted that each measured comet will present its individual story of formation for exploration by an ELT equipped with an N band spectrograph like METIS.
Note: This program can ideally be combined with another ELT proposal to measure the original ices in the planetary formation disk using METIS in LM band high dispersion spectroscopy.

1.1- Project Title: The internal structure of asteroids and comets - body formation and evolution in the planetary disk

1.2- Project Category: 4

1.3- Abstract:
Asteroids and comets are the ""living memories"" from the formation era of planetesimals in the outer solar system. The internal constitution constrains the formation and evolution scenario of the body. Recent improvements in thermal modeling techniques allow meanwhile to estimate thermal properties of the surfaces of minor bodies from mid-IR (N band) photometry, this way also

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constraining the internal body constitution, i.e. large, dust-covered vs monolithic bare-rock vs rubble pile objects. The principle capability of constraining the internal structure of minor bodies from the thermal properties is promising since it allows assessing the constitution of rather primordial bodies like cometary nuclei and C- and D-type asteroids as well as more evolved ones like the S- and M-type asteroids. From that, constraints on scenarios for the planetesimal formation in the proto-planetary disk as well as for the impact of the collision history on the body constitution may evolve. F
or objects of 10 km and larger surface resolved measurements will be possible.

1.4- Publication agreement: yes

2.1- PI: Hermann Boehnhardt

2.2- CoIs: N/A

2.3- Institute: Max-Planck Institute for Solar System Research

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: boehnhardt@mps.mpg.de

3.1- Source of targets: orbital information from IAU Central Bureau and JPL ephemeris

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 25, 2500, mJy, N

3.4- Target size: extended source, 200, 2000

3.5- Number of targets: 50

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +90

3.8- Moving target?: yes, 2 arcmin/h (average max.), some may be (much) faster when getting close to Earth

3.9- Variable target?: yes, N/A

3.10- Target type: solar system body

4.1- Spatial resolution: 10, 2

4.2- Field-of-view: 2x2arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 1, 300

5.1- Wavelength range: N, Q

5.2- Spectral Resolution: 500-1000

6.1- Instrument: METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: 1, 10, N/A

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 500

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, VLT/VLTI, VLT, Keck, JWST

9.2- Critical aspects / limiting factors for the science case:
In terms of priority: (0) moving target capability, (1) N band filter imaging photometry

9.3- Detailed description or other comments:

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Recent improvements in thermal modeling techniques allow meanwhile to estimate thermal properties of the surfaces of minor bodies from mid-IR photometry. The thermal emission of objects in the Earth vicinity peaks at mid-IR wavelengths and (combined) N- (and Q) -band measurements at different rotational phases and a range of phase angles are key ingredients to determine the thermal inertia. The thermal inertia of large, dust-covered main-belt asteroids is found to be very low, while monolithic bare-rock objects have thermal inertia values which are about 2 orders of magnitude higher. Rubble-pile objects are expected to have values in between. Tidal forces during encounters with large bodies in the solar system cause regular reorganizations of such rubble piles, resulting in thermal properties which are characteristic for a mixture of dusty and rocky surface regions. First indications on the internal constitution of a small body came from N-bands observations at a 4m-class tel
escope. The thermal inertia of 25143 Itokawa was found to be in the expected range for rubble-pile objects - which was later supported by the Japanese spacecraft Hayabusa when visiting this asteroid. The principle capability of constraining the internal structure of minor bodies from the thermal properties is promising since it allows assessing the constitution of rather primordial bodies like cometary nuclei and C- and D-type asteroids as well as more evolved ones like the S- and M-type asteroids. Connected to this is the intriguing expectation that scenarios for the planetesimal formation in the proto-planetary disk as well as for the impact of the collision history on the body constitution may evolve. Both scenarios will then be constrained by observational results. The key point are accurate thermal measurements of minor bodies for which, given the faintness of the objects, N (and Q band) photometry with an ELT is required. It is noteworthy that for objects of 10 km and
larger surface resolved measurements will be possible.

1.1- Project Title: The inner 10 pc of M31, M32 and M33: what drives the formation of supermassive
blackholes?

1.2- Project Category: 2

1.3- Abstract:

We propose to take very high resolution imaging of the inner regions (<10 pc) of M31, M32 and M33. Working at the diffraction limit of the telescope in the near-infrared, we will be in position to explore the vicinity (down to 2 light months) of three (very different in mass) supermassive blackholes. Together with line-of-sight velocities of individual bright stars in these regions we plan to obtain (using a time baseline of 15 years) stellar proper motions. These studies will allow us: a) to estimate the mass of these SMBHs with an

accuracy of 30%, b) to explore whether there is anisotropy or counterrotation in the innermost stellar dynamics and if that correlates with the mass of the SMBH, c) to probe whether the stellar population properties around SMBH vary with the mass of the blackhole. This information will be key to understand which feedback mechanism is behind the tight relation found between the host galaxy bulge mass and its SMBH mass.

1.4- Publication agreement: yes

2.1- PI: Ignacio Trujillo

2.2- CoIs: Carme Gallart, Jorge Casares, Artemio Herrero, Marc Balcells

2.3- Institute: Instituto de Astrofisica de Canarias

2.4- Country of Employment: ES

2.5- Career Stage: postdoc

2.6- E-mail: trujillo@iac.es

3.1- Source of targets: none

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 10, 12, Vegamag/arcsec2, I

3.4- Target size: extended source, 0, 2000

3.5- Number of targets: 3

3.6- Density of targets: N/A

3.7- Target coordinates: RA:00h42m44 - 00h42m45;Dec:+41d16m08 - +41d16m09, RA:00h42m41 - 00h42m42;Dec:+40d51m54 - +40d51m55, RA:01h33m50 - 01h33m51;Dec:+30d39m35 - +30d39m36

3.8- Moving target?: no

3.9- Variable target?: yes, 15 per century

3.10- Target type: star cluster

4.1- Spatial resolution: diffraction, 2

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4.2- Field-of-view: 2x2arcsec

4.3- Multiplexity and pick-off FoV: 1, 2x2arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: J, H, K

5.2- Spectral Resolution: 10000-20000

6.1- Instrument: MICADO

6.2- Desired special mode: precision astrometry, N/A

6.3- Desired AO mode: LTAO

7.1- Integration time per target or field and per setup: 7.5, 7.5, airmass=1.15; laser tomography A0

7.2- Longest continuous observation time on a target or field: 5

7.3- Shortest integration time on a target or field: 5

7.4- Total time: 22.5 (3 targets x7.5)

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 100

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
The observations should be repeated during 15 years to get a long time baseline.

9.3- Detailed description or other comments:
The relation between the host galaxy bulge mass and its supermassive black

hole (SMBH) mass is one of the most striking connection astrophysics has found. This relationship implies that the evolution of the whole galaxy and its SMBH is intimately linked, suggesting some feedback mechanism controlling the coeval evolution of both structures. To fully understand how this process works, it is necessary to explore the immediate vicinity of the SMBH, where the most violent phenomena are taking place. This close look is fundamental if we want to understand which are the feeding mechanisms that control SMBH formation and what is the reaction of the blackhole to the matter accretion.

In recent years, we have reached an unprecedented view of the inner region of our own galaxy, being able to observe the effect of its supermassive blackhole on its nearby stellar orbits. However, this detailed view of the SMBH environment is restricted to a single object. If we want to cover the full picture of SMBH formation and evolution, we need to expand our analysis to objects with very different masses. This analysis is important since the connection between the SMBH and their host bulge is known to extend over several decades in mass whereas the physical process (if just a single origin) that drives such relation is unknown.

The E-ELT will allow us to probe the sphere of influence of SMBHs within a large range in mass in the Local Group. For example, M31 has a SMBH with (

$1.1-2.3)x10^8M_{sun}$, M32 has a SMBH with $(2-4)x10^6M_{sun}$ and M33 has a SMBH with $<3x10^3M_{sun}$. Working at the diffraction limit of the telescope (~10 mas) will allow us to have a detailed view of the centres of these galaxies, with a resolution as high as 2 light months from the SMBHs. This resolution will provide a direct access (both through imaging and spectroscopy) to the individual brightest stars in their SMBH neighborhood.

A detailed analysis of the closest vicinity of these SMBHs will let us to address several open questions: do the stellar population properties around SMBH vary depending on the stellar mass of the SMBH? Is there any enhanced star formation in the vicinity of SMBH? Is the chemical composition of SMBH nearby stars affected by the conditions of this extreme environment? Do the stars orbiting the SMBH have different kinematical signatures depending on the mass of the SMBH? Answering these questions will tell us what mechanism (if just a single one) is driving the formation of SMBH across a large range of masses.

To address our objectives we want to measure accurate positions (<1 mas) and line-of-sight velocities for ~100 individual stars in the inner 10 pc of M31, M32 and M33. These measurements will be repeated once every year during a baseline of 15 years to allow us to measure proper motions of the stars. With these observations we will have:

1. Determination of the mass of the SMBH of each of these galaxies with an accuracy of <30%. This would be important for M33 where present data is only able to provide us with an upper limit. In the case of M31, having the largest SMBH mass, their stellar orbits would be much affected than for the other cases and ~15 year closed orbits could be

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fully traced.
2. Determination of departures of the isotropy in the dynamics of the stars in the vicinity of the SMBH. This will give us information about the distribution of the matter around SMBH.
3. Evidence of near-infrared flares from accreting gas around the SMBH. This will give hints on very energetic electrons or moderately hot gas within the innermost accretion region.

>From the first set of data during the first year (both photometrically and spectroscopically) we will get the following information:

1. The type of stars that live in the SMBH environment.
2. A rotation curve based on individual stars.

Due to the fact that M31, M32 and M33 are close (m-M~24.7 mag), high resolution (R=10000) spectroscopic measurements of their individual stars are feasible. We will explore whether their stellar atmospheres has been modified by the nearby presence of the radiation of the SMBH.

The main constrain for this scientific case is the effect that crowding can have for identifying individual stars within the inner 10 pc of M31, M32 and M33. The distance modulus of these galaxies is very similar (m-M~24.7 mag). So, we will provide numbers for the worst crowding case: M32. The surface brightness at the centre of this galaxy is ~10 mag/arcsec2 (I-band). Assuming that the tip of the RGB would be at I=20.4 mag, the expected numbers of density of stars if we go one magnitude deeper (I=21.5 mag) would be ~2000 arcsec^{-2}. This implies an average star to star separation of ~0.02 arcsec.
This separation is enough for doing precise photometry at the diffraction limit in the K-band (FHWM~0.015arcsec).

Using the E-ELT (Version 2.13), assuming that LTAO is available, a 5 mas/pixel, an A0V star of I_{AB}=21 mag, and collecting the light over 5x5 pixels (i.e. basically the PSF circle), we get in 5 seconds exposure time a high S/N (>100) in the NIR bands, enough for precise photometry.

To have spectra of the above stars and calculate proper motions, we assume again LTAO and an A0V (I_{AB}=21 mag) spectra. The radius of circular S/N reference area is 7.5 mas. It is possible to reach S/N~30 along the radial range of J-band with R=2000 in 10 minutes integration time. This should produce velocity accuracy of ~15 km/s. We are assuming that the spectrograph will have a large multiplex range. For some of these brightest stars (I_{AB}=21 mag), spectra with R=10000 and S/N>70 could be obtained with less than 6 hours.

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1.1- Project Title: A dynamical measurement of the expansion history of the Universe

1.2- Project Category: 1

1.3- Abstract:
We propose to perform a direct observation of the expansion history of the Universe by obtaining the first measurement of the so-called "redshift drift". The redshift drift is a very small, but systematic drift as a function of time that is expected to affect the redshifts of all cosmologically distant sources partaking in the Hubble flow. This effect is a direct measure of the difference between the expansion rate today and the expansion rate at the redshift of the measurement. A redshift drift experiment would be unique among cosmological observations in that it would provide an entirely model-independent measurement of the expansion history, directly probing the global dynamics of the Robertson-Walker metric. We propose to observe the redshift drift by monitoring the redshifts of Lyman alpha forest and other absorption lines towards a sample of very bright QSOs in the redshift range $2 < z < 5$ using the ultra-stable, high-resolution optical spectrograph on the E-ELT over a period of 10--20 yr.

1.4- Publication agreement: yes

2.1- PI: Jochen Liske

2.2- CoIs: CODEX Team

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: postdoc

2.6- E-mail: jliske@eso.org

3.1- Source of targets: existing QSO catalogues (NED, SDSS) + new cats from VST/VISTA + LSST

3.2- Preparatory work on targets required?: yes, Surveys to find more bright high-z QSOs + spectroscopic follow-up, photometric monitoring to measure variability

3.3- Target brightness: 15, 17, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 20

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-70 - +70

3.8- Moving target?: no

3.9- Variable target?: yes, 0.13 per year

3.10- Target type: IGM, AGN

4.1- Spatial resolution: seeing, 1

4.2- Field-of-view: fiber

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 350 - 700

5.2- Spectral Resolution: >100000

6.1- Instrument: CODEX

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 200, 200, 0.8 arcsec seeing, airmass < 1.5

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: 1800

7.4- Total time: 4000

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 65

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
There are two critical aspects for this programme to be successfull:
1. This is a photon-limited experiment so the product of the total photon collecting area and the total system throughput (telescope+instrument) should be as high as possible. For D=42m, a total throughput of >20% is required.
2. Stability: It is essential that the instrument is stable enough to allow radial velocity measurements that are photon noise limited down to the cm/s regime over a timescale of decades.

9.3- Detailed description or other comments:
This science case is a DRM case and a science showcase of the CODEX instrument study.

The fundamental idea of this experiment is to measure the redshift of a cosmologically distant object at two different epochs separated by a number of years. The difference between the two redshifts is a direct measure of the difference of the Hubble parameter at the redshift of the object and today. In practice, we use not one but hundreds of distant "objects" (QSO absorption lines) at different redshifts, thereby mapping out the expansion history. Here, we have opted to use 20 QSOs as targets, but the exact number is flexible. Since the redshift measurements have to be very precise we require an extremely high (accumulated) S/N for each line-of-sight, and hence about 200 hours of total integration time per object. Each object would be observed 50-100 times over a period of 3-4 years, to be repeated ~11 years after the first set of observations, for a total experiment duration of ~15 years.

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1.1- Project Title: The impact of the host galaxy environment to trigger SNe and GRBs: probing the SN factory NGC2770.

1.2- Project Category: 1

1.3- Abstract:
The recent discovery of X-ray bursts in a few SNe (called X-ray flashes, XRFs), reveals a soft transition between standard SNe and cannonical GRBs. NGC2770 is the closet GRB host galaxy to date. There, appart from an XRF, 3 standard SNe have occurred in the last nine years. We propose to observe the field of NGC2770 and its satellite galaxy NGC2770B in order to study the enviromental effect to trigger SNe and GRBs.

1.4- Publication agreement: yes

2.1- PI: J. Gorosabel

2.2- CoIs: A.J. Castro-Tirado, M. Jelinek, A. De Ugarte Postigo, S. Guziy, P. Kubanek

2.3- Institute: IAA-CSIC

2.4- Country of Employment: ES

2.5- Career Stage: faculty

2.6- E-mail: jgu@iaa.es

3.1- Source of targets: GTC

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 17, 29, ABmag/arcsec2, V

3.4- Target size: extended source, 100000, 200000

3.5- Number of targets: 1

3.6- Density of targets: N/A

3.7- Target coordinates: RA:9.159 - 9.159;Dec:33.085 - 33.085

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: SN

4.1- Spatial resolution: diffraction, 3

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 350 - 1100

5.2- Spectral Resolution: nbimaging

6.1- Instrument: other, Narrow-band imager similar to OSIRIS at GTC. Filter width should between 13 and 100 Amstrong.

6.2- Desired special mode: precision photometry, Tunable filter narrow-band imaging

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: 1, 3, I assumed a 42m diameter, but unfortunatelly there is no narrow-band imaging calculator for ELT.

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 10

7.4- Total time: 3

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

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9.1- Synergy with other programmes: JWST, It is not essential but morphological information obtained from Space would help quite a lot.

9.2- Critical aspects / limiting factors for the science case:
This unique object is mainly visible from the Northern Hemisphere (declination = +33 degrees)

9.3- Detailed description or other comments:
It is well established that long Gamma-Ray Bursts (GRBs) are created by the explosion of massive stars, showing similarities with Supernovae (SNe). The recent discovery of X-ray Flashes (XRFs) in a few SNe makes the frontier between SNe and GRBs even more diffuse. This finding support a unified model where SNe-XRFs-GRBs would be explained just by different physical-chemical properties of the collapsing star (mass, angular momentum, metallicity). The SN factory, NGC2770, showed in the last 9 years 2 SNe and 1 XRF, making it an ideal laboratory to study the environment impact to trigger a SN or/and an XRF. Our final goal is to derive a star-formation rate/extinction/metallicity/shocked-material map of NGC2770, specially at the regions where the explosive events occurred.
Besides, as an extra, the field of NGC2770 allows to study its dwarf satellite galaxy NGC2770B, approximately 3' from NGC2770. Long slit spectroscopy has recently shown that NGC2770B shows one of the lowest metallicities in the local Universe. By means of ELT we intend to study this small galaxy and most importantly the diffuse material bridgering these two galaxies. The final goal of studying NGC2770B is to study the role played by the intergalactic gas-flow and the tidal interactions to trigger the GRB phenomena. It is important to note that the NGC2770 declination is +33 deg, so it is hardly observable from the Southern Hemisphere.

We intend to study the impact of the host environment in the production of supernovae (SNe) and Gamma-Ray Burst (GRBs) explosions. For this, we propose to image deeply NGC2770 and its satellite galaxy NGC2770B at Hα, Hβ, [OII], [OIII], [NII] and [SII]. For this purpose tunable filter strategies (like in OSIRIS at GTC) would be very helpful, alhough other techniques (like large field of view IFUs) could still be valid.

GRBs typically occur at very high redshift (mean redshift z ~2.7), so their host galaxies tend to be unresolved from ground based telescopes. Even when a GRB is optically detected, it is normally not possible to accurately pinpoint it in a specific part of the corresponding host galaxy. Only two GRB hosts are close enough to allow morphological studies from the ground and to precisely localize the GRB in them, but NGC2770 at a redshift of z=0.007 is the closet host galaxy detected to date (equivalent to 27 Mpc). So NGC2770B offers a unique opportunity to study a GRB host in the local Universe.
XRFs are thought to be a transition between GRBs and SNe (Soderberg et al. 2008). Furthermore, NGC2770 not only harboured recently (January 2008) an XRF, it also showed two SNe (SN1999eh and SN2007uy) in the last 9 years. This is why NGC2770 has been named as the ``Supernova Factory''''''''''''''''''''''''''''''''. In the past no special attention was paid to NGC2770 until an XRF (SN2008D/XRF080109) was discovered in it in January 2008. This is the reason why this host has been very poorly observed to date, with very few dedicated programmes aimed to its study, specially using narrow band imaging techniques.

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Recent studies on GRB and SN hosts rise two interesting aspects: i) a rough morphological study based on another spatially resolved GRB host (GRB060505; Thoene et al. 2008) indicates that GRBs tend to lie on the regions with the lowest metallicities of the host. ii) Surprisingly, an HST study of high redshift GRB hosts (Fruchter et al. 2006) suggests that the distribution of GRBs in the hosts do not follow the same distribution as SNe, since GRBs are far more concentrated in the very brightest regions than are SNe. The low redshift NGC2770, which harboured both SNe and GRBs, allows us to check the suggestions given in i) and ii).
We intend to obtain the star formation rate and the metallicity in the different regions of NGC2770 and NGC2770B, including the explosion sites of SN2007uy, SN1999eh and SN2008D/-XRF080109. We propose to observe Hα, Hβ, [OII], [OIII], [NII] and [SII], in order to construct the R23, N23, extinction Ne and Te-maps. We are also very interested in mapping the regions with shocked material, so it would be also very important to observe the [SII] doublet to determine the presence of possible shocked regions in the NGC2770 and NGC2770B.

The surface flux densities at NGC2770 and NGC2770B are expected to be around 10-16 erg cm-2 s-1 A-1 arcsec-2, so easily reachable with a 10m-class telescope like GTC. However, the diffuse material falling from NGC2770B to NGC2770 is extremely faint with surface flux densities of the order of 10-21 erg cm-2s-1 A-1 arcsec-2, which would require a large amount of time in a 10-m class telescope. Thus, in order to achieve all the scientific goals of this proyect a very large collecting area is required as the one of ELT.

References:

- Fruchter, A. et al. 2006, Nature, 441, 463.
- Thoene, C. et al. 2008, ApJ, 676, 1151.

1.1- Project Title: The Galactic Center: I: Star Formation near a MBH - a test case for evolution in galaxy nuclei

1.2- Project Category: 2

1.3- Abstract:

Our broad aim is to determine the evolution and star formation history of the central (1pc) cluster, as a general probe of star fomration near a massive black hole

1.4- Publication agreement: yes

2.1- PI: Genzel

2.2- CoIs: MPE Galactic Center Team

2.3- Institute: MPE

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: genzel@mpe.mpg.de

3.1- Source of targets: n.a.

3.2- Preparatory work on targets required?: yes, current and future VLT observations are essential to fully and quickly take advantage of the ELT capabilities

3.3- Target brightness: 6, 20, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: > 10000

3.6- Density of targets: N/A

3.7- Target coordinates: RA:17:45:40 - 17:45:40;Dec:29:00:30 - -29:00:30

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per year

3.10- Target type: star

4.1- Spatial resolution: diffraction, 4

4.2- Field-of-view: 1x1arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: J, H, K, L

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5.2- Spectral Resolution: bbimaging, nbimaging, 1000-2000, 2000-3000, 3000-5000, 5000-10000

6.1- Instrument: MICADO

6.2- Desired special mode: precision photometry, precision astrometry, N/A

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: 0.001, 10, N/A

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 5

7.4- Total time: n.a.

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 100

7.6- Are the observations time critical?: yes, proper motions measurements need to connect to VLT data

8.1- Does the execution of observations require real-time decisions?: yes, seeing & previous results, none

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
ediffraction limited imaging and spectroscopy,
long time baseline

9.3- Detailed description or other comments:
see:
- MICADO science cases
- Large Prgrogram proposal 183.B-0100

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1.1- Project Title: The Galactic Center: II: The central cusp - a laboratory for stellar dynamics and a probe of the gravitational potential
SF near a MBH

1.2- Project Category: 1

1.3- Abstract:
The focus is here to quantitatively understand the only galactic nuclear cusp around a massive black hole for which detailed studies are possible, and to use orbits as precision tools for exploring the gravitational potential.

1.4- Publication agreement: yes

2.1- PI: Gillessen

2.2- CoIs: MPE Galactic Center Team

2.3- Institute: MPE

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: ste@mpe.mpg.de

3.1- Source of targets: n.a.

3.2- Preparatory work on targets required?: yes, current and future VLT observations are essential to fully and quickly take advantage of the ELT capabilities

3.3- Target brightness: 6, 20, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: > 10000

3.6- Density of targets: N/A

3.7- Target coordinates: RA:17:45:40 - 17:45:40;Dec:29:00:30 - -29:00:30

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per year

3.10- Target type: star

4.1- Spatial resolution: diffraction, 4

4.2- Field-of-view: 1x1arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: J, H, K, L

5.2- Spectral Resolution: bbimaging, nbimaging, 1000-2000, 2000-3000, 3000-5000, 5000-10000

6.1- Instrument: MICADO

6.2- Desired special mode: precision photometry, precision astrometry, N/A

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: 0.001, 10, N/A

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 5

7.4- Total time: n.a.

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 100

7.6- Are the observations time critical?: yes, proper motions measurements need to connect to VLT data

8.1- Does the execution of observations require real-time decisions?: yes, seeing & previous results, none

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

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8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
diffraction limited imaging and spectroscopy,
long time baseline

9.3- Detailed description or other comments:
see:
- MICADO science cases
- Large Prgrogram proposal 183.B-0100

1.1- Project Title: The Galactic Center: III: The Accretion Flow onto the massive black hole - an archetype of low-efficiency AGN
SF near a MBH

1.2- Project Category: 1

1.3- Abstract:
SgrA* is the prototypical LLAGN and has shaped the theory about radiatively inefficient accretion - the most common type of MBH accretion. SgrA* is also a unique laboratory for studying strong gravity, given that flares arise at < 10 Schwarzschild radii. The current consensus is that the quiescent radio to submm radiation
is thermal synchrotron emission. NIR/X-ray flares of duration 100 min arise when electrons are transiently
accelerated to non-thermal
-factors of > 1000, perhaps in the form of hot spots (e.g. magnetic loops), just
outside the last stable orbit. Orbital motion might explain the 20 min quasi-periodic substructure (QPO)
observed in several IR flares.

1.4- Publication agreement: yes

2.1- PI: Eisenhauer

2.2- CoIs: MPE Galactic Center Team

2.3- Institute: MPE

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: eisenhau@mpe.mpg.de

3.1- Source of targets: n.a.

3.2- Preparatory work on targets required?: yes, current and future VLT observations are essential to fully and quickly take advantage of the ELT capabilities

3.3- Target brightness: 6, 20, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: > 10000

3.6- Density of targets: N/A

3.7- Target coordinates: RA:17:45:40 - 17:45:40;Dec:29:00:30 - -29:00:30

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per year

3.10- Target type: star

4.1- Spatial resolution: diffraction, 4

4.2- Field-of-view: 1x1arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: J, H, K, L

5.2- Spectral Resolution: bbimaging, nbimaging, 1000-2000, 2000-3000, 3000-5000, 5000-10000

6.1- Instrument: MICADO

6.2- Desired special mode: precision photometry, precision astrometry, N/A

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: 0.001, 10, N/A

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 5

7.4- Total time: n.a.

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 100

7.6- Are the observations time critical?: yes, proper motions measurements need to connect to VLT data

8.1- Does the execution of observations require real-time decisions?: yes, seeing & previous results, none

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: yes, 10

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
diffraction limited imaging and spectroscopy,
reacting quickly to flares

9.3- Detailed description or other comments:
see:
- MICADO science cases
- Large Prgrogram proposal 183.B-0100

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1.1- Project Title: The evolution of metallicity in the intergalactic medium from high redshift.

1.2- Project Category: 1

1.3- Abstract:
The distribution of metals in the universe at high z is a basic clue to its evolution.This proposal is to study the "smoking gun", direct detection of escaping gas from galaxies. This will be detected using redshifted MgII in absorption, which is a useful direct metallicity indicator. A study equivalent to DEEP2 (1000 objects) can be conducted out to z = 3 in 30 hours with the E-ELT, and out to z = 5 a study of 100 galaxies implies a similar observing period. We outline the latter here.

1.4- Publication agreement: yes

2.1- PI: John Beckman

2.2- CoIs: N/A

2.3- Institute: Inst. Astrofisica Canarias

2.4- Country of Employment: ES

2.5- Career Stage: faculty

2.6- E-mail: jeb@iac.es

3.1- Source of targets: HST

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 24, 28, Vegamag, J

3.4- Target size: extended source, 200, 40

3.5- Number of targets: 20

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy cluster

4.1- Spatial resolution: 50, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 10, 1000

5.1- Wavelength range: J

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: EAGLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.3, 1.0, N/A

7.2- Longest continuous observation time on a target or field: 1.0

7.3- Shortest integration time on a target or field: 1000

7.4- Total time: 30

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, N/A

9.2- Critical aspects / limiting factors for the science case:

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Image stability which affects critically the fraction of light in the image which enters the spectrograph

9.3- Detailed description or other comments:
This proposal is a direct reflection of recent work in this area, in which the presence of galactic winds of significant metallicity was detected by stacking the spectra of star forming galaxies at z = 1.4 to observe the resonance doublet of MgII at 280nm rest wavelength. (Weiner et al. ApJ. 692, 187, Feb. 2009). The
spectra were obtained with the Keck telescope using spectral resolution of order 5000, in which a component blue shifted with respect to the systemic velocity of a galaxy was picked out , revealing metal-bearing galactic winds with outflow velocities from 300 to 500 km/s. These winds, with velocities well above the escape velocity of the galaxies, are clearly able to feed metals into the IGM, and the technique gives not only the dynamical parameters of the winds but also a direct look at their metal content. This is
This proposal using the E-ELT with EAGLE is designed to follow the equivalent processes out to redshifts
in the range 4 to 5, in the first instance, where the redshifted features lie within the J band. The procedure will be to search for suitable objects in one of the HST deep fields, using i-band dropout as an
initial selection method. It may prove necessary to refine the redshift derivations using either short timescale photometric imaging observations with the E-ELT prior to the spectroscopic programme, or
longer exposures with 10m class instruments.
The observations in the proposal are for spectroscopy in the rest-frame range of 300nm with a resolution of order 5000 to separate the absorption from the emission components in the selected star forming
galaxies. Given the possibility of multiple object spectroscopy, of order 10 to 15 objects per field, the
basic programme of 100 objects required to provide a reasonable chance to get detections on individual galaxies of the most favourable kind (brightest emission, highest metallicity) should be possible in no more than 4 nights´observations. The technique is not exceptionally demanding as we require
resolution no better than 40 mas. The selection of redshift range is to set the redshift range within the
J band. This is a trial experiment and should pave the way for extension to higher z by combining measurements in the H or K bands with JWST multi-band imaging. I have selected the initial field here
as the HDF-N, but this is an example to demonstrate the proposal. It can be equally well carried out for
the well known and well studied deep fields in both northern and southern hemispheres.
The final result of the programme of which these observations form a first step will be to obtain a calibrated estimate of the relative metallicity escape rates as functions of redshift to complement direct observations of the Ly-alpha forest metallicity lines using QSO´s and of the SFR in galaxies from

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their hydrogen emission line strengths.

1.1- Project Title: 3D reconstruction of the Intergalactic Medium

1.2- Project Category: 2

1.3- Abstract:
The Intergalactic medium (IGM) is the reservoir of baryons for galaxy formation. In turn galaxies emit ionizing photons and expell metals and energy through powerful winds which determines the physical state of the gas in the IGM. The interplay of galaxies and the gas in the IGM is therefore central in the field of galaxy formation. The goal of this programme is to use the Lyman-α forest in the spectra of LBGs to reconstruct the 3D density field of the IGM at $z\sim2.5$ to study the topology of the IGM in the linear regime and to correlate the position of galaxies with the density peaks.

1.4- Publication agreement: yes

2.1- PI: Patrick Petitjean

2.2- CoIs: E. Rollinde, OPTIMOS Scientific team

2.3- Institute: Insitut d""""""""""Astrophysique de Paris

2.4- Country of Employment: FR

2.5- Career Stage: faculty

2.6- E-mail: petitjean@iap.fr

3.1- Source of targets: VLT, VISTA, SDSS, NED

3.2- Preparatory work on targets required?: yes, N/A

3.3- Target brightness: 19, 25, Vegamag, R

3.4- Target size: extended source, 200, 1000

3.5- Number of targets: 9000

3.6- Density of targets: 1

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: N/A

4.1- Spatial resolution: seeing, 3

4.2- Field-of-view: 10x10arcmin

4.3- Multiplexity and pick-off FoV: 40, 2x2arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: 370 - 700

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: GLAO

7.1- Integration time per target or field and per setup: 1, 2, Good seeing...

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 1

7.4- Total time: 800

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

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8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, N/A

9.2- Critical aspects / limiting factors for the science case:
Availability of multi-object spectroscopy (40 objects in 7x7 arcmin) in the OPTICAL.

9.3- Detailed description or other comments:
We would like to reconstruct the 3D density field of the neutral hydrogen in the IGM. This would allow to study the topology of the IGM using different technics, including the Euler characteristics but also the powerful skeleton (Caucci et al. 2008, MNRAS 386, 211). This would give important clues on the formation of structures at high redshift. In addition to this, by observing the galaxies in the field, we would place the galaxies into the reconstructed density field to characterize the spatial correlation between galaxies and the IGM.

The Lyman-α forest most likely arises from spatially continuous absorption by moderate density fluctuations around the mean density in a warm photo-ionized IGM. The spatial distribution of the IGM is
therefore related to the distribution of dark matter in a simple manner. Nusser \& Haehnelt (1998, MNRAS 303, 179) and Rollinde et al. (2001, A\&A, 376, 28) have demonstrated that using this simple relation it is possible to infer the continuous dark-matter distribution along the line of sight.

This method has been extended to a full 3D reconstruction of the distribution of matter using a grid of
spatially close lines of sight (Pichon et al. 2001, MNRAS, 326, 597; Caucci et al. 2008, MNRAS, 386, 211). The bayesian inversion method interpolates the structures revealed by the absorptions in the spectra.
Once the density field is recovered, topological tests can be applied to recover the true characteristics of the density field. We have in particular tested the Euler characteristics but also investigate much promising and powerful tools such as the skeleton.

The most important goal of this programme is to reconstruct the topology of the IGM from the Jeans length to beyond the linear scales. Structures at small scales will be then correlated with field galaxies to investigate the connection between galaxies and the IGM. Large scales should reach the linear regime in order to address cosmological issues. This must be at least of the order of 1~degree or about 100~Mpc comoving at $z>2$.

An optimal number of 900 background sources per square degree should be reached. It has been shown by various authors (see Caucci et al. 2008) that at a typical magnitude of $r = 24-25$ the mean separation of QSOs at $z\sim$ 2.8 will be 6.8 and 5.2~arcmin which corresponds to

approximately 80 and 130 sources per square degree respectively. This is therefore not enough for our purpose. If we add however Lyman Break Galaxies as background sources we can reach 4.3 and 1.2~arcmin mean separation
or 200 and 2500 background sources per square degree. We should therefore target a typical magnitude of $r=24.8$ to reach about 900 sources per square degree.

Using Lyman Break Galaxies as background sources implies several difficulties compared to quasars. First, LBGs are not point-like sources. However, (a) they have been shown to be small ($<$0.5 to 1~arcsec typically) so that the whole flux can be put in a sufficiently wide slit or better a small IFU;
(b) the intergalactic clouds have been shown to have dimensions much larger than a galaxy so that we can assume that the mean absorption in front of a QSO or a LBG are identical. Secondly, LBGs often show a Damped Lyman-α system at the emission redshift. However, (a) the Lyman-α absorption associated with the DLA will only decrease by a negligible amount the redshift range on which
the Lyman-α forest can be studied; (b) associated metal lines should be carefully removed; this is why we need an intermediate resolution and $R\sim5000$ is adequate (note that the reconstruction could be performed at somewhat smaller resolution); (c) even if we retrieve from the spectra the wavelength windows in which metals are supposed to be blended with the forest, we will have enough information
if we observe enough background sources in this window. This is why it is safe to reach 1000 sources per square degree eventhough 900 could be in principle enough.

1.1- Project Title: Searching for the variability of fundamental physical constants with QSO absorption spectra

1.2- Project Category: 1

1.3- Abstract:
Astronomical observations are the only way to probe possible variations of dimensionless constants (the fine structure and the proton-to-electron mass ratio) in space-time.
Indeed, observations of absorption lines in
the spectra of distant astronomical objects provided the first hints that the fine-structure constant might change its value over time, though recent observations are consistent with a null result.

We are proposing high-resolution spectroscopy of QSOs with an ultra-accurate wavelength calibration
and ultra-high S/N as obtainable at the ELT to detect or achieve a substantial improvement of the constraints on the variability of fundamental constants. The new observations will be more sensitive by about 2 order of magnitude compared to present and controversial limits
Measured variations would have far reaching consequences for the unified
theories of fundamental interactions, for the existence of extra dimensions and for the existence of Dark Energy in the form of scalar fields acting in the late universe and causing the Universe acceleration.

1.4- Publication agreement: yes

2.1- PI: Paolo Molaro

2.2- CoIs: CODEX team

2.3- Institute: INAF-OAT

2.4- Country of Employment: IT

2.5- Career Stage: faculty

2.6- E-mail: molaro@oats.inaf.it

3.1- Source of targets: QSo absorption system catalogues, SDSS

3.2- Preparatory work on targets required?: yes, not critical. A characterization of the absorption systems would be useful in the target selection

3.3- Target brightness: 16, 18, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 20

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: IGM, AGN

4.1- Spatial resolution: seeing, 1

4.2- Field-of-view: fiber

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A, N/A

5.1- Wavelength range: 350 - 10000, V

5.2- Spectral Resolution: >100000

6.1- Instrument: CODEX

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 5, 10, 0.8 arcsec, airmass <1.5, glunar phase, thermal background...

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: 900

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:

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Wavelength calibration and instrumental stability which should allow radial velocity measurements down to the cm/s regime

9.3- Detailed description or other comments:

This science case is a DRM case and a science showcase of the CODEX instrument study.

Over the past few years there has been great interest in the possibility that the fundamental constants of nature might show temporal variations over cosmological time scales. A variability of the coupling constants appears quite naturally in the attempts to find a unified theory of the fundamental interactions and in quintessence models for Dark Energy. The required cosmological constant value is so small that a quintessence is a likely candidate for Dark Energy. Thus a detection would have great impact in cosmology since it might be connected with the scalar field responsible for the Universal acceleration. A precise detection of the variability of a constant could be used for the reconstruction of the quintessence potential and of the equation of state of Dark Energy. At the moment of writing there are claims for a variability of both fine structure and the proton-to-electron mass ratio at 5 and 4 C.L., respectively, although they are contrasted by nu ll results and the whole issue is highly controversial. The most effective way to look for their variability is through the analysis of metal lines of intervening absorption systems observed in the spectra of distant QSOs. The energy levels of high mass nucleus are subject to relativistic corrections which are sensitive to the mass number. These have been calculated for the most frequently observed resonance lines and constitute the popular Many-Multiplet method to look for variations in the fine structure constant.
More specifically, Murphy et al (2004,astro-ph/0310318) claimed a variability of -5.7 (+/- 1.1) ppm (ppm stands for parts per million) from the measurements of the relative radial velocity shifts between different metal absorption lines of 143 QSO absorption systems with redshifts up to 4. On the other hand, other authors failed to reproduce Murphy et al.""s result obtaining no variability.

Measuring the variability of these constants implies the measurement of a tiny variation of the position of one or few lines with respect to other reference lines. It is not much different than revealing exoplanets, but with the limitations that only few lines can be used and QSO are much fainter than stellar sources. High-resolution spectroscopy of QSOs with an ultra-accurate wavelength calibration and ultra-high S/N as obtainable with an ELT will provide a substantial improvement ofthe constraints on the variability of fundamental constants. The achievable accuracy depends on the wavelength calibration, the width of the absorption line and the photon noise. The metal lines in QSO absorption spectra have intrinsic widths of a few km/s, rarely of less than 1 km/s. A resolving power of R=150,000 is thus optimal. The recent concept study of CODEX shows that for relatively bright QSOs it should
be possible to reach the photon noise limit for the wavelength measurement of absorption features. It should thus be possible to reach a sensitivity of ~10-7 - 10-8, which represents an improvement of two to three orders of magnitudes.

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The strategy of this proposal is to select few targets from the sample of QSO already used for this purpose which show the best properties (simplicity, strength and number of lines, redshift) to perform the most precise and accurate measurement. Then the observations will be extended to other targets to increase the sample either to follow in detail the variability with redshift or to increase further the bound trough a measurement combination.

1.1- Project Title: Probing the interplay of galaxies and the intergalactic medium from which they form

1.2- Project Category: 2

1.3- Abstract:
The formation of the first autonomous sources of radiation, stars and black holes, leads to heating, reionization and pollution of the Intergalactic Medium (IGM) with metals.
We propose to investigate the enrichment history of the IGM and the galaxy-IGM interplay at z=2-4 by observing weak absorption features in a sample of QSOs using the high-resolution optical spectrograph on the E-ELT.
In this redshift range, the IGM provides a fundamental fossil record of the galaxy formation process and a unique link to the inter-stellar medium properties and to the role of galactic feedback on cosmic structures.
Pushing observations to the low-density IGM is required to study the expected weak absorption features of residual metals in a variety of ionization states and infer the underlying density, temperature and ionization fields.
Relating the absorbers/galaxy physics in a robust and quantitative way will constrain and guide theoretical models currently under development, mainly based on the implementation of galactic winds in hydrodynamical simulations.

1.4- Publication agreement: yes

2.1- PI: Stefano Cristiani

2.2- CoIs: CODEX Team

2.3- Institute: INAF - Trieste Astronomical Observatory

2.4- Country of Employment: IT

2.5- Career Stage: faculty

2.6- E-mail: cristian@oats.inaf.it

3.1- Source of targets: Existing QSO catalogues (e.g. NED, SDSS) + new cats from VST/VISTA + LSST

3.2- Preparatory work on targets required?: yes, Surveys to find more bright high-z QSOs + spectroscopic follow-up

3.3- Target brightness: 15, 17, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 20

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: AGN

4.1- Spatial resolution: seeing, 2

4.2- Field-of-view: fiber

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 370 - 750

5.2- Spectral Resolution: >100000

6.1- Instrument: CODEX

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 20, 20, 0.8 arcsec seeing, airmass < 1.5, dark moon

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 1800

7.4- Total time: 400

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 65

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
This is a photon-limited experiment so the product of the total photon collecting area and the total system throughput (telescope + instrument) should be as high as possible. For D=42 m, a total throughput of > 20 % is required.

9.3- Detailed description or other comments:
This science case is a science showcase of the CODEX instrument study.

1.1- Project Title: Young Massive Stars Clusters in M31 and M33

1.2- Project Category: 3

1.3- Abstract:
In the last decade, massive Galactic clusters have been found or indentified near the center of the Milky Way or in regions close to the bar-spiral arm interaction region. Their distribution suggests some link with the structure of our Galaxy and triggering star formation mechanisms. Our project aims at multiplying the number of resolved young massive clusters studied in spiral galaxies by a factor of ~20.
Studying the properties and distributions of these clusters in the Local Group spirals (Milky Way, M31, M33) will allow us to constrain the role of the local conditions in the formation and evolution of massive stars and clusters: (a) the mass and type of the spiral galaxy; (b) the presence or absence of a central supermassive black hole, a bar or an interaction region between the bar and the spiral arms; and (c) the galactic metallicity. But these clusters have typical radii of 1 pc, which at the distance of M31 and M33 represents angular sizes of only 0.25 arcsec. To carry out photometry and spectroscopy of individual stars we need NIR diffraction-limited images and multi-IFU spectroscopy at high spatial resolution in a telescope of ~40m.

1.4- Publication agreement: yes

2.1- PI: A. Herrero

2.2- CoIs: F. Najarro, I. Negueruela, D.J. Lennon, C. Evans, F. Comerón, J. Puls, B. Davies, D. Figer, M.A. Urbaneja, J. Maíz Apellániz, A. Marín Franch, M. García

2.3- Institute: Instituto de Astrofísica de Canarias

2.4- Country of Employment: ES

2.5- Career Stage: faculty

2.6- E-mail: ahd@iac.es

3.1- Source of targets: existing space and ground-based multiband photometry of M31 and M33

3.2- Preparatory work on targets required?: yes, analyses (f.e., integrated spectra) of young massive cluster candidates in M31 and M33

3.3- Target brightness: 19, 23, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: 50-200

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3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 2;Dec:30 - +45

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star, star cluster

4.1- Spatial resolution: 10, 2

4.2- Field-of-view: 2x2arcmin

4.3- Multiplexity and pick-off FoV: 5, 2x2arcsec

4.4- Plate scale stability: 3, 3600

5.1- Wavelength range: 800 - 2400

5.2- Spectral Resolution: bbimaging, 3000-5000

6.1- Instrument: EAGLE, MICADO

6.2- Desired special mode: N/A

6.3- Desired AO mode: MOAO

7.1- Integration time per target or field and per setup: 0.003, 2.8, 0.8 arcsec seeing

7.2- Longest continuous observation time on a target or field: 2.3

7.3- Shortest integration time on a target or field: 10

7.4- Total time: 60

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

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8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, any

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, other, GTC, Keck

9.2- Critical aspects / limiting factors for the science case:
spatial resolution; spectral resolution

9.3- Detailed description or other comments:
The discovery of very massive young Galactic star clusters during the last decade has been very intense (see Figer, 2008, IAU Symp. 250). The detailed study of these clusters and their stellar population allows us to determine important characteristics as its IMF and chemical composition, and study the evolution of coeval massive stars under different conditions. Moreover, their distribution in the Galaxy reveals new clues for the structure of the Milky Way. These very massive clusters seem to concentrate near the Galactic center (Central Cluster, Arches, Quintuplet) or at the base of the Scutum-Crux arm, where it encounters the Galactic bar (RSGC1, RSGC2, RSGC3). Whether this is just a statistical effect or is related to physical conditions determining the triggering of star formation (like the presence of a central supermassive black hole or the bar-arm interaction region, see Garzón et al., 1997, ApJ 491, L31) has still to be confirmed.

This study is hampered by two effects arising when we look along the disc of the Galaxy: the large extinction and the large crowding produced by the foreground stars present in the line of sight. As a result, only a handful of these clusters has been discovered.

Studying these massive clusters in other galaxies will help us to clarify the role of the local conditions in their formation and evolution and will contribute to better know the structure of the host galaxies (like 30 Dor and R136 in the LMC, see Zinnecker & Yorke, 2007, ARAA 45, 481 or Massey, 2003, ARAA 41, 85). To these aim M31 and M33, the nearest spirals, are ideal targets to compare with the Milky Way: they embrace the Milky Way mass, galaxy type and metallicity; M31 has a supermassive central black hole (Bender et al., 2005, AJ 63, 280) but no bar, while M33 has neither a massive central black hole (Merritt et al., 2001, Science 293, 1116) nor a bar. The LMC, having very massive clusters but no central massive black hole and only the hint of spiral arms or a bar-like structure, offers an additional possibility for comparison.

However, studying individual stars in young massive clusters at the distances of M31 and M33 is not possible with present-day facilities. In fact, the only resolved young massive clusters that could be studied up to now are those in the Milky Way. In Table 1, adapted from Figer (2008), we give the main physical characteristics of these clusters. They have typical radii of the order of 1pc, or 0.25 arcsec at 800 Kpc. Thus, a cluster as the Quintuplet, with an estimated population of 100 O stars and a radius of 1.0 pc, will appear in M31 as an object with a radius of 0.25 arcsec, too small for current observational facilities to allow a detailed study. Other clusters in the table will look slightly different, but never with radii larger than 0.7 arcsec.

Table 1. Properties of young Galactic massive star clusters. Masses in solar masses, radii in parsec and angular radii in arcsec

Cluster	log(Mass)	Linear Radius	Angular Radius at 800 Kpc
Westerlund 1	4.7	1.0	0.258
RSGC2	4.6	2.7	0.696
RSGC1	4.5	1.3	0.335
Quintuplet	4.3	1.0	0.258
Arches	4.3	0.19	0.049
Center	4.3	0.23	0.059
NGC 3603	4.1	0.3	0.077
Trumpler 14	4.0	0.5	0.129
Westerlund 2	4.0	0.8	0.206

Such study becomes possible with the E-ELT. With diffraction-limited images in the J band achieving 6mas/pixel and assuming the PSF FWHM to be about 1.5 times larger, we obtain for the Quintuplet cluster about 2500 resolution elements over the cluster area. Even with a stellar concentration towards the center it will be possible to resolve the cluster population and construct Color-Magnitude Diagrams (assuming comparable performance in the H-K bands). Afterwards, selection and IR spectroscopy of isolated objects will be possible. With sub-arcsec sizes for the clusters, and several clusters in a FoV of 2x2 arcmin, MOAO will be the required technology. Even for the Arches cluster, the most demanding case in Table 1, we will be able to resolve at least half of its stellar population.

Immediate objectives:

- resolve the population of young massive star cluster candidates in M31 and M33 by means of diffraction limited JHK photometry.
- Construct CMDs. Compare with synthesis population models to obtain first guesses of cluster parameters. Select the most promising candidates for NIR spectroscopy.
- Obtain 0.8-2.4 microns spectra of the massive stellar population of the clusters at R=4000 using high spatial resolution IFUs assisted by MOAO. Derive stellar parameters and abundances

This will multiply by ~20 the number of resolved young massive clusters studied in spiral galaxies. With these data we will

- Construct a 2-D map of the young massive cluster population in M31 and M33.
- Review possible differences between M31, M33 and the Milky Way (and the LMC) using resolved populations. Correlate these differences with galactic characteristics (supermassive central black hole, bar-arm interaction region, etc.)
- Compare the results with predictions of star formation and galactic structure models.

Time Justification

We need to obtain diffraction-limited photometry of young massive clusters in M31 and M33 in the JHK bands. Each galaxy contains about 100 cluster candidates with M > 104 Msun. To cover the Upper Main Sequence down to B2V types, we need to reach mk= 22.5, without extinction. Aiming at obtaining SNR= 5 for mk= 25 we need 40 seconds for K, 20 for H and 10 for J, or 70 seconds per cluster. This means a total of 4 hours to sample about 200 clusters.

Spectroscopy will be made at medium (R= 4000) resolution using MOAO. We estimate that mk= 19.0 will allow us to cover all early and late supergiants in M31 and M33. For these stars, SNR= 80 per resolution element is appropriate to derive the required stellar parameters. Using 2x2 arcsec IFUs with 55 mas/pixel and under normal (0.8 arcsec) seeing conditions, the E-ELT web ETC (with LTAO) results in 2.3 hours exposure time to reach the desired SNR at all points in the K-band. In the H-band, under similar conditions, the E-ELT ETC gives 30 minutes, resulting a total of 2.8 hours exposure time per cluster. Assuming we select for spectroscopy only 50 per cent of the initial candidates, this gives a sample of 100 clusters. Within a 2x2 arcmin FoV we expect to have several cluster candidates. We estimate to observe the 100 clusters with 20 setups, giving a total of 56 hours for the spectroscopy of the whole sample of massive stellar clusters in M31 and M33. The total time (photome
try+spectroscopy)
amounts to 60 hours.

1.1- Project Title: Extragalactic black holes: are ULXs intermediate mass black holes?

1.2- Project Category: 1

1.3- Abstract:
The nature of ULXs in nearby galaxies is highly controversial: are they the long-sought intermediate mass black holes or a new state of stellar-mass black hole X-ray binary? Only radial velocity studies can unambiguously solve this puzzle, and we have chosen the brightest ULXs (B<22) in NGC 5204 and Holmberg II. We propose long-slit spectroscopy with ELT to obtain the first radial velocity curve of two ULX companion stars and probe whether they contain ~100-1000 Msun black holes or not. Excellent ground seeing conditions (<0.6") and intermediate spectral resolution (R~5000) are requested to avoid crowding and contamination by

background nebular lines.

1.4- Publication agreement: yes

2.1- PI: Jorge Casares

2.2- CoIs: I. Negueruela, F. Vilardell, A. Herrero, T. Shahbaz

2.3- Institute: IAC

2.4- Country of Employment: ES

2.5- Career Stage: other

2.6- E-mail: jcv@iac.es

3.1- Source of targets: HST

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 21.35 , 21.92, ABmag, B

3.4- Target size: point source

3.5- Number of targets: 2

3.6- Density of targets: N/A

3.7- Target coordinates: RA:08 - 14;Dec:+58 - +71

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: other, X-ray Binary

4.1- Spatial resolution: seeing, 6

4.2- Field-of-view: longslit

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

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5.1- Wavelength range: 300 - 500, B

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: other, long-slit spectrograph, Wavelength
range: 350-900nm, Resolution: R=5000-10000

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 10, 10, 0.6", 1.3 airmass and dark conditions

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 1800

7.4- Total time: 20

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 70

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
Spatial resolution should not be worse than 0.6" to avoid contamination by nearby objects and to allow an accurate background light subtraction.

9.3- Detailed description or other comments:
Introduction

ULXs (Ultraluminous X-ray Sources) are extragalactic X-ray point sources with X-ray luminosities in the range LX~10^{39} -10^{41} ergs/s, well in excess of the Eddington limit for a stellar-mass BH (typically 5--10Msun in our galaxy). They have been discovered over the last decade (by

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XMM and Chandra) and tend to be found in galaxies with a high star-formation rate like the Antennae or the Cartwheel. The nature of their compact accretors is one of the big open questions in current astrophysics. Proposed scenarios are super-Eddington and beamed collimated accretion onto stellar-mass BHs (King et al. 2001) or accretion onto IMBHs (intermediate-mass BHs) of $10^{2}-10^{4}$ Msun (King \& Dehnen 2005). The existence of IMBHs represents an exciting possibility: they may be remnants of massive stellar collapse in the early universe or result from the collapse of dense stellar clusters. They are expected to play a key role in the formation of supermassive BHs in galactic nuclei. The observed variability and spectra of ULXs point to accreting binaries and there are several cases where periodicities have been reported, although no single dynamical piece of evidence has yet been presented. Possible optical counterparts have been reported in several papers and, in some cases, they turned out to be background AGN (Lopez-Corredoira & Gutierrez 2006). However, in most cases the observed optical colours and spectra are consistent with OB stars (e.g. NGC 3031 X-11: Liu et al. 2002; NGC 1313 X-2: Mucciarelli et al. 2005) and furthermore, orbital X-ray modulation has been detected (NGC 3379: Fabbiano et al. 2006). Deriving dynamical masses of the brightest ULXs is the ONLY way to settle the debate as to the nature of the compact object and the existence or otherwise of IMBHs.

Observing strategy:

Since ULXs tend to be located in star-forming regions they are usually contaminated by nebulosity and/or nearby young stars, so detailed spectroscopy under good seeing conditions <1" with the largest telescopes is mandatory Although targets are faint, their long orbital periods (several days for our targets, as estimated for an assumed ~20 Msun companion) allows for long integrations without significant velocity smearing. The radial velocity solution provides the mass function, a lower limit to the mass of the compact object which, for an intermediate mass black hole, would be very large. In addition, model atmosphere fitting will constrain the stellar parameters Teff and log g which, combined with the observed magnitude, reddening and distance will yield the radius and luminosity of the OB star. These, together with the Roche lobe geometry and orbital solution, will constrain the mass of the BH. This observing strategy has been proven with GEMINI+GMOS for M33 X-1, a B=19 high mass X-ray binary with a 16 Msun BH (Orosz et al. 2007). ELT will enable us to extend this analysis ~3.5 mag fainter and target the brightest ULXs. We have broad experience in both the analysis of orbital parameters of high mass X-ray binaries (e.g. Casares et al. 2005) and spectral analysis of massive stars (e.g. Negueruela et al. 2006; Urbaneja, Herrero et al. 2005).

Target Selection:

There are over 200 ULXs currently known (Liu & Mirabel 2005) but only a handful of optical counterparts have been identified. Optical colours and spectra are consistent with OB stars and furthermore, orbital X-ray modulation has been detected, giving support to an X-ray binary scenario. We focus on the two brightest ULXs, Holmberg II and NGC 5204, which have B=21.35 and 21.92 respectively.

NGC 5204 ULX: has been observed regularly in the last 10 years by ROSAT and Chandra, with an average LX~3x10^{39}$ ergs/s and 50 % variability. The optical counterpart was finally identified by Liu et al. (2004) and show colours consistent with an O5V-B0Ib companion, but no optical spectroscopy has yet been reported. HST imaging shows the presence of cluster of star formation at ~1.5" West (HST-1) and a nearby star (U2) at only ~0.5" North. A 0.6" slit will be used to avoid degradation in spectral resolution and minimize the amount of background light from contaminating stars and nebular emission. This will be oriented at PA=8.2^deg, i.e. perpendicular to the direction of the stellar cluster, in order to minimize contamination from the latter. For these reasons, also seeing conditions <0.6" are requested. U2, which is only 0.5" North from the ULX, is 1.8 mags fainter in B so its contribution to our spectra will be negligible.

Holmberg II ULX: is located in a star-forming region and is contaminated by nebulosity and nearby young stars. The optical counterpart has colours consistent with a O4V-B3Ib star (Kaaret et al. 2004). Previous low-resolution (~7 Angs) spectroscopy obtained with the 6m BTA telescope under 1-2" seeing shows a featureless continuum with strong broad nebular emission lines superimposed (Lehmann et al. 2005). The photospheric absorptions of the OB star are probably concealed by the strong nebular lines, broadened by the poor resolution. Therefore, high resolution spectroscopy (R~5000) under excelent seeing conditions is mandatory to carefully subtract the nebular background light and unveil the spectrum of the OB star.

Instrumental set-up:

Searching for dynamical evidence of IMXBs in ULXs is one of the hotest topics in modern astrophysics. We believe that ELT, with its large collecting area and frontline instruments, will offer a unique opportunity to obtain an important result on the two brightest ULXs and make significant impact in the field. Since ULXs are located in star-forming regions they are contaminated by nebulosity and nearby young stars. Therefore, good seeing conditions <0.6" are required to resolve the counterparts in crowded fields whereas high spectral resolution (R~5000) is essential to clear out nebular lines from the underlying OB spectrum. The later is crucial to extract radial velocities from the photospheric absorptions and hence derive unbiased dynamical information. The wavelength range 3500-5500 Angs contains several HeI and HeII lines, ideal for the cross-correlation analysis and spectral classification. At R=5000 also the rotational broadening V sin i of the donor star will be determi
ned from which additional constraints to the binary mass ratio can be set.

We estimate exposure times of 1800s to yield S/N~30, using the ETC available in the web for R=5000, 0.6" seeing, 0.6" slit and 1.3 airmass. This S/N is sufficient to extract radial velocities from individual spectra and confirm whether the optical counterpart of these ULXs are indeed X-ray binaries. Since the expected orbital period of both Holmberg II and NGC 5204 ULX is several days we propose to obtain two 1800s spectra (elapsed in time by as much as possible i.e. 3-5 hours) every night that meets our observing restrictions (i.e. dark time and seeing ~0.6"). Ten hours of data (distributed over a baseline > 10 days (depending on weather conditions) will be obtained per target.

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1.1- Project Title: The growth of supermassive black holes in obscured galactic nuclei

1.2- Project Category: 2

1.3- Abstract:

Ultraluminous infrared galaxies (ULIRGs) dominate the star formation in the universe and they are long suggested to be the birthplaces for supermassive black holes powering active galactic nuclei. Due to the significant obscuration, the feeding processes in the central regions of ULIRGs are impossible to probe at optical or even near-infrared wavelengths. We propose MIR spectroscopy with METIS to observe the nuclei of a representative sample of nearby obscured ULIRGs. The data will be used to measure the velocity field of molecular and ionized gas in these nuclei, in order to study the gas flow, the masses of the black holes and the feeding processes of gas onto these black holes.

1.4- Publication agreement: yes

2.1- PI: Maarten Baes

2.2- CoIs: Paul van der Werf

2.3- Institute: Universiteit Gent

2.4- Country of Employment: BE

2.5- Career Stage: faculty

2.6- E-mail: maarten.baes@ugent.be

3.1- Source of targets: IRAS Revised Bright Galaxy Sample

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 10, 13, Vegamag, K

3.4- Target size: extended source, 200, 2000

3.5- Number of targets: 50-100

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - 25

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 2x2arcsec

4.3- Multiplexity and pick-off FoV: 1, 2x2arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: M, N

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: MCAO

7.1- Integration time per target or field and per setup: 0.5, 2, N/A

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

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8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, N/A

9.2- Critical aspects / limiting factors for the science case:
N/A

9.3- Detailed description or other comments:
In recent years is has become clear that supermassive black holes (SMBHs) form an integral part of galaxy nuclei. The fact that the black hole mass and total galaxy mass are closely related is truly remarkable, given that there is a factor of 108 between the AU-size Schwarzschild radius of the black hole and the kpc-size dimension of the galaxy. This is generally interpreted as evidence that the formation of the black hole is directly related to the formation process of the stellar population, e.g., in a violent burst of star formation. The picture of the simultaneous buildup of a SMBH with an extreme burst of star formation provides a new context for the luminous and ultra-luminous galaxies (LIRGs and ULIRGs), which are major mergers undergoing strong starbursts, and for which it has long been suggested that these are the birthplaces of SMBHs powering active galactic nuclei. Studies of local ULIRGs demonstrate that they plausibly evolve into moderate mass field ellipticals.

The giant ellipticals in the local universe would then be the result of similar but much more extreme events at higher redshifts. Indeed, the recently identified population of submillimetre galaxies (SMGs) provides the more luminous high redshift counterpart of the local LIRGs and ULIRGs and may be responsible for the formation of local massive spheroids and for generating QSO activity at high redshift. Still many fundamental questions remain unanswered concerning the buildup of SMBHs and their relation to massive star formation, such as: What are the masses of the SMBHs in the nuclei of nearby (U)LIRGs? How does gas in the circumnuclear region flow towards the accreting SMBH? Do stellar mass and SMBH mass build up simultaneously in (U)LIRGs, or does one component precede the other? Is the star formation process terminated by feedback from the SMBH? How does feedback from the starburst affect the environment? Does a “normal” M-sigma relation appear in the most evolved (
U)LIRGs? How is the black hole fed during the phase of mass !
buildup?

METIS at the E-ELT provides the unique opportunity to probe a representative sample of local (U) LIRGs by mapping gas flows and measuring dynamic black hole masses. On the one hand, the need to get the highest possible spatial resolution to resolve the sphere of influence of black holes requires the large aperture of an E-ELT. On the other hand, the very large obscuration towards these nuclei necessitates the use of the longest accessible wavelengths, and therefore automatically favours mid-infrared wavelengths. Fortunately, various spectral features are available in the M and N bands to probe different environments in the nuclear region: the ionic lines probe the photoionized gas, H2 lines probe the warm molecular gas, the broad silicate feature contains information on the amount of absorbing material along the line of sight and additional information

on the AGN. For tracing black hole masses using gas motions, we can use the Brα (4.05 μm), the [NeII] (12.81 μm), H2 0—0
S(2) (12.28 μm) and H2 0—0 S(3) (9.66 μm) lines. In addition to providing measurements of the black hole mass, these lines can also be used to trace the gas flow towards in and towards the region of influence of the black hole.

A METIS/E-ELT observing program to systematically address these fundamental issues must constitute a systematic study of a significant sample of (U)LIRGs. The sample must cover a range in luminosities and evolutionary stages, be unbiased, and large enough to derive statistically reliable results. To cover for instance four luminosity bins over the LFIR range from 1e11 to 3e12 Lsun, a sample of about 50—100 objects would be needed. Such a sample would automatically also cover a range of types, since luminosity is correlated with other parameters such as IR colour (which in turn is thought to depend on evolutionary stage). The IRAS Revised Bright Galaxy sample contains 146 (U)LIRGs at δ<25, all of which are at z<0.088. Extending this volume out to z<0.15 adds a large number of more luminous ULIRGs, in particular with warm IR colours. For each galaxy, we would observe the nuclear region with the IFU in the lines mentioned above (Brα and [NeII] only at z<0.2 and z<0.03 re
spectively). In total, a dedicated program of several hundred hours (for a Macon altitude site) with METIS/E-ELT will be able to address fundamental issues in the buildup of SMBHs in galactic nuclei and its relation to extreme bursts of star formation.

1.1- Project Title: SCUBA2 on E-ELT

1.2- Project Category: 3

1.3- Abstract:
A SCUBA2 type instrument on an E-ELT would be an incredibly powerful tool for unlocking the mysteries of star formation. It would provide detailed submm mapping at a few arcsec resolution acros a wide field of view. This would be a perfect complement to ALMA. It would essentially be a survey instrument for ALMA follow-up, and a machine for generating ALMA source lists, as well as solving fundamental problems of star formation in its own right.

1.4- Publication agreement: yes

2.1- PI: Derek Ward-Thompson

2.2- CoIs: N/A

2.3- Institute: Cardiff University

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: D.Ward-Thompson@astro.cf.ac.uk

3.1- Source of targets: None. It will provide sources for follow-up with ALMA.

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 0.1, 100, mJy, Q

3.4- Target size: point source

3.5- Number of targets: 1000s

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: ISM

4.1- Spatial resolution: diffraction, 1

4.2- Field-of-view: 10x10arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: -, -, -, -, -, -, -, -, -, -, -

5.2- Spectral Resolution: bbimaging

6.1- Instrument: other, SCELT (SCUBA2 for ELT)

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1s, 1hr, N/A

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 1

7.4- Total time: 100s

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: yes, To be timely for ALMA

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, N/A

9.2- Critical aspects / limiting factors for the science case:
High, dry, submm-friendly site

9.3- Detailed description or other comments:
N/A

1.1- Project Title: Transiting exomoons

1.2- Project Category: 4

1.3- Abstract:

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There are indications that the presence of the Moon may have had important effects on the origin and evolution of life on Earth. Furthermore, the giant exoplanets in habitable zones of their host stars are not habitable, but their moons may be. Therefore, the detection of exomoons may be a necessary step towards detection and study of life. Here we propose a program for direct detection of exomoons with the E-ELT via transits.

1.4- Publication agreement: yes

2.1- PI: Valentin D. Ivanov

2.2- CoIs: et al.

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: vivanov@eso.org

3.1- Source of targets: CoRoT, SuperWasp, XO, etc.

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 8, 12, Vegamag, J

3.4- Target size: point source, ., .

3.5- Number of targets: 1

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, see text per sec

3.10- Target type: exoplanet

4.1- Spatial resolution: seeing, 10

4.2- Field-of-view: 2x2arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: J

5.2- Spectral Resolution: bbimaging

6.1- Instrument: MICADO

6.2- Desired special mode: precision photometry, high time-resolution, N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 3, 6, It was determined by the lenght of the transit event and the Hill sphere radius for the given system.

7.2- Longest continuous observation time on a target or field: 6

7.3- Shortest integration time on a target or field: 3

7.4- Total time: 24

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 24

7.6- Are the observations time critical?: yes, transit events, but can be selected from multiple events

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
Currently, the targets are unkown, but it is likelty they will be extremely brigth (and in fact, this is necessary to provide
suficient S/N) and short integrations will be required, so it is critical to have detectors that would allow fast readout and
low readout noise.

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9.3- Detailed description or other comments:
The moons are potentially important for the evolution of the life on Earth. Moon-induced tides increase Earth""""s core temperature, stimulate tectonics and may even be responsible for the migration of the complicated life forms from seas to land. Detecting moons around extrasolar planets may tell us how common these processes are, and what is their role in the origin end evolution of life in general.

The detection of exomoons is extremely challenging and so far it seems to be possible only for moons around transiting planets, via two methods pioneered by Sartoretti & Schneider (1999): transit timing and direct detection of their photometric signature during transits. The former is likely to work if the satellite is distant and massive, the later promises a nearly secure detection of all large enough moons for the given photometric accuracy. Both methods are extremely demanding to the photometric accuracy, and the time resolution.

The necessary photometric accuracy is determined by the moon-to-star radii ratio r_moon/r_star: the drop in the stellar flux is ~(r_moon/r_star)**2. Our Solar system has six planetary satellites with radii ~1500-2600 km, that would produce transits with depth 4-13 micromag, a Mars sized satellite would cause 24 micromag transit depth, and an Earth sized one: 83 micromag. Therefore, the required accuracy for direct detection is <=10 micromag (signal-to-noise S/N>=100000), per each point of the light curve. The duration of the satellite produced transits are comparable with those of the "normal" hot-Jupiter transits (typically 1-3 hours or even longer for a planet in the habitable zone), and we need to sample the transits with at least 5 measurements to obtain some estimate of the transit shape, so we can afford to integrate at least 12-36 minutes to obtain the required accuracy of each measurement. The E-ELT Imaging ETC indicates that for V=12 mag star we will obtain this S/N
in ~6 min, under seeing limited conditions. There is an ample room for improvement - transiting planets around brighter hosts are known, the AO can help to suppress the background (but may not be usable on the brighter stars, even defocusing may be necessary). This calculation ignores the fact that extremely short integration may be needed, increasing the contribution of the readout nose, and may reduce the cadence.

Our previous experience (Caceres et al. 2009) with transits indicates that the photometric accuracy is dominated by red noise and systematic effects, rather than by Poisson noise, and it takes considerable effort to reduce them. Nevertheless, we can achieve at 8-m telescope light curve with r.m.s.~0.4 milimag, with sampling of 0.1-1 sec - 10**3-10**4 times shorter than the one considered here.

Timing effects cause by exomoons depend on the system configuration. Typically, a few earth mass satellite around a hot jupiter causes ~10-40 sec transit displacement (Brown et al. 2001). This is comparable with the accuracy routinely achievable from space (Pont et al. 2007) and even from the ground (Gillon et al. 2006, Caceres et al. 2009). The simulations suggest timing accuracy of ~0.6-1 sec (Ivanov et al. 2009) but the systematical effects that reduce it by an order of magnitude.

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The sample selection cannot be discussed in detail at this time. Although 59 known transiting planet systems are known currently, none is suitable for this project. Our targets need to meet at least two conditions. First, they need to be from the difficult to find "cold" transiting jupiters on low-eccentricity orbits, because the life time of the exomoons around hot jupiters is relatively short and they are likely to be be rare, if present at all. There is only one published transiting planet with P>9 days and eccentricity~0 but the on-going surveys such as CoRoT, Super-WASP are likely to discover systems, better suited for us. Second, the observed systems must have neighboring stars within the field of view for reference sources as bright or brighter than the target.

The observations will be carried out in J-band utilizing the fast readout, intrinsic to the near-infrared detectors, and minimizing the sky background. The observing time spent on each target is determined by the duration of the individual transits, adding a few hours before and after the transit to cover the Hill sphere, and to obtain plateau observations, important for the removal of systematic effects. It is impossible to predict how many transiting systems have to be observed to discover even a single exomoon because estimates of the frequency of the exomoons are based on our Solar system and a few upper limits (Brown et al. 2001, Pont et al. 2007) . The models of Sartoretti & Schneider (1999) indicate that if an exomoon is present around a transiting planet, the probability of detection is nearly one. A few transits will have to be observed to account for the periods when the exomoon is aligned with the planet. For detection of Trojan planets and rings observations from a few epochs can be averaged to minimize the systematics.

The larger collecting area of the E-ELT will open an entirely new class of problems, like the detection of exomoons, Trojan planets, and rings. In most cases, these observations will not require extremely high spatial resolution, so they can take advantage of the time when AO correction is poor. Photometric conditions are not required either, because this project relies on relative measurements only. The observations are time critical being centered at the transit events, but there are multiple events that one can choose from, so this is not a major limitation.

References:

Brown et al. 2001, ApJ, 552, 699
Caceres et al. 2009, A&A, accepted (astro-ph/0905.1728)
Ivanov et al. 2009, in "Science with VLT in the ELT Era", 2009, 487
Gillon et al. 2006, A&A, 459, 249
Pont et al. 2007, A&A, 476, 1347
Sartoretti P., & Schneider J.,1999, A&AS, 14, 550

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1.1- Project Title: Formation and Evolution of the two giant elliptical of the Coma cluster

1.2- Project Category: 2

1.3- Abstract:
Under the LCDM paradigm, giant elliptical galaxies in the center of clusters are believed to be the end-products of the violent star formation and merger events that took place in the central regions of clusters. Some of these galaxies (cD) show an faint stellar halo that could have formed as the result of stellar accretion during the cluster mass assembly. These extended halos are extremely faint and can not be observed by standard techniques. Nevertheless they can be investigated by detecting some tracers such as PNe. The closest central galaxies in clusters are those in the Coma cluster, being ideal targets for 40-m telescopes.

1.4- Publication agreement: no

2.1- PI: J. Alfonso L. Aguerri

2.2- CoIs: P. Sanchez-Blazquez

2.3- Institute: Instituto de Astrofisica de Canarias

2.4- Country of Employment: ES

2.5- Career Stage: postdoc

2.6- E-mail: jalfonso@iac.es

3.1- Source of targets: VLT, SDSS

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 2.3x10-18, 1.5x10-19, fl, V

3.4- Target size: point source

3.5- Number of targets: 1000

3.6- Density of targets: N/A

3.7- Target coordinates: RA:13.00 - 13.50;Dec:+27.5 - +28.5

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: other, PNe

4.1- Spatial resolution: seeing, 5

4.2- Field-of-view: 2x2arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 480 - 550, V

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: other, Narrow band filters and multiobject spectroscopy

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 2, N/A

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: yes, Coma Cluster is observable during Spring time

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, N/A

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9.2- Critical aspects / limiting factors for the science case:
For this program is critical use narrow-band filters, MOS spectroscopy and FOV as large as possible.

9.3- Detailed description or other comments:
This program try to study the old extended stellar population of the two closest cD galaxies located in the Coma cluster. According to the standard paradigm for structure formation, galaxies grow by mergers and accretion of smaller subsystems. The outermost regions of galaxies should contain fossil records of its mass assembly because of the long dynamical times. Numerical simulations, predicts that the stars found in the external regions of galaxies did not form in situ. They were unbound from galaxies during the accretion events that characterize mass assembly in a hierarchically clustering Universe. The giant galaxies located in the densest region of galaxy clusters are the ideal targets in order to test this galaxy formation theory. The two closest galaxies of this type are located in the Coma cluster.

Standard observational techniques are not valid in order to study the extended halos of this objects. The extremely faint surface-brightness of these halos makes difficult theis study by doing absortion line spectroscopy. Nevertheless, we can circumvent this problem by resolving individual stars located in those halos. One of the most suitable stellar tracers are planetay nebulae (PNe). Their bright emission in the [OIII] line make that these objects could be observed at large distances. Furthermore, by measuring the fluxes of adequate

diagnostic emission lines, it should be possible to derive O and Ne abundances at different projected radii

Nevertheless, a 40-m class telescope as E-ELT is necessary in order to obtain a clear detection of the main emission lines at the distance of the Coma cluster.

We can observe thousands of these objects in the halos of the two giant galaxies in Coma. These observations will allow : i) the detection of structures and comparison with predictions from cosmological simulations; ii) the determination of the mass and the orbital anisotropy of their halos; iii) the measurement of the metallicity distribution of the stars in the halos of the galaxies. These distributions can also be compared with expectations from numerical simulations.

This observations will constitude a unique dataset of information for testing galaxy formation in high-density environments.

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1.1- Project Title: Stellar populations in NGC 5128

1.2- Project Category: 2

1.3- Abstract:

We propose to obtain medium resolution (R=5000) spectra of giant stars in the nearest elliptical galaxy: NGC 5128 (Cen A). Such giants with an an I magnitude around 25 will allow an unprecedented view of the kinematics and chemical composition of this galaxy. This will provide new insight in the process of formation and evolution of such giant galaxies. We envisage a large programme of 400h, to be accomplished over a period of 5 years (10 nights/year), to adequatly sample different galactic radii.

1.4- Publication agreement: no

2.1- PI: Piercarlo Bonifacio

2.2- CoIs: OPTIMOS-EVE Science Team

2.3- Institute: Observatoire de Paris

2.4- Country of Employment: FR

2.5- Career Stage: faculty

2.6- E-mail: Piercarlo.Bonifacio@obspm.fr

3.1- Source of targets: VLT, HST

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 24, 25.3, Vegamag, I

3.4- Target size: point source

3.5- Number of targets: 250

3.6- Density of targets: 200

3.7- Target coordinates: RA:13 - 14;Dec:-43 - -42

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: seeing, 0.3

4.2- Field-of-view: 10x10arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 10, 3600

5.1- Wavelength range: 845 - 870

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: GLAO

7.1- Integration time per target or field and per setup: 50, 70, dark time, 1

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 3600

7.4- Total time: 400

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 13

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

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8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: other, HST/VLT

9.2- Critical aspects / limiting factors for the science case:
spectral resolution should not be less than R=5000 and mutiplex less than 300

9.3- Detailed description or other comments:
The detailed study of nearby galaxies has increasingly received more attention in recent years due to the realisation that many of the big cosmological questions can be answered by examining the structure, distribution and properties of stellar populations in the Milky Way and her neighbours.
These stellar populations, some of which have ages comparable to the age of the Universe, trace the history of cosmic star-formation; they contain the specific merging history of the galaxy they belong to; they probe and are influenced by the dark matter; and indeed some of them were even in place before the epoch of reionisation and will allow us to probe into the dark ages.

Several such ``galactic archaeology'' studies are currently underway in the Milky Way (e.g. RAVE, SEGUE) and others are being planned (e.g. GAIA, SIM); the aim is to provide complementary information to that obtained for samples of galaxies in the distant field by observing the Milky Way to a degree of detail that is beyond reach in studies of the distant universe. The satellites of the Galaxy, Andromeda, M33 and others are also currently under close scrutiny.
However, since merging is a stochastic process, studies of the Local Group are not sufficient, and it will be necessary to investigate a substantial sample of galaxies to place findings of the Milky Way into context and to make statistical comparisons to theory and models.
A thorough understanding of galaxy formation therefore requires us to extend such surveys to encompass galaxies over a range of masses, environments and morphological types. This requires kinematic information, in the form of radial velocities, and detailed information on the chemical composition, not only metallicities but abundance ratios for several elements so as to reconstruct the star formation and chemical enrichment histories of these galaxies.
t has also been possible to demonstrate that different galaxies have a different chemical evolution, probably as a consequence of different star formation histories (see for example Bonifacio et al. 2004, Pompeia et al. 2008).
A great deal of work still needs to be done in the

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Local Group (LG), and certainly the more distant members will require an ELT for this detailed analysis. However the Local Group does not display the full variety of morphological types which one would like to study, and in particular, no giant elliptical galaxy.
This implies that there is a strong motivation to extend this kind of studies to galaxies in nearby groups.
As a by-product it will be also interesting to compare the properties of LG galaxies to those of galaxies in other groups, to look for differences and similarities.

The two most promising targets for this are the Sculptor group, at a distance of about 2 Mpc and the Cen A group, at a distance of about 4 Mpc.

The Cen A group of galaxies is the most prominent association of bright galaxies in the southern sky. Its dominant galaxy NGC 5128 (also called Cen A, giving the name to the group) is a giant elliptical galaxy (it is also a peculiar radio galaxy and a Seyfert 2 galaxy) which probably offers us the best opportunity for a detailed study of a galaxy of this type.
Our goal is therefore to obtain metallicities and kinematics of stellar populations in the halo of NGC5128 (Cen A).

The target selection can be obtained from HST photometry which is already available (Rejkuba et al. 2005), supplemented with further data to be acquired. For this proposal we relie on a simulation of the galaxy.
we first produce a catalogue of stars with appropriate characteristics for a given star formation and chemical evolution history, initial mass function, surface brightnesses and distance modulus with a code (developed by J.Liske and E.Tolstoy in the context of the Design Reference Mission for the E-ELT) which uses BaSTI stellar evolution tracks (http://193.204.1.62/index.html).

We modelled the stellar population in Cen A by assuming a constant star formation rate from 10 Gyr ago to 6 Gyr ago and a chemical composition with a mean metallicity [M/H]= -0.6 (Rejkuba et al. 2005} and a +0.4\,dex enhancement of the alpha elements.
For the velocity dispersion of the galaxy we used 100 \kms, as suggested by studies of its globular clusters system (Woodley et al. 2007). We used a distance modulus m-M=27.92 (Rejkuba 2004) and a de Vaucouleur brightness profile in V-band with R_e = 330''''''

(van den Bergh 1976).

We explored several radii, 3.5, 5, 7, and 10, in units of R_e, which correspond to physical distances of aproximately 20, 30, 40 and 60 kpc, from the photocentre of the galaxy. The surface brightness in V-band corresponding to the above radii is of 25.2, 26.3, 27.4, 28.7 mag/arcsec2.

For each of the explored radii we used the model to create a stellar catalogue of the stars in a surface of 5""""x 5"""", to match the surface brightness. It is clear that each of these catalogues is only a possible realisation of a portion of the galaxy. For each of the stars we generated a spectrum which was fed to the OPTIMOS-EVE simulator. Each spectrum was generated by searching the Munari et al. (2005) synthetic stellar library at R=20000 for the spectrum with the closest characteristics (log g, T_eff, [M/H], [alpha/Fe]) to each of the stars in the catalogue. We then rescaled the spectrum for the apparent V magnitude of the star and corrected it by its Doppler shift. At 7 R_e we find 2 targets brighter than I=25. The simulated spectrum with the lowest resolution of OPTIMOS-EVE resulting from 50 1h integrations attains a S/N ratio of 8. ns of 1 hour each and the final S/N ratio is 8. With such a spectrum we can measure the radial velocity with an accuracy of a few \kms. The CaII lines are not the only ones discernible in the spectrum, there are many FeI and TiII. At this very low S/N ratio one may, nevertheless, obtain a metallicity estimate from the spectrum, to within a factor of 2. The high multiplex of OPTIMOS-EVE ensures that in the 50 hours of integration at least 250 spectra can be acquired (still leaving about 100 fibres to sample the sky background). The stars may be sorted in bins of similar effective temperature and gravity (from the colours) and metallicity (from the spectra) and the spectra within each bin may be stacked, a stack of 10 spectra should obtain an S/N ratio around 24, and from this an estimate of the [alpha/Fe] ratio may be obtained.

In summary, our simulated observations show that it is feasible to sample the kinematical and basic chemical information of stellar populations at various distances from the center of Cen A from 30 to 100 kpc. If we immagine selecting 8 such fields (400 hours of integration), with an average of 250 targets/field (the other fibres being used to adequately sample the background) we would end with 2000 stars which will afford a clear description the chemodynamical state of the old populations of Cen A.

References

Bonifacio, P., Sbordone, L., Marconi, G., Pasquini, L., & Hill, V. 2004, A&A, 414, 503

Pompeia L., Hill V., Spite M., et al. 2008, A&A 480, 379

Rejkuba, M. 2004, A&A, 413, 903

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1.1- Project Title: The architecture of planetary systems - including Earth-mass planets in the habitable zones - with age

1.2- Project Category: 3

1.3- Abstract:
Planets orbiting stars are common and hundreds of them are already known around an heterogeneous sample of field, mature stars of different metallicities and poorly-constrained ages. Here, we propose to investigate the architecture of planetary systems with parental stellar mass in the range 0.3-1 Msol and planets of 1 Earth-mass up to super-Jupiters by exploring the surroundings, including the habitable zones of many targets, of 400 fully-proved star members of the Pleiades (125 Myr) and Hyades (625 Myr) open clusters. Characterizing planets around cluster stars will provide unique constraints on the planet-mass dependence on stellar size for stars of constant age and metallicity that share a common birth and early dynamical evolution. Additionally, our results will be compared with the properties of the older "field" planetary systems to provide an evolutionary picture of the planet orbits as a function of the planet and star masses in the wide age interval 100 Myr to sever
al Gyr.

1.4- Publication agreement: yes

2.1- PI: M. R. Zapatero Osorio

2.2- CoIs: R. Rebolo (IAC), E. Pallé (IAC), V. J. S. Béjar (IAC), C. Eiroa (UAM), J. A. Caballero (UCM), D. Barrado y Navascués (LAEFF-CAB), I. Ribas (IEEC-CSIC)

2.3- Institute: IAC

2.4- Country of Employment: ES

2.5- Career Stage: faculty

2.6- E-mail: mosorio@iac.es

3.1- Source of targets: Published catalogues of stars in the Pleiades and Hyades open clusters

3.2- Preparatory work on targets required?: yes, e.g. precise photometry, radial velocity survey

3.3- Target brightness: 7, 16.5, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 400

3.6- Density of targets: ?

3.7- Target coordinates: RA:3 - 4;Dec:14 - 17, RA:3.5 - 4.5;Dec:20 - 30

3.8- Moving target?: no

3.9- Variable target?: yes, 9 per year

3.10- Target type: star

4.1- Spatial resolution: seeing, 2-3

4.2- Field-of-view: 2x2arcsec

4.3- Multiplexity and pick-off FoV: 1, 2x2arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: 400 - 1800

5.2- Spectral Resolution: 50000-100000, >100000

6.1- Instrument: CODEX, SIMPLE

6.2- Desired special mode: special calibration, radial velocity precision of 1 cm and 100 cm

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.5, 1, N/A

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 300

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 90

7.6- Are the observations time critical?: yes, Individual spectra have to be taken weeks aparts.

8.1- Does the execution of observations require real-time decisions?: yes, we need to check the s/n of the data, N/A

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8.2- Would you welcome remote observing capabilities?: yes, Checking the data in real-time

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, VLT/VLTI, also synergy with GTC, Keck, Subaru.

9.2- Critical aspects / limiting factors for the science case:
Very stable, high-resolution spectrographs (optical and near-infrared) are required for this program.

9.3- Detailed description or other comments:
In recent years, a plethora of planets have been found orbiting mature stars of the solar neighborhood: more than 340 planets in ~270 planetary systems as in May 2009 (http://exoplanet.eu/catalog.php). Simultaneously, enormous progress has been made in our understanding of the mass and orbital properties of these planets (Udry & Santos 2007; Butler et al. 2006). Furthermore, the finding of transiting planets (planets passing in front of and back of the stellar disk) has largely contributed to the knowledge of the planetary atmospheres through detailed observations of the primary and secondary transits (e.g., Charbonneau et al. 2002; Tinetti et al. 2007; Swain et al. 2008). Because of an observational bias (most planet-search techniques are more sensitive to massive planets in rather close orbits - less than 5 AU), the great majority of the planetary discoveries are related to Jupiter-mass bodies with quite hot (sometimes inflated) atmospheres because they receive great quanti
ties of stellar irradiation. These planets orbit quiet, Main Sequence, low-rotation solar-type stars with typical spectral types G and K. Only recently, searches have expanded the stellar sample to less massive (early-M) and more massive (F-type and giant GK) stars with great success (e.g., Pasquini et al. 2007; Bonfils et al. 2007): for example, multiple planets with a mass slightly above that of Earth are found around the M3V star GJ\,581 (Mayor et al. 2009). A picture is emerging where (i) planetary systems posses a large variety of properties (Santos et al. 2005), (ii) metallicity may play a role on the planet formation (the rate of massive planets in close-in orbits tends to be higher for metal-rich stars, Sozzetti et al. 2009), and (iii) lighter stars appear to host less massive planets (see Fig.~1).

Yet, all these properties are derived from an heterogeneous sample of stars with a mixture of mature ages (typically >1 Gyr) and metallicities. Furthermore, these findings provide the final view of the planetary systems architecture while the stars lie on the Main Sequence, and because the parent stars may have formed in different environmental conditions, it is difficult to elucidate the planetary system evolution (and possible formation) from observations of "field" stars only.

We propose here to investigate the planetary systems of two nearby open star clusters, which may offer unique opportunity to understand the planet mass - star mass relationship, if any, and the architectural evolution of the planetary orbits for a wide range of parental stellar masses and planet sizes. By studying an homogeneous list of stars in open clusters we can strictly control the sample since all cluster stars are supposed to have formed coevally, with the same chemical composition than the parental molecular cloud, and evolved under similar enviromental conditions, which may have an impact on the architecture and evolution of planetary systems. Additionally, the detection of chemical peculiarities in planet-hosting stars belonging to a particular cluster with respect to other cluster members would be a direct proof that planet pollution/engulfment is at work. These comparisons are much more uncertain in field stars.

Two clusters are ideal for these tasks: the Pleiades and the Hyades. Both are young (with two distinct ages) and nearby (125 Myr, 120 pc - the Pleiades; 625 Myr, 45 pc - Hyades), and have a numerous (>1000 and >400 stars), very well known stellar population, which is confirmed by means of photometric diagrams, radial velocity and proper motion studies. The Pleiades shows a metallicity pretty much solar (Gebran & Monier 2008), while the Hyades is slightly metal-rich ([Fe/H]= +0.13, Paulson et al. 2003). Fortunately, these two clusters have been deeply explored for long and hundreds of Pleiades and Hyades stars are well characterized. Many comply with the required conditions (brightness, low activity, slow rotation) for taking advantage of the best performance of planet searches via the radial velocity method.

Presently, the radial velocity technique is among the most sucessful techniques for the detection of planets around stars: the great majority of the known exo-planets results from applying this method to the high-resolution optical spectra of bright stars. With the advent of the E-ELT, provided that this large telescope is equipped with stable, high-resolution optical and near-infrared spectrographs, a velocity accuracy of a few cm/s in the optical and <1 m/s in the near-infrared is expected. This will enable us to detect Earth-mass planets in the habitable zones of stars with magnitudes down to V = 12-13 mag (e.g., CODEX) and J = 13 mag (e.g., SIMPLE). The Earth imposes a velocity amplitude of 9~cm/s to our Sun at the orbital distance of 1 AU, and a velocity amplitude of 0.52 m/s to a 0.3-Msol star at 0.1 AU (in the habitable zone of the low-mass star). More massive planets inside, at, and outside of the habitable zones come for granted.

We propose to search for Earth-size to super-Jupiter planets inside, at, and outside of the habitable zones (up to a few AU) of two selected, homogeneous samples of 400 G--M-type stars belonging to the Pleiades and Hyades clusters by means of accurate radial velocity measurements. The total sample is approximately divided in 200 stars per cluster, a number sufficiently high to perform reliable statistics. Given the age and distance of Pleiades and Hyades, stars brighter than V, J ~ 13 correspond to a mass >0.15 Msol (Hyades) and >0.3 Msol (Pleiades), which show surface temperatures typical of stars warmer than mid-M. For such spectral types, it is already proven that the radial velocity technique is successful (down to an accuracy of less than 1 m/s as of today) provided the stars are single and show very little activity and slow rotation. Queloz et al. (1998) have obtained the rotational velocity of a large sample of Pleiads concluding that at least half of the cluster stars

in the mass range 1-0.5 Msol are slow rotators with vsini values of less than 10 km/s. Higher mass Pleiades stars are characterized by higher rotation rates and they are not ideal for our search. Among the Hyades population there are also many slow rotators for which the best performance of the radial velocity technique can be pursued with the E-ELT. The common stellar mass range for the Pleiades and Hyades for which radial velocity accuracies of ~1-100 cm/s can be obtained is 0.3-1

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Msol. It is possible to find a total of 400 Pleiades and Hyades stars in such mass interval that are not binaries and comply with the requirements of low activity and slow rotation. Cochran et al. (2002) and Sato et al. (2007) have started a radial velocity program with the Keck and OAO telescopes to search for hot-Jupiters around Hyades stars. We will take advantage of the results of those surveys and will focus ours on the less massive planets. Sato et al. (2007) has reported on the finding of
the first massive planet (msini = 7.6 Mjup) ever discovered!
in an open cluster; it happens to be a very bright Hyades star.

Our immediate goal is to identify and characterize the planetary population around these stars covering (i) a planetary mass range over two orders of magnitude: from planets as small as the Earth (0.00315 Mjup) to several times the mass of Jupiter, and (ii) the habitable zones of the majority of the target stars, which go from less than 0.1 AU to ~1 AU (orbital periods from weeks to ~1 yr). Observations must be appropriately scheduled to explore such large range of orbits, i.e., data must be taken in interval of days, months, and years for the longest periods. Candidates will have to be observed with a more detailed time coverage for deriving reliable orbital parameters and planet masses.

Our ultimate goal is to study and compare the orbital properties (e.g., eccentricity, semi-major axis, period) of all found planetary systems including the frequency of massive (Jupiter-like), intermediate-mass, and Earth-mass planets as a function of the stellar mass and orbital size for the two clusters. Furthermore, because this program explores the Pleiades and Hyades stars in a consistent manner and the target list is homogeneous in terms of metallic content and age, we may be able to tackle for the first time the impact of the presence of Jupiter-mass planets on the formation of the smallest planets.

All this knowledge will be compared between clusters and also with the planetary systems of the field to address the architectural evolution of the systems in the age interval 100 Myr to several Gyr. We note that at the age of 400--700 Myr (quite close to the Hyades age) our Solar System may have experienced a dramatic change in the orbital distribution of the massive planets since it is believed that the gas giants Jupiter and Neptune migrated in orbit at this time, causing millions of objects in the asteroid belt and the Kuiper belt to be ejected or thrown away toward the inner regions of the system. In this respect, the Hyades is a unique cluster to investigate the architecture of planetary systems at the age of several hundred Myr. By the time the E-ELT operates normally, several ground-based projects (e.g., HARPS-NEF on the WHT, ESPRESSO on the VLT) are expected to have provided the discovery of Earth-mass planets around the brightest field stars of mass similar to that
of our program. Only the E-ELT will be capable of exploring the presence of Earth-size planets in the habitable zones of 0.3-1 Msol Pleiades and Hyades stars. Therefore, the comparison between clusters and the field can be complete for the entire stellar (0.3-1 Msol) and planetary (1 Earth to super-Jupiters) mass ranges and for a wide interval of orbital sizes, including the habitable zones of the majority of the stars.

Regarding future space missions, they will be useful to enlarge our knowledge on the massive planetary population. GAIA (to be launched in December 2011) will be able to detect long-period,

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massive planets using microarcsecond-precision astrometry of stars with V < 13 mag (including the Pleiades and Hyades). With the E-ELT we will detect the short-period planets more rapidly and easily than the long-period ones. PLATO (if finally aproved) and GAIA will provide detections of planet transits in those cases where the geometry of the planetary systems is favorable. This only represents a small fraction (<10%) of the total planetary population, and may be insufficient for a reliable comparison of the planetary systems properties between clusters and the field.

References.

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Tinetti, G., et al. 2007, Nat, 448, 169.
Udry, S., & Santos, N.C. 2007, ARA&A, 45, 397.

1.1- Project Title: Characterizing the atmospheres of transiting rocky planets within the habitable zone of M stars

1.2- Project Category: 4

1.3- Abstract:

We propose the follow-up observations and atmospheric characterization of previously known transiting rocky planets around M-stars. Visible and near-infrared medium-to-high resolution spectra of the in transit and out of transit star+planet system will be observed, and from their ratio measurements, the transmission spectrum of the planetary atmosphere will be obtained. Our recent characterization of the Earth""""s transmission spectrum has shown that most of the major

atmospheric constituents present strong absorption features. These includes the important atmospheric bio-markers water, oxygen and methane (as seen in combination). Our simulations using the empirical Earth""""s transmission spectrum, and the observed stellar spectra for a variety of stellar types, indicate that the E-ELT is capable of retrieving the transmission spectrum of an Earth-like planet around an M-star. This will require to co-add observations during several transits to a total of 25 hours of
in transit data, plus another 25 hours of out of transit data

1.4- Publication agreement: yes

2.1- PI: Enric Palle

2.2- CoIs: I. Ribas, M.R Zapatero-Osorio, R. Rebolo, G. Tinetti, F. Selsis, D. Barrado, S. Udry, A. Garcia-Muñoz

2.3- Institute: Instituo de Astrofisica de Canarias

2.4- Country of Employment: ES

2.5- Career Stage: postdoc

2.6- E-mail: epalle@iac.es

3.1- Source of targets: KEPLER, CoRot, PLATO?, Ground-based surveys?

3.2- Preparatory work on targets required?: yes, pre-indentification of suitable targets by transit and RV measurements

3.3- Target brightness: 8, 12, Vegamag, V

3.4- Target size: point source, 0.1, 1

3.5- Number of targets: 1 to 5

3.6- Density of targets: -

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: exoplanet

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4.1- Spatial resolution: seeing, 2-3

4.2- Field-of-view: 2x2arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 300 - 2500, 2500 - 15000

5.2- Spectral Resolution: 500-1000, 1000-2000, 2000-3000

6.1- Instrument: EAGLE, CODEX, HARMONI, METIS, OPTIMOS

6.2- Desired special mode: precision photometry, high time-resolution, other, High stability

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 20, 25, average seeing, several airmasses, Moon out of the field of view

7.2- Longest continuous observation time on a target or field: 4

7.3- Shortest integration time on a target or field: 180

7.4- Total time: 55

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 100

7.6- Are the observations time critical?: yes, Observations during a transit venet, but with an ample range of opportunities to choose from

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, other, KEPLER, CoRoT, PLATO?

9.2- Critical aspects / limiting factors for the science case:
Ultra-stable low-to-mid resolution spectroscopy

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9.3- Detailed description or other comments:
Since the discovery in 1992 of the first planet outside the solar system (or exoplanet), the number of planet detections is increasing exponentially. Based on HST high-precision spectrophotometric observations of four planetary transits of HD 209458, Charbonneau et al (2002) detected the absorption from sodium in the planetary atmosphere. Richardson et al (2007) reported the first extrasolar planet infrared spectra (7.5-13.2 um), of the transiting HD 209458b. Using Spitzer and this same methodology Tinetti et al (2007) and Swain et al (2008) have recently reported the presence of water and methane, respectively, in the atmosphere of the extrasolar planet HD189733b. Recently, the optical and near-infrared transmission spectrum of the Earth, was obtained during observations of a lunar eclipse (Palle et al, 2009). It was found that some of the Earth""""s weakest atmospheric features become much more prominent than in the reflected spectrum. Moreover, the fingerprints of the
Earth´s ionosphere and of the major atmospheric constituent, N2, which are missing in the reflected spectrum are also detectable. These results indicate that the technique of transit spectroscopy of rocky planets will be a much more powerful tool for atmospheric characterization than the preceding modelling efforts predicted.

Many discoveries of Earth-size planets are expected in the next decades, and some will be located in the habitable zone of their parent stars. Obtaining their atmospheric properties will be highly challenging, but the greatest reward will happen when one of those planets shows a spectrum like that of our Earth. This proposal tries to fulfill this challenge. Here we propose the follow up of previously know transiting rocky planets around low-mass M stars. The E-ELT, however, is not envisioned as a transit planet-hunting tool. Thus, transiting rocky planets will need to be fed to E-ELT by other observing programs/missions.

There are presently two space mission capable of finding rocky planets around relatively bright M-type stars: CoRoT and KEPLER. Among the two mission, KEPLER is the best situated to provide suitable targets for the E-ELT (the possibility that CoRoT also finds a suitable target cannot be ruled out, but it is statistically very unlikely). KEPLER will survey thousands of stars for transits in a in the Northern Cygnus arm of our Galaxy. It is expected that KEPLER will retrieve between 50 and 640 terrestrial inner-orbit planets, depending on the size (and radius) distribution of these planets. To confirm the planetary nature of the KEPLER candidates RV follow-up observations can be conducted from the northern hemisphere with the upcoming HARPS-NEF instrument at the WHT. While most of the targets will be around G and K stars, if only 1 or 2 candidates are found around a M star, it would immediately become a candidate for our proposal. The space-based mission Plato, which migh be co
ntemporary to the E-ELT could also statistically find a suitable target, but the mission has not been approved yet. Ground-based searches for transiting rocky planets can also provide confirmation of a suitable candidate, at the moment however, there is not a clear roadmap to find small rocky planets around M stars with the present searches. In the foreseeable future, the James Webb Space Telescope (JWST) will be another great tool to characterize extrasolar planets trough transit spectroscopy. However, although the JWST would be able to do a rough characterization of a

transiting super-Earth around an M star, this is only true for the closest M stars (within 10-20 pc), which statistically rules out the KEPLER targets. Thus, the E-ELT will be the most suitable instrument to do the KEPLER follow-up.

The immediate objective of this proposal is to characterize the possible atmosphere (and surface, depending on cloudiness) of any transiting rocky planet within the habitable zone of an M-star. In particular, late-type M stars are the most favourable to retrieve the planetary spectrum, other spectral type parent stars make this observations too difficult even for the E-ELT.

The characterization of the major molecular species of the atmosphere can lead to a complete understanding of the chemical composition, formation and evolution of the planet. In some cases, if the conditions are right, the spectrum can lead to the detection of biological activity in the planet, i.e. a proof for life outside the solar system.

To retrieve the planetary spectra, our aim will be to take hundreds of individual spectra of the star +planet system in and out of transit. The spectra will have typical exposure times of just a few minutes. These individual spectra will need to be combined in in and out of transit pairs to get their ratio spectrum. In turn, these resulting ratio spectra will need to be co-added for several transits until a sufficient S/N ratio is reached. Our calculations, base on the E-ELT on-line tools, indicate that about 25 hours integration time (or 10-15 transits) of in transit and out of transit data are necessary to reach this goal. The rotational period of late-type M dwarfs ranges from a few hours to a few days, with possible planetary transits lasting on the order of hours. This means that transit events in our targets could happen almost every night, and the necessary S/N ratio of our observation could be reach within 1 month of observations.

By definition, all the E-ELT observations will be measuring the spectral features of an Earth-like planet: Earth itself. Thus, the major challenge for this proposal is to accurately account for the telluric spectral features of the Earth"""'s atmosphere. Each individual spectrum will need to be decontaminated of the local atmospheric signatures in order to avoid false positive detections. Luckily, because of their different geometries, there are some spectral features that are different for the Earth"""'s globally-averaged transmission spectrum and the telluric spectrum of the local atmosphere on top of the telescope (Zapatero-Osorio & Palle, in preparation). We are hoping to use these spectral features, in combination with standard calibration techniques, as a control test to improve our decontamination and to make sure that the final retrieved spectrum is not a telluric contamination.

1.1- Project Title: Galactic Archaeology: Unravelling the assembly history of the Milky Way with nucleochronometry

1.2- Project Category: 2

1.3- Abstract:
he radioactive elements offer a unique opportunity for the direct age determination of individual stars.
The measure requires high resolution and high S/N ratio, since the error on the derived age is very sensitive on the error on the measured abundance.
CODEX at the E-ELT will be capable of providing measures of radioactive and reference elements with errors of 0.03 dex, corresponding to a 2Gyr error on the age of an individual star.
We propose to use CODEX to measure the age of 100 halo giants with metallicity ~ -3.0, this will provide the age of the formation of the Galactic Halo with an accuracy of 0.2Gyr.
Any observed spread in eccess of this would testify an age spread within the Halo.

1.4- Publication agreement: no

2.1- PI: Piercarlo Bonifacio

2.2- CoIs: Luca Pasquini

2.3- Institute: Observatoire de Paris

2.4- Country of Employment: FR

2.5- Career Stage: faculty

2.6- E-mail: Piercarlo.Bonifacio@obspm.fr

3.1- Source of targets: HK-Survey,HE Survey, SDSS

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 12, 15, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: seeing, 0.9"

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 10, 3600

5.1- Wavelength range: 370 - 670

5.2- Spectral Resolution: >100000

6.1- Instrument: CODEX

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 2, 0.8

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 1

7.4- Total time: 600

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

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8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
The resolution should not be lower than 120000 and it should be possible to attain S/N=1000

9.3- Detailed description or other comments:
The understanding of the way galaxies were assembled is one of the key problems of modern astrophysics. Cosmological simulations show how this can happen through hierarchical merging. Observationally we still have few constrains on this phenomenon, even for the Milky Way.
One of the key physical parameters to be determined are the time-scales on which the different pieces of a galaxy are assembled.
The Milky Way consists of four components:
Halo, Bulge, Thin Disc, Thick Disc.
The absolute and relative ages of these components and the time interval for the formation of each of them are subject to a very active research.
This in fact is one of the main objectives of the GAIA satellite (Turon et al. 2008).
The accurate parallaxes measured by GAIA will allow to construct Hertzsprung-Russel diagrams for the different populations. Interpretation of these diagrams with theoretical isochrones will allow to determine ages.

An independent avenue to age determinations is offered by the technique of radioactive dating, the so-called nucleocosmochronometry.
The basic technique is the same when dating meteorites (Tilton, 1988) or stars (Butcher, 1987) and relies on comparing the present abundance ratios of radioactive and stable nuclear species to the theoretically predicted ratios of their production.
The only radioactive nuclei with a long

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enough lifetime for astronomical application,
and relative ease of observation
are 232Th (mean lifetime 20.3 Gyr)
and 238U (mean lifetime 6.5 Gyr).

Any sample of radioactive nuclei decays according to the exponential law.
If the the mean lifetime (tau) and the
the initial and present number of nuclei are known, one can obtain the time
interval that has elapsed since the nuclei were produced.
In practice, to use the decay
processes to determine an age, one measures the present number of nuclei of the
unstable species (n_X) relative to the number of nuclei of a stable element
(n_R) which is related to the number of unstable
nuclei initially produced (n_{X0}).
One assumes that the two nuclei have a common
nucleosynthetic origin and that
n_{X0} is simply proportional
to the number of nuclei of the stable species,
n_R.
The proportionality constant is called the ``production ratio''''''.
It is possible to compute the error in derived age stemming
from the errors in the measured abundances of the radioactive
and reference element.
All radioactive
elements (Th and U) and the reference elements (Eu, Hf,...)
are observed as ionised species and have similar
line formation properties. This means that abundance
errors due to inaccurate atmospheric parameters (Teff, log g,...)
cancel out to a large extent, when considering
the abundance ratio X/R.
For Th the mean lifetime tau = 20.3Gyr, assuming an error on the
abundance of 0.03 dex, we have an error of ~2Gyr on the age
of an individual star, which is
slightly larger, but comparable with the accuracy of the age
estimate obtained by using stellar evolution theory for open clusters
(Grundahl et al. 2008).

The age of the Halo
is currently constrained by the ages
of the Globular Clusters, which can be determined
in several ways, among which
main sequence fitting and the white
dwarf cooling sequence are probably the most accurate.
The oldest clusters show an age of ~13.8 Gyr

while some clusters may be 2 to 3Gyr younger (Gratton et al. 2003). The best age determinations have an accuracy of ~1Gyr. It should however be noted that it is customary to find in the literature ages which differ by several Gyr, for the same Globular Cluster, based on the same technique (e.g. MS fitting), but different photometry, reddening, metallicity and theoretical isochrones.

The most metal-poor Globular Clusters have a metallicity ~-2.5. In contrast the field Halo population extends down to a metallicity of ~ -4.0, at least. The age of this metal-weak tail of the Halo is poorly constrained. The determination of the age of a field star is always difficult. In order to estimate the age of the metal-weak Halo we can measure with cosmochronometry, the age of 100 giants of metallicity <= -3.0, the mean age of the sample should provide an estimate of the age of the Halo with an accuracy of 0.2Gyr. A spread in the measured ages significantly above this value would be an indication that the metal-weak Halo formed over a period of time larger than 0.2Gyr. The excess spread would directly provide an estimate of how long this period was.

This accuracy and number of targets is, in principle, within the capabilities of CODEX, provided S/N~ 1000 may be achieved. We simulated a CODEX observation of the metal-poor giant CS 22873-055 (metallicity ~ -3, Cayrel et al. 2004), assuming a Th abundance A(Th)=-2.89 (The solar Th abundance is 0.08; Caffau et al. 2008). The star has a visual magnitude V=12.65, the E-ELT ETC (http://www.eso.org/observing/etc/bin/elt/elt/script/eltsimusp , the ETC provides a maximum resolution of 100000, however the S/N for higher resoltuion can be obtained by scaling the S/N provided by the ETC for R=100000 by a factor \sqrt{(R/105)}.} in spectroscopic mode, for a resolution R=120\,000 and seeing limited mode (0.8" seeing) provides S/N ~1000 for a 1h integration. About 50 halo giants with metallicity <= -3 are already known and studied with high resolution

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spectra, so that their atmospheric parameters are well known. It is foreseeable that at least as many will be known by the time CODEX is built, through the exploitation of existing or on-going surveys of metal-poor stars. We may consider interesting targets for our purpose those down to V=15.
If we assume that on average we will need 6 hours of integration for each star, to reach the required S/N ratio, the observation of 100 targets takes 600h, i.e. 75 nights, a conceivable target in 4 or 5 years of observation.

References

Butcher, H. R., ``Thorium in G-dwarfs as a chronometer for the Galaxy"""", 1987, Nature 328, 127

Caffau, E., Sbordone, L., Ludwig, H.-G., et al., ``The solar photospheric abundance of hafnium and thorium. Results from CO5BOLD 3D hydrodynamic model atmospheres"""", 2008, A&A, 483, 591

Cayrel, R., Depagne, E., Spite, M., et al., ``First stars V - Abundance patterns from C to Zn and supernova yields in the early Galaxy"""", 2004, A&A, 416, 1117

Gratton, R. G., Bragaglia, A., Carretta, E., et al., ``Distances and ages of NGC 6397, NGC 6752 and 47 Tuc"""", 2003, A&A, 408, 529

Grundahl, F., Clausen, J.~V., Hardis, S., & Frandsen, S., ``A new standard: age and distance for the open cluster NGC 6791 from the eclipsing binary member V20""""

Tilton, G.~R., ``Principles of radiometric dating"""", 1988, in Meteorites and the Early Solar System (eds. Kerridge, J. F. & Matthews, M. S. Univ. Arizona Press, Tucson, p.249

Turon, C., Primas, F., Binney, J., et al., ``Galactic Populations, Chemistry and Dynamics"""", 2008, ESA-ESO Working Groups, Report No. 4

1.1- Project Title: Taxonomy of the formation of Low Mass Objects: from the Local Bubble to the Perseus Arm

1.2- Project Category: 3

1.3- Abstract:

One of the most important astrophysical phenomena which is needing a comprehensive explanation is star formation, specially in the low-mass range, down to substellar masses, specially in an environment as different as the Perseus Arm, located beyond 2 kpc, when compared with the Local Bubble. This E-ELT proposal deals with this issue and several specific questions: i) evolution of Young Stellar Objects, specially for Very Low Luminosity Objects, and those having also very low mass. ii) Protoplanetary disk properties (accretion, ices and grains) and evolution. iii) Multiplicity in very low-mass, very young objects. Observations done at different wavelengths and taken with different techniques would provide (together with the data in the literature) an uniform database, a requirement for accurate classification of Young Stellar Objects. Spectral features available such as H(alpha), Br(gamma), CaII IRT (stellar classification, accretion and age indicators) in the optical, and

on the other hand PAH, ices and silicates from the disk in the mid-IR will allow to link stellar and disk evolution. Multiplicity and disk morphology in young, embedded objects will be tackled with mid-IR imaging. Here we propose to create a platform of observational data, complemented with theoretical interpretation, on which a sound paradigm for the stellar and brown dwarf formation and early evolution can be built.

1.4- Publication agreement: yes

2.1- PI: David Barrado y Navascués

2.2- CoIs: Bayo, Bouy, de gregorio, Dent, Duchene, Eiroa, Fernandez, Hodgkin, Huelamo, Isella, Joergens, Kamp, Lopez-Marti, Maldonado, Menard, Melo, Mendigutia, Morales-Calderon, Mora, Moro-Martin, Palau, Pinte, Riviere, Santos, Solano, Stelzer, Sterzik

2.3- Institute: LAEX-CAB, Centro de Astrobiologia, INTA-CSIC

2.4- Country of Employment: ES

2.5- Career Stage: faculty

2.6- E-mail: barrado@laeff.inta.es

3.1- Source of targets: GTC, Spitzer, IRAM, Subaru, VLT, VISTA, UKIRT

3.2- Preparatory work on targets required?: yes, wide survey

3.3- Target brightness: 1e-5, 1e-3, mJy, J

3.4- Target size: point source

3.5- Number of targets: 300

3.6- Density of targets: N/A

3.7- Target coordinates: RA:20 - 6;Dec:-15 - +70

3.8- Moving target?: no

3.9- Variable target?: yes, N/A

3.10- Target type: star

4.1- Spatial resolution: 100, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 600 - 20000, V, R, I, J, H, K, L, M, N, Q

5.2- Spectral Resolution: 300-500, 2000-3000, 10000-20000

6.1- Instrument: EAGLE, MICADO, HARMONI, METIS, OPTIMOS

6.2- Desired special mode: precision photometry, coronography, N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.1, 3, 0,8 arcsec, 1.15 AM

7.2- Longest continuous observation time on a target or field: 3

7.3- Shortest integration time on a target or field: 360

7.4- Total time: 300

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, VLT/VLTI, SKA/SKAPF, other, IRAM, GTC

9.2- Critical aspects / limiting factors for the science case:
No critical factor

9.3- Detailed description or other comments:
Few years ago, Andre et al. (1999) discovered the first Class 0, very low luminosity protostar in Taurus. Later on, Kauffmann et al. (2005) presented an object with Lum<0.1 Lsun, which could be the first Class 0 substellar object. In this same association, about 1 Myr old, Class II (CTTs) and Class III (WTTs) objects can be found, with very different Spectral Energy Distribution, despite the fact they should be coeval. Spitzer observations have revealed that some of these Class III stars have transition disks (Calvet et al. 2005), which present a large cavity between the star and the internal edge of the disk. Nowadays, there is a significant number of coeval, low luminosity objects in several star forming regions which have very different properties. The classification by Lada et al. (1987) suggests that there is a monotonic evolution Class 0 to Class II phase in less than 1 Myr. However, the fact that a very well-known association such as Taurus contains Class 0, I , II and III objects argue against this simple scenario. We propose to revisit the problem with a holistic perspective, with a wide wavelength coverage. Moreover, we need to extent our detailed

star formation studies away from the solar neighborhood. The Perseus Arm, located beyond 2 kpc, is an ideal hunting ground, which avoids the much larger confusion present in the galactic center direction.

GOALS:

i) The central object.-
The spectral typing can be achieved with low-medium resolution in the optical. However, the presence of accretion might hinder the classification, since the excesses, together with veiling change both the spectral shape and the depth of the spectral features. Moreover, the classification is even more complicated for embedded objects, since they might be not detectable in the optical or even at near-IR the confusion with the medium might be very important. Mid-resolution spectra are required for a more sophisticated analysis, such as the surface gravity (and, hence, the true age), which can be estimated with several alkali doublets detectable at red and near-IR wavelength. Problems associated to veiling can be overcame using several of them at different bands.
Diagnostics.- Low- and med-res spectroscopy, covering 0.5-1.0 micron only for objects detected at visible wavelengths (OPTIMOS type). Low- and med-red spectroscopy in the ZJHK bands for the whole sample (HARMONI/EAGLE type).

ii) The inner disk and the interaction with the central object: accretion, activity, outflows.-
The optical and near-IR spectroscopy will allow to study lines such as H(alpha), Br(gamma), Pa (beta), HeI6678, CaII IRT, and so on, appear at very different bands, from the optical to the near-IR. Some among them allow to study activity and accreting related phenomena. A similar, complete study in the near-IR is needed, in order to measure accretion rates for obscured objects by envelopes and disks (since the inclination factor might play an important role). Forbidden lines such as [OI], [OII] and [SII] are indicative of the presence of outflows, which are very important to regulate the initial evolution of angular momentum. Rapid rotators will be detected.
Diagnostics.- Med- and high-res spectroscopy, covering 0.5-1.0 micron only for objects detected at visible wavelengths (OPTIMOS type). Med- and high-red spectroscopy in the JHK bands for the whole sample (HARMONI/EAGLE type).

iii) The disk/envelope as a whole.- As clearly shown by different theoretical models, disk evolution is complex issue, even more difficult to tackle if an envelope is taken into account. Different parts of an envelope or a disk can be observe at different wavelengths and produce distinct, complementary phenomena. The stellar photosphere is mainly reachable in the optical; the near-IR opens a window to the disk, for the nearest parts to the star, as we move to longer wavelength, we have access to cooler, more distant parts of the disk. Therefore, only a multiwavelength approach can provide a complete picture of YSO evolution, since any missing piece of the puzzle might be crucial. This analysis is essential to locate any object in a HR diagram and to start to understand its properties (disk mass and size, inclination, etc). We note that models such as Robitaille et al. (2007) are able to fit SEDs, but with a significant number of free parameters. Among them, the disk inter

nal radius and inclination are reliable. In few cases, others such as geometry (flare or flat disk) and the grain size (large or small) can be estimated (Pinte et al. 2008). However, in order to reduce the degeneracy of model fitting, as many as possible SED datapoints (photometry or spectroscopy) are required (Bouy et al. 2008, Huelamo et al. 2007).
Diagnostics.- Complete SED, from the optical to mm wavelengths, for the whole sample.

iv) Ices, PAH and silicates at 10 micron.-
Boogert et al. 2008 conducted a study in 41 low-mass YSO, which show prominent absorption features present at mid-IR. Most of them were attributed to absorption in the vibrational modes of molecules in ices. At the low temperatures of dense clouds and circum-protostellar environments atoms and molecules freeze out rapidly on dust grains. For slightly more evolved objects, broad emission features in the mid-IR start to appear due to grains, whose size seem to grow and to adopt crystalline structures (Apai et al. 2004). As an example, Sicilia-Aguilar has found in the Coronet cluster that about 70% of the members do not show silicate emission or have flat features which should correspond to large grains. This might contradict the results by Furlan et al. (2006), who have been able to derive a classificatory scheme based on Taurus -ie, coeval- spectra. Finally, transition disks have been found and carefully studies using mid-IR IRS spectroscopy, at least in the case of Tau
rus (Calvet et al. 2005). Paradoxically, much older stars have similar properties. This is the case of the transition disks discovered in the 10 Myr cluster NGC7160, the age when stars are supposing to start assembling big planetesimals and Jupiter-like planets.
Diagnostics.- Low-res optical spectroscopy in the mid-IR (METIS-type instrument).

1.1- Project Title: Earth twins in the habitable zone of Solar-type stars

1.2- Project Category: 3

1.3- Abstract:
We propose in this program to probe the presence of Earth twins
in the habitable zone in a sample of 20 solar-type stars, through radial velocities obtained with the HRS on the E-ELT. Our scientific goals are: 1) to detect Earth-mass planets in the habitable zone around solar-type stars and thus build-up a list of suitable targets for future space missions aiming at

characterizing their atmosphere; 2) to determine the frequency of Earth twins around neighboring stars; 3) to derive statistical properties of
low-mass planets and 4) to characterize the multi-planet aspect of systems with Earth twins.

1.4- Publication agreement: yes

2.1- PI: Stéphane Udry

2.2- CoIs: Christophe Lovis, Dominique Naef, Luca Pasquini, the CODEX collaboration

2.3- Institute: Genva Observatory

2.4- Country of Employment: CH

2.5- Career Stage: faculty

2.6- E-mail: stephane.udry@unige.ch

3.1- Source of targets: HARPS, Hipparcos

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 5, 10, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 20

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - 0

3.8- Moving target?: no

3.9- Variable target?: yes, 3 per day

3.10- Target type: star

4.1- Spatial resolution: seeing, >3

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 380 - 680

5.2- Spectral Resolution: >100000

6.1- Instrument: CODEX

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 60, 80, seeing<=0.8"""", airmass<2, moon=grey

7.2- Longest continuous observation time on a target or field: 0.3

7.3- Shortest integration time on a target or field: 1

7.4- Total time: 1400

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 80

7.6- Are the observations time critical?: yes, Exact dates of observations do not matter. A correct temporal sampling is critical. A detailed observing scheme will be provided by us.

8.1- Does the execution of observations require real-time decisions?: yes, Real time choice of best target is a necessary., HARPS like pipeline producing science grade reduced data.

8.2- Would you welcome remote observing capabilities?: yes, Access to reduced data in real time.

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
The most critical aspect is the achieved radial-velocity precision. An ultra stable instrument with an ultra precise simultaneous wavelength calibration device. Apart from the instrumental precision, the choice of targets (ultra quiet stars) and the observing sampling are critical for allowing us to average out/damp astrophysical noise sources (p-mode oscillation, granulation, activity jitter).

9.3- Detailed description or other comments:

Here is the complete abstract of the related DRM proposal:

Five years of sub-m/s radial-velocity measurements of quiet stars in the HARPS-GTO planet-search programme have unveiled the tip of a large population of Neptune-mass and super-Earth planets present around about 30% of G and K dwarfs of the solar neighborhood, within 0.3 AU from the central star. These findings support recent results of synthetic planet-population models that, moreover, predict the existence of a large population of Earth-mass planets at all separations. We propose in this ambitious large program to directly probe the presence of Earth twins in the habitable zone in a sample of 20 close-by solar-type stars, through radial velocities obtained with the High-Resolution optical Spectrograph (HRS, e.g. CODEX) on the European Extremely Large Telescope (E-ELT). The high resolution and long term stability of HRS coupled with the large collecting area of the E-ELT provide an unequaled facility for
measuring stellar radial velocities at the few cm/s level. Simulations show, moreover, that stellar noise (p-mode, granulation, activity) can be averaged down to this level for the quietest dwarf stars. The scientific goals of the proposal are 1) to detect Earth-mass planets in the habitable zone around solar-type stars and thus build-up a list of suitable targets for future space missions aiming at characterizing their atmosphere; 2) to determine the frequency of Earth twins around neighboring stars; 3) to derive statistical properties of low-mass planets, priceless constraints for planet-formation models; and 4) to characterize the multi-planet aspect of systems with Earth twins.

1.1- Project Title: Protocluster formation, clusters discovered by ALMA through the Sunyaev-Zeldovich effect

1.2- Project Category: 2

1.3- Abstract:
Planck will make soon a census of high redshift candidate clusters with blind surveys exploiting the peculiar signal originated by the Sunyaev-Zeldovich effect. ALMA will perform follow up observations of those candidates and make additional pencil beam surveys to pick up the most distant ones. With all this information in hands it will be fundamental to infer the properties of these protoclusters studying their stellar populations and interstellar medium properties via infrared photometric and spectroscopic observations.

1.4- Publication agreement: yes

2.1- PI: Paola Andreani

2.2- CoIs: Carlo Baccigalupi, any other interested, Manuela Magliocchetti

2.3- Institute: ESO

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: pandrean@eso.org

3.1- Source of targets: ALMA, Planck

3.2- Preparatory work on targets required?: yes, ALMA follow ups of Planck + ALMA pencil beam surveys

3.3- Target brightness: 20, 24, ABmag, K

3.4- Target size: point source

3.5- Number of targets: 10

3.6- Density of targets: 10

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: N/A

4.1- Spatial resolution: 75, 3

4.2- Field-of-view: 1x1arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 2000 - 20000

5.2- Spectral Resolution: 1000-2000

6.1- Instrument: METIS

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6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 30, 100, N/A

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 1000

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, N/A

9.2- Critical aspects / limiting factors for the science case:
AO

9.3- Detailed description or other comments:
N/A

1.1- Project Title: Observing Titan''s surface and atmosphere activity

1.2- Project Category: 4

1.3- Abstract:

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Titan, real-scale laboratory of pre-biotic and abiotic organic chemistry, may help us understand the origin of the aminoacids needed for the apparition of life. But on Titan, methane should be consumed by this chemistry within tens of millions of years. We need to understand first the source of replenishement for the methane, and constrain the methanologic cycle on Saturn"s satellite. This goal can be achieved with high-resolution spectroscopy or IFS in the infrared, to both monitor the atmospheric phenomena (e.g. methane clouds) and retrieve the surface albedo that will allow us to comprehend the surface"s nature.

1.4- Publication agreement: yes

2.1- PI: Mathieu Hirtzig

2.2- CoIs: Athena Coustenis, Michel Combes, Eric Gendron

2.3- Institute: Observatoire de Paris - LESIA

2.4- Country of Employment: FR

2.5- Career Stage: postdoc

2.6- E-mail: mathieu.hirtzig@obspm.fr

3.1- Source of targets: VLT, IMCCE

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 9, 7, ABmag, I

3.4- Target size: extended source, 0.40, 0.45

3.5- Number of targets: 1

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: yes, N/A

3.9- Variable target?: yes, 6 per day

3.10- Target type: solar system body

4.1- Spatial resolution: diffraction, 100

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: I, J, H, K

5.2- Spectral Resolution: 20000-50000

6.1- Instrument: HARMONI

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.01, 0.1, N/A

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 24

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: yes, visiblity of target on the sky

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
The AO loop must be efficient since the target is supposed to be spatially resolved even though its size is roughly equal to the value of the seeing; high spectral resolution is peferable

9.3- Detailed description or other comments:

To recover information on Titan''s surface and atmosphere, we must use either or both of the two following methods:
1- integral field spectroscopy on Titan in the near infrared, to recover simultaneously images and spectra of all the resolved areas
2- close succession of narrow-band images (I to K bands) to localize the transient clouds, to adjust the spectroscope slit along on Titan''s diameter to recover subsequently spectra from both the cloud and the surface (see Negrao et al 2007 for an example achieved at the VLT in 2004)
The 24 hours of observation time asked should be distributed in 4 sessions of 6 hours over 16 days, to gather data from four different orbital phases.

1.1- Project Title: Detailed characterization of the galaxies with the most intense star formation at z=1-4

1.2- Project Category: 2

1.3- Abstract:
We propose to obtain 1-D and 2-D/AO (resolution lower than 50 mas) NIR spectroscopy for a representative sample of 500-1000 IR-bright galaxies at z=1-4 selected with the Spitzer, Herschel, SCUBA-2, and/or ALMA deepest surveys, all of them being extremely faint at optical (R>25) and NIR (K>22) wavelengths. These galaxies are known to dominate the SFR density of the Universe at z>1, and be an important phase in the early formation of the most massive galaxies in the downsizing scenario. Our main goal is obtaining robust estimations of parameters such as the stellar and dynamical mass, kinematics, SFR, metallicity, ages of the stellar populations, etc.. in a galaxy-by-galaxy basis. Exploiting the synergies with JWST and ALMA to also characterize the dust and gas properties, this project will be a giant step forward on our understanding of the formation of galaxies in a key epoch of galaxy evolution.

1.4- Publication agreement: yes

2.1- PI: P.G. Pérez-González

2.2- CoIs: G. Barro, I. Pérez-Fournon, J. Gallego, J. Cepa, I. Trujillo

2.3- Institute: Universidad Complutense de Madrid

2.4- Country of Employment: ES

2.5- Career Stage: faculty

2.6- E-mail: pgperez@astrax.fis.ucm.es

3.1- Source of targets: Mainly Spitzer and Herschel, and also SCUBA2, JWST and ALMA. May also be detected at faint photometric levels by VLT, Subaru, HST.

3.2- Preparatory work on targets required?: yes, Observations and cataloguing with Spitzer (done) and Herschel.

3.3- Target brightness: 23, 26, ABmag, H

3.4- Target size: extended source, 100, 400

3.5- Number of targets: 1000

3.6- Density of targets: >4

3.7- Target coordinates: RA:03:15 - 03:30;Dec:-27:45 - -28:00

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy, AGN

4.1- Spatial resolution: 50, 1

4.2- Field-of-view: 10x10arcmin

4.3- Multiplexity and pick-off FoV: 20, 1x1arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: 900 - 2500

5.2- Spectral Resolution: 1000-2000, 2000-3000, 3000-5000

6.1- Instrument: EAGLE, OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: MOAO

7.1- Integration time per target or field and per setup: 10, 20, AO, any sky brightness

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 600

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, other, Herschel

9.2- Critical aspects / limiting factors for the science case:
The science case need the largest collecting area and sensitivity in the NIR possible, <=0.05" angular resolution for MOS/IFU, FOV of 25-100 arcmin2. Multiplexing larger than 20.

9.3- Detailed description or other comments:
The redshift range between z=1 and z=4 is of special relevance in galaxy evolution. Indeed, it is now well established that the Universe had a period of high star formation efficiency 7-8 Gyr ago (at z>1), possibly lasting several Gyr. The cosmic star formation rate (SFR) density peaked at z~1, when it was approximately 10 times larger than at z=0 (Madau et al. 1996; Pérez-González et al. 2005; Hopkins Beacom 2006). An important fraction (>40%) of the total stellar mass density observed in galaxies today formed at z=1-4 (Dickinson et al. 2003; Perez-Gonzalez et al. 2008), just leaving ~10% of the current stellar mass content of the Universe to be formed at z>4. In addition, the formation of galaxies follows a "downsizing" scenario (Cowie et al. 1996): the most massive galaxies formed first at z>2-4, and rapidly (with high SFR efficiencies), being remarkably compact at z>2 (e.g., Trujillo et al. 2007), while the star formation in less massive

systems proceeds more steadily to lower redshifts in more extended structures (Heavens et al. 2004; Juneau et al. 2005; Pérez-González et al. 2005, 2008ab).

Most of the previous results were obtained with samples of galaxies selected in the rest-frame ultraviolet (UV) and optical (see also Steidel et al. 1996; Ferguson et al. 2000), and using SFR estimators strongly affected by dust extinction. Although the general picture seems secure, these two factors could still introduce significant biases. The conclusions from optical studies can be tested with surveys at wavelengths where the effects of dust extinction are negligible: in the infrared (IR) and radio. IRAS and ISO probed the local and intermediate-z Universe ($z<0.7$). They showed that galaxies with dust-enshrouded star formation (ultra/luminous IR galaxies: U/LIRGs) have undergone strong evolution from $z<0.7$ to $z=0$ (Flores et al. 1999; Franceschini et al. 2001; Chary & Elbaz 2001). At higher redshifts ($z\sim2$), sub-mm observations also revealed a population of dusty star-forming galaxies that are hardly detected in the UV/optical (Smail et al. 1997; Chapman et al. 2003).

More recently, the Spitzer/MIPS surveys at 24 micron have detected star-forming galaxies and AGN at $0<z<3$ (Le Floc"h et al. 2004; Egami et al. 2004; Alonso-Herrero et al. 2004), with a peak of detection efficiency at $0.5<z<2.5$. These surveys have shown that the cosmic SFR density is dominated by LIRGs at $z>0.5$, and (U)LIRGs play a leading role in the formation of galaxies at $z\sim2$ (Pérez-González et al. 2005, 2008a; Le Floc"h et al. 2005; Caputi et al. 2006, Daddi et al. 2007). Surprisingly, the LIRGs at $z\sim1$ already present spiral morphologies and do not seem to be directly linked to interactions/mergers compared to galaxies of similar mass or color (Shi et al. 2005, Marcillac et al. 2008).

Although we know of the importance of star-forming IR-bright galaxies in the process of galaxy formation at $z>1$ and we have already detected large numbers of them with Spitzer/MIPS and (sub-)mm surveys (roughly 4 sources/arcmin2 are detected by MIPS at 24 microns at $z>1$), we are still lacking a comprehensive characterization of their properties. The main reason is that a good fraction of them are very faint in the optical/NIR, beyond the photometric and (specially) spectroscopic observing capabilities of 8-10m class telescopes. Indeed, more than one third of the galaxies at $z>1$ detected by MIPS at 24 micron have $R>25$ and 75% of these have $K>22$, thus being too faint for currently available optical/NIR (single- and multi-object) spectrographs. The surface density of IR-bright sources detected at z>1 will be larger when the Herschel, SCUBA2, and ALMA surveys at 100-1000 micron are carried out. These new facilities will also be more effective than MIPS in detecting star-forming galaxies at z>2 (e.g., Franceschini et al. 2006). Remarkably, they will allow us to obtain extinction estimates for galaxies at z=2-4 in the low mass end of the stellar mass functions (e.g., Pérez-González et al. 2008a, Marchesini et al. 2009), i.e., for the building blocks in a hierarchical scenario.

Making further progress in our understanding of the formation of galaxies requires studying in detail the properties of the optically faint galaxies detected in the MIR-FIR, known to dominate the SFR density of the Universe at z>1 (contributing at least 50% to rho_SFR, Pérez-González et al. 2005). It is necessary to obtain robust estimations of the redshift (through integrated spectroscopy), the stellar and dynamical mass, kinematics, SFR, metallicity, ages of the stellar populations, etc for each galaxy in 2 dimensions (through IFU spectroscopic observations), accounting for the extinction effects, and to disentangle the frequency and properties of (un)obscured AGNs.

The properties outlined above could be inferred from 1-D and 2-D spectroscopic observations in the NIR centered at emission lines such as Halpha or [OII], once combined with ancillary data at UV and MIR/FIR wavelengths (see, e.g, Kennicutt 1998). UV observations alone are subject to uncertain extinction corrections, since the correlation between the UV slope and the attenuation is complex, depending strongly on parameters such as the stellar population age or the dust-stars relative geometry (Witt & Gordon 2000; Goldader et al. 2002; Kong et al. 2004; Burgarella et al. 2006). Halpha-Hbeta observations can be used to get more precise estimations of the extinctions. Alternatively, the combination of observed (not extinction corrected) UV and/or Halpha/[OII] SFRs and IR derived SFRs allows a consistent analysis of the star formation and extinction properties on a galaxy-by-galaxy basis, once each estimator is calibrated against the others (Kewley et al. 2003; Wu et al. 2005; Calzetti et al. 2005, 2007; Alonso-Herrero et al. 2006). The combination of several tracers (UV, Halpha or [OII], IR) gives the best SFR estimations, since it accounts for the photons coming from the newly-formed stars which do not interact with anything or are just scattered (detected in the UV), the photons that interact with the gas (reemitted through lines), and the photons that interact with the dust (reemitted in the IR). This method has been discussed for HII regions in M81 (Pérez-González et al. 2006) and M51 (Kennicutt et al. 2007), for nearby galaxies (Bell 2003; Iglesias-Páramo et al. 2006, 2007;

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Calzetti et al. 2007) including (U)LIRGs (Alonso-Herrero et al. 2006), and for distant sources (Hopkins & Beacom 2006).

Concerning stellar masses and ages, the best estimations based on stellar population modelling are subject to important uncertainties due to the effect of dust attenuation and the lack of knowledge of the star formation history (SFH) of each galaxy, and even due to the use of photometric redshifts (e.g., Kriek et al. 2008). The uncertainties can be diminished by using rest-frame NIR fluxes (probed by Spitzer/IRAC), which are less affected by dust extinction, as they usually trace the stellar population dominating the total stellar mass of galaxies. The emission-line fluxes (especially Halpha) can be used to constrain the SFHs (Charlot & Longhetti 2001; Pérez-González et al. 2003; Kauffmann et al. 2003), while the IR dust emission can be used to constrain the extinction in the models (e.g., Gordon et al. 2000). Dynamical masses measured with emission-line profiles and maps can be used to test the stellar mass estimates (e.g., Drory et al. 2004, Erb et al. 2005, Bundy et al. 2007) and the velocity field or dispersion (based on emission or absorption lines) for each object.

The feasibility and usefulness of NIR observations centered at Halpha or [OII] wavelengths have been demonstrated for UV-selected galaxies (Erb et al. 2006), Halpha-selected galaxies (Tresse et al. 2002) and a few tens of very bright IR-selected sources up to z~0.7 (Rigopoulou et al. 2000; Franceschini et al. 2003, Cardiel et al. 2003). There are also a few galaxies at z~2 with 2-dimensional Halpha maps obtained with VLT/SINFONI, all of them relatively bright (K<22), biased towards blue galaxies, and not representative of the IR-bright galaxy population (Forster-Schreiber et al. 2009). These galaxies present a great variety of dynamical properties (some are mergers, some are disks, some are extremely compact), all with similar SFR efficiencies (e.g., Pérez-González et al. 2008b), and they present typical sizes below 2-3 kpc (0.1"-0.4"; e.g., Buitrago et al. 2009). Currently, our detailed observations of z>2 galaxies are so scarce and biased that we still lack a clear picture of how galaxies form in the early Universe.

We propose to extend the detailed spectroscopic analysis of IR-bright sources to higher redshifts (z=2-4) and a wider range of optical/NIR/MIR luminosities with the study of a sample of 500-1000 IR-bright galaxies (sources with very intense and dusty starbursts, and enough of them to have statistically meaningful results as a function of important parameters such as stellar mass, SFR, activity, size, gas content), selected at 24-1000 micron with Spitzer, Herschel, SCUBA-2, and/or ALMA in some of the deepest cosmological fields (e.g., GOODS-N, GOODS-S, EGS, COSMOS, or UKIDSS UDS), being representative examples of those objects known to dominate the SFR density of the Universe at z>1 (contributing at least 50% to rho_SFR, Pérez-González et al. 2005).

E-ELT will be the only facility in the world to be able to do NIR integrated (with the OPTIMOS instrument) or AO/IFU (with EAGLE) multi-object spectroscopy for faint and small objects such as those in our sample (expected magnitudes: R=25-28, JHK=23-26; sizes below 0.5"). Exploiting the synergies with other future facilities, and combining the E-ELT maps with 2-D data from JWST and/or ALMA, we will be able to characterize in detail and simultaneously the stellar, dust and gas properties of z=2-4 galaxies with spatial resolution, and advance in our understating of the galaxy formation mechanisms in a key epoch in galaxy evolution.

1.1- Project Title: Stellar kinematics of z~1-2 star forming and active galaxies

1.2- Project Category: 2

1.3- Abstract:

The advent of 30-m class telescopes will streamline the measurement of stellar kinematics in galaxies at z~1, possibly up to z=2. This will enable the direct determination of stellar masses of galaxies at intermediate/high z, which can be compared with mass estimates of their black holes (derived from broad or narrow emission line kinematics), and mass estimates of their cold gas that remains for further accretion and star formation (derived from CO or H_2 lines). This will shed light on the types of galaxies that are formed from dusty, possibly interacting galaxies at the era of maximum QSO and star formation activity. For this reason, we will request NIR integral field unit datasets of recently discovered z~1-2 IR-bright systems to observe the CaII triplet stellar absorption lines.

1.4- Publication agreement: no

2.1- PI: Kalliopi Dasyra

2.2- CoIs: large collaboration

2.3- Institute: Spitzer Science Center / CEA Saclay

2.4- Country of Employment: other

2.5- Career Stage: postdoc

2.6- E-mail: dasyra@ipac.caltech.edu

3.1- Source of targets: Spitzer and optical spectroscopic catalogs, possibly assisted by Herschel catalogs

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 18, 25, Vegamag, R

3.4- Target size: extended source, 100, 600

3.5- Number of targets: ~20

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: 50, 2

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 1400 - 2600

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: HARMONI

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 3, 4, detector sensitivity

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 70

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 75

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, remote observing trigerred at the time of queue observations could be optimal to assist the telescope operator/night assistant in optimizing the observations

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, use of these facilities will optimize the determination of black hole and gas mass

9.2- Critical aspects / limiting factors for the science case:
spectral resolution < 3000, spatial pixel scale >100 mas

9.3- Detailed description or other comments:
N/A

1.1- Project Title: Measuring black hole and neutron star masses in Galactic sources

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1.2- Project Category: 1

1.3- Abstract:
The distribution of black hole and neutron star masses as found in X-ray binary systems will provide important information on the supernovae forming these compact objects, as well as on the behaviour of matter under the extreme circumstances as found in neutron stars. In addition, a group of X-ray binaries resides in ultra-compact binaries where the orbital period is shorter than 1 hour. Such objects are strong sources of gravitational wave radiation and they will be detectable by LISA.

1.4- Publication agreement: yes

2.1- PI: Peter Jonker

2.2- CoIs: Tom Maccarone, Gijs Nelemans

2.3- Institute: SRON & CfA

2.4- Country of Employment: NL

2.5- Career Stage: faculty

2.6- E-mail: p.jonker@sron.nl

3.1- Source of targets: VLT, Blanco, Chandra

3.2- Preparatory work on targets required?: yes, wide survey, precise astrometry, radial velocity survey

3.3- Target brightness: 22.5, 26, Vegamag, I

3.4- Target size: point source

3.5- Number of targets: 500

3.6- Density of targets: N/A

3.7- Target coordinates: l:3 - 357;b:-2 - +2

3.8- Moving target?: no

3.9- Variable target?: yes, 10 per hour

3.10- Target type: other, black hole/neutron star X-ray binaries

4.1- Spatial resolution: seeing, 0.2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: 1, slitlet

4.4- Plate scale stability: 1, 2700

5.1- Wavelength range: 500 - 2000

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: OPTIMOS, SIMPLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.08, 0.17, N/A

7.2- Longest continuous observation time on a target or field: 0.5

7.3- Shortest integration time on a target or field: 100

7.4- Total time: 300

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, SKA/SKAPF, other, LISA, Lofar & eRosita

9.2- Critical aspects / limiting factors for the science case:
spectral resolution

9.3- Detailed description or other comments:

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This text describes the need for an E-ELT for the study of Galactic X-ray binaries.

The main questions to be answered are:

-what is the mass distribution of compact objects in X-ray binaries. In particular what is the lowest black hole mass (related) what is the maximum mass of a neutron star?

-ultra-compact X-ray binaries: these objects can be used as tracers of binary evolution, in addition, they are strong gravitational wave sources.

For the first point, phase resolved intermediate resolution (R~5000) spectra of a suit of targets with I band magnitudes ranging 22.5-24 is needed, preferentially eclipsing systems. Doppler smearing of the spectral lines limits the integration times to approximately 1/20th of the binary orbital period, which in these systems with orbital periods of a few hours implies exposures of 5 to 10 minutes. These observations can be made in either the optical (BVRI bands) or in the near-infrared part (JHK bands) of the spectrum. The spectral resolution is set by the need to resolve the velocity broadened stellar absorption lines, which is typically several tens of km/s.

For the ultra-compact X-ray binaries, the main challenge lies in the fact that the equivalent widths of the emission lines of the accretion disc are very low (a few Angstrom, with broad but shallow lines). Furthermore, the orbital period, by definition, is very short (less than 1 hour), implying short exposures in the case of a phase resolved study (e.g. to study the motion of the companion star). Note that the white dwarf companion stars are dim. Luckily, the orbital period (an important parameter for searches of gravitational waves) can be measured from periodicities in the emission line velocities. The line ratios are tracers of the chemical composition of the mass donor stars which constrains binary evolution models. These source, as a sample, are 2--3 magnitudes fainter than the sources in the first category.

Planned and started surveys in various wavebands (radio: EVLA; X-rays: eROSITA; optical: EGAPS) will identify a very large fraction of the population of X-ray binaries out to the Galactic Center providing the sample of sources for the E-ELT.

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1.1- Project Title: Proto-planetary disks with aperture masking: bridging the gap to VLTI

1.2- Project Category: 3

1.3- Abstract:

MIDI on the VLTI has been very successful in observing proto-planetary disks. Its lowest angular resolution roughly matches the highest spatial frequencies of the E-ELT if the latter is equipped with an aperture mask working in the N-band. Observations with MATISSE, the successor of MIDI, when combined with the E-ELT aperture mask, would be very powerful in resolving all angular scales of the disks. Suitable targets with structure on all scales exist, and aperture masking is a proven technique. This has never been done before.

1.4- Publication agreement: yes

2.1- PI: Christian Hummel

2.2- CoIs: N/A

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: chummel@eso.org

3.1- Source of targets: ALMA, VizieR

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 40, 20000, mJy, N

3.4- Target size: extended source, 10, 500

3.5- Number of targets: 50

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 10, 3

4.2- Field-of-view: 2x2arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 1, 3600

5.1- Wavelength range: N, Q

5.2- Spectral Resolution: nbimaging

6.1- Instrument: METIS

6.2- Desired special mode: other, Aperture mask

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.02, 0.5, good seeing conditions

7.2- Longest continuous observation time on a target or field: 0.5

7.3- Shortest integration time on a target or field: 60

7.4- Total time: 10

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 5

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, N/A

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9.2- Critical aspects / limiting factors for the science case:
The aperture mask is critical due to its proven track record in high-fidelity reconstructions of bright targets.

9.3- Detailed description or other comments:
There is a number of heavily resolved proto-planetary disks as observed by MIDI, but single dish imaging has been limited to the 8m class of telescopes, thus leaving a huge gap in angular resolution to the shortest MIDI baselines (about 47m). Star forming regions are often complex and have structure on all scales. They are best studied in the infrared, allowing to penetrate large amounts of dust. Aperture masking is a technique which gives superior results to adaptive optics imagery when observing bright targets. The throughput is on the order of 10%, while for interferometry it is on the order of 2%. In terms of limiting sensitivity, the two techniques are therefore somewhat similar, and complementary in terms of their spatial frequency coverage. Combining the two techniques provide much stronger constraints than each one individually.

In the mid-infrared, matching the resolution of ALMA will be a challenge; therefore a comprehensive approach of an aperture mask in METIS with MATISSE at the VLTI is necessary.

The science case is of well known importance. As an example, we have observed a high-mass young stellar object with MIDI and an aperture mask in the T-ReCS instrument of Gemini South. In both angular scale regimes, the target was resolved. A disk was detected and modeled, but the link between the sub-arcsecond and the sub-100 mas scales is unclear. Studying it would be scientifically important for the understanding of high-mass star formation end evolution.

1.1- Project Title: Planets in the Galactic Bulge and external dwarf galaxies

1.2- Project Category: 3

1.3- Abstract:
Up to now all studies of the frequency of extrasolar planets are confined to our galaxy, the majority of the surveys are even focusing on our immediate solar neighbourhood. Since the formation of stars and planets depends on the local density of stars, the chemical abundance
of the material from which these are forming and from the frequency of nearby supernovae and the presence or absence of nearby hot stars, it is expected that also the frequency and properties of planets depend on these factors. While the detection of planets in our neighbourhood is interesting at such, these studies do not allow us to say anything about the influence of the environment on the formation and evolution of planets, and the do not tell us how frequent planets in the universe real

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are. With OPTIMOS-EVE it will be possible to detect planets of stars in the Galactic Bulge, and even dwarf galaxies. These observations will thus shed more light onto the influence of the environment on the formation and evolution of planets, and last not least tell us, how frequent planets in the universe really are.

1.4- Publication agreement: yes

2.1- PI: Eike W. Guenther

2.2- CoIs: Michael Andersen, Hans-G. Ludwig, Piercarlo Bonifacio

2.3- Institute: Thueringer Landessternwarte Tautenburg

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: guenther@tls-tautenburg.de

3.1- Source of targets: VLT, VISTA

3.2- Preparatory work on targets required?: yes, pre-imaging

3.3- Target brightness: 18, 20, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 200

3.6- Density of targets: 2

3.7- Target coordinates: RA:17 - 19;Dec:-40 - -20, RA:18 - 20;Dec:-40 - -20, RA:5 - 7;Dec:-80 - -60, RA:0 - 2;Dec:-80 - -60

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: N/A

4.1- Spatial resolution: seeing, 1

4.2- Field-of-view: 10x10arcmin

4.3- Multiplexity and pick-off FoV: 60, fiber

4.4- Plate scale stability: 0.1, 900

5.1- Wavelength range: 500 - 1800

5.2- Spectral Resolution: 20000-50000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: GLAO

7.1- Integration time per target or field and per setup: 50, 200, airmass<2

7.2- Longest continuous observation time on a target or field: 1.0

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 25

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
Not critical. Could even be done under less than perfect conditions.

9.3- Detailed description or other comments:
Using precise measurements of the radial velocities (RVs), now more than 300 extrasolar planets have been indirectly detected by the reflex motion induced by the planet on its host star. The number of transiting extrasolar planets now exceeds 50. While these results are very important and

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opened up a new field of astronomical research, most RV-search programs focus on old stars in the solar neighbourhood. Since it is generally not known were these stars formed, our knowledge on the effects of the environment on planet formation is very limited. Search programs for transiting planets usually select fields in the Milky Way which most likely sample stars in the disk of our galaxy.

Since planets form within a few Myr in the circumstellar disks, environmental effects on the properties of the disk during that time
will have tremendous impact on the formation of planets. The formation of planets thus will not only depend on the metallicity of the disk but all precesses that change the properties of the disk will have an effect on the formation of planets. One can envision quite a number of environmental effects which may play a role in changing the evolution of the planet-forming disks. The first one is presence of a hot star in the vicinity of the planet forming disk. This is because a nearby hot star produces copious UV radiation which then might erode the disk of a nearby low-mass star. Thus, a hot star might prevent the formation of planets in the disk of low-mass stars in its vicinity. The presence or absence of supernova are believed to also effect the formation and evolution of planets. In dense clusters, the disks interact gravitationally with other stars in the cluster. If the interaction is strong the disk can even be destroyed altogether. Thus, the formation of planets at
least at large orbital distances in the environment of a dense stellar cluster might be difficult. However, one can also imagine that a close-by stellar companion may facilitate
the formation of planets. It is for example known that binary stars has often unusually massive planets.

Consequently, it is expected that not only the abundance of heavy elements influences the formation of planets but also the local
density of stars, the presence or absence of hot stars, and the frequency of supernovae. Since these factors have also changed during the evolution of our galaxy, it is expected that also efficiency of planet formation must have changed during the evolution of our galaxy. Thus, we know only very little about the frequency and properties of planets in general, as our knowledge is based on studies of the solar neighbourhood. In order to really understand the formation of planets in general we have to study planets in different environments.

OPTIMOS-EVE will be a big leap forward as it will allow for the first time to detect planets in such different environments in nearby dwarf galaxies (SMC, LMC, Sagittarius dwarf galaxy) using an efficient detection mode by radial velocity measurements. We will have the opportunity to get insight how frequent planets globally are in the universe beyond our home galaxy. Additionally, from these observations we will obtain further ideas how the environment influences the formation and evolution of planets.

While the goal of the project is the detection of massive planets, this survey will also shed new light on the question where life in the universe can in principle exist. In this context the concept of a ``galactic habitable zone''''''''''''''' has been introduced, as a region in a
galaxy were there are enough heavy elements to form terrestrial planets, sufficient time for biological evolution, and an environment free of life-extinguishing supernovae. Since these factors

also influence the formation and evolution of giant stars, we will also learn something about where galactic habitable zones are potentially
located.

We plan to observe appropriate fields in at least one dwarf galaxies, 3 fields per object, so in total 9 fields. This results in a total need of observing time of 200 hours or 25 nights (assuming 8 hours per night) spread over a period of 5 years. Our observing time estimate is conservative. For instance, in our example discussed below 45 to 60 simultaneous targets can be found already at a brighter limiting magnitude of V=19.4 mag. If this is generally the case in all target fields this would reduce the total observing time by a factor of 1.7. The saving could be used for extending the sample, or adding another object providing another environment.

After the initial detection of periodic RV-variations it is thus essential to carry out further tests to draw conclusions about the
nature of the variations. Because it is possible with OPTIMOS-EVE to obtain RV-measurements simultaneously in the optical and in the NIR, we can very effectively distinguish the RV-signals caused by planets from other stellar spots, blends etc. In the cause of the observations we will also be able to detect the oscillations of the giant stars which will allow us to constrain the masses of the stars to a high accuracy by combining the RV-data with the distance of the stars.

1.1- Project Title: TNO, icy relics of the early Solar System

1.2- Project Category: 4

1.3- Abstract:
Trans-neptunian objects (TNOs) are icy bodies, relics of the early stage of the Solar System and their study is of great cosmogonical interest as they have the most pristine materials that can be found in any Solar System object. The aim of this proposal is to significantly improve our knowledge of their surface composition and the resurfacing processed that affect them. We plan to obtain high S/N spectroscopy in the 500-2500nm range of a large series of selected TNOs of a wide range of sizes, and spectroscopy in the 3000-5000nm spectral region of the largest members of the population.

1.4- Publication agreement: no

2.1- PI: Javier Licandro

2.2- CoIs: Alvaro Alvarez Candal, Alan Fitzsimmons

2.3- Institute: Instituto de Astrofísica de Canarias

2.4- Country of Employment: ES

2.5- Career Stage: faculty

2.6- E-mail: jlicandr@iac.es

3.1- Source of targets: Minor Planet Center

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 17, 21.5, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 60

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-25 - +56

3.8- Moving target?: yes, 4

3.9- Variable target?: no

3.10- Target type: solar system body

4.1- Spatial resolution: seeing, 2

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 1000 - 2500, 3000 - 5000

5.2- Spectral Resolution: 100-300

6.1- Instrument: HARMONI, METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.4, 1.5, 0.8

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: 1600

7.4- Total time: 300

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, fast transfer of images, videoconf with telescope operator and support astronomer

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
The telescope should be able to guide in moving targets

9.3- Detailed description or other comments:
The trans-neptunian belt (TNB) is formed by icy bodies that accreted in the protoplanetary disk beyond in the 5-30AU region from the Sun. These planetesimals were the building blocks that formed the giant planets. In the present days the TNB extend from Neptune to about 47AU. TNOs are the icy planetesimals that survived the planetary accretion phase and latter dynamical scattering and collisional processes. They are thought to be among the most pristine bodies in the solar system, relics of the early stage of the planet formation. It is also well established that Centaurs (objects with orbits within Jupiter and Neptune) and short period comets are TNOs recently scattered form the TNB.

The investigation of the surface composition of transneptunian objects (TNOs) and Centaurs provides essential information on the conditions in the early solar system where these objects formed. It is essential to understanding the formation and the evolution of the population. TNOs represent the most pristine material available for ground based investigation, so the knowledge of

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the compositional nature of the whole population can provide constraints on the processes that dominated the evolution of the early solar nebula as well as of other planetary systems around young stars. Even though, space weathering due to solar radiation, cosmic rays, internal activity, and interplanetary dust, affect the uppermost surface layer of these bodies. Energetic collisions could also have played an important role eroding the upper layers and dragging materials from the interior. So, the investigation of their surface composition is also crucial to understand these resurfacing processes.

Studies of the physical properties of these objects are still limited by their faintness, and many open questions remain concerning their surface composition. Compositional determination is mainly done by spectroscopy in the 500-2500nm spectral range. This wavelength range provides the most sensitive technique available from the ground to characterize the major mineral phases, ices and organics present on TNOs. Diagnostic spectral features of silicate minerals, feldspar, carbonaceous assemblages, organics, and water-bearing minerals are present in the visible (V) and near-infrared (NIR) spectral regions. At NIR wavelengths there are also signatures from ices and hydrocarbons. Low-resolution spectra (R<300) of about 50 TNOs have been obtained so far, most of them with rather low S/N (about 10). The best S/N spectra, in particular in the infrared, were obtained using SINFONI at VLT.
Up to now, H-K spectra with S/N=50 can be obtained only for TNOs with H=18 or brighter in reasonable exposure times. With E-ELT and HARMONI it will be possible to attain S/N > 50 for TNOs with H=19.5 in about 1.5hr in the whole 1000-2500nm spectral range. Good S/N spectra have been obtained only of the few large TNOs (those with diameters larger 1000km, less than 10 objects). ELT will be able to obtain spectra of about 50 TNOs with S/N > 50 and resolution R about 200 in the NIR. This is a huge improvement as we will be able to determine their surface composition with an unprecedented accuracy by combining ELT spectra with albedo determinations obtained from the Herschel TNO large programme, and using scattering models. We will also be able to attain S/N between 10-20 in the K band for much smaller TNOs, allowing comparing the surface properties of small objects with that of the large ones. The aim is to obtain very high S/N (>100) for the 10 larger objects, and >50 for a sele
cted sample of medium-size TNOs, and >10 for about 50 small TNOs. We will use the already obtained spectra and photometry to select the most interesting TNOs, covering a wide range of sizes and colors. The study of TNOs of a wide range of sizes is critical. While this size spectrum provides a singular opportunity to study a variety of planetary processes, the largest objects may be very different from their smaller brethren. This complicates the task of understanding the small bodies by extrapolating results from the more easily studied large objects. We will use also visible spectra of these targets obtained with smaller telescopes.

On the other hand, the 3000-5000nm spectral region is even more diagnostic in particular of ices and organics. But only Pluto and Charon were observed in the L and M band, being particularly good the spectra obtained with NACO@VLT using the prism mode. The prism mode of NACO demonstrated to be very efficient to obtain high S/N spectra of Pluto, a V=14 (L=15) magnitude object, and a reasonably good L-band spectrum of Charon (V=17). The limiting factor to observe TNOs is that it should be bright enough to be used as natural guide stars for visible AO sensing. If a similar prism mode is included in METIS, all TNOs with V=19 could be observed. Also some others fainters could be observed during close approaches to V<19 field stars.

Two groups of TNOs are of great interest and we will pay special attention to them:
1) The largest Pluto-like TNOs, Eris, and Makemake, are of particular interest. They have spectra dominated by methane. In the case of Pluto, N2 and CO have also been detected. Eris and Makemake seem to have N2, but no direct detection is reported until now. CO and N2 signatures are very week in Pluto's NIR spectrum, so better S/N spectra is needed to study these ices in the other two. The presence of these species on the largest objects is likely due to their large masses, which allow for volatiles to be retained. These TNOs resemble planets with tenuous atmospheres, active resurfacing, and possibly differentiated interiors. We plan to obtain very high S/N 500-5000 nm spectra of these objects, at different rotational phases and epochs to study the resurfacing processes and the formation/evolution of their atmospheres. Notice also that with the spatial resolution of the ELT (3 times that of HST), it will be possible to resolve those TNOs and thus study different regions of
their surfaces as it has been done using HST in the case of Pluto.

2) The large TNO 2003 EL61 and the family of objects associated to it. This is a group of objects with surfaces composed mainly of water ice and depleted in carbon chains respect the to other TNOs, and with similar orbital parameters. It has been claimed that this is a collisional family. The existence of this group of TNOs can give unique information on the collisional evolution of the TNB and the effects of space weathering on almost pure water ice surfaces.

Notice that the declination of the known objects in both groups will range between –2 and 35 degrees when ELT be operational. Particularly important is the case of Makemake (declination 25 deg.).

1.1- Project Title: Testing planetary pollution and stellar models using precise abundaces in twin binaries

1.2- Project Category: 3

1.3- Abstract:

The study of visual binary solar type stars can be very precise when using differential chemical abundance analysis for systems where the difference in temperature is very low. These systems are composed of ``twin'''''''''''''''''''''' stars where age, metallicity and temperature (mass) will be essentially the same.

We propose to check the chemical abundances for each component of a sample of ``twin'''''''''''''''' binaries to look for possible differences in the chemical composition. Besides the determination of precise metallicities, we will study elements such as lithium and beryllium which provide strong constraints on the interior of solar type stars.

1.4- Publication agreement: no

2.1- PI: S. G. Sousa

2.2- CoIs: M. Amler

2.3- Institute: Centro de Astrófisica da Universidade do Porto

2.4- Country of Employment: PT

2.5- Career Stage: postdoc

2.6- E-mail: sousasag@astro.up.pt

3.1- Source of targets: VizieR

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 5, 12, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 76

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: diffraction, 1

4.2- Field-of-view: fiber

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: U, B, V, R, I, J, H, K, 100 - 150000

5.2- Spectral Resolution: >100000

6.1- Instrument: CODEX

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.25, 1, seeing 1.5

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 30

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
S/N

9.3- Detailed description or other comments:
N/A

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1.1- Project Title: Mg Isotopes in Very Metal-Poor K Dwarfs

1.2- Project Category: 2

1.3- Abstract:
Magnesium isotopes are crucial to determine the role of AGB stars in the early evolution of our Galaxy (e.g. Melendez & Cohen 2007, ApJ 659, L25). We propose to observe very faint very metal-poor ([Fe/H] < -2.5) cool K dwarfs in order to obtain their Mg isotopic ratios.

1.4- Publication agreement: yes

2.1- PI: Jorge Melendez

2.2- CoIs: N/A

2.3- Institute: Centro de Astrofisica da Universidade do Porto

2.4- Country of Employment: PT

2.5- Career Stage: postdoc

2.6- E-mail: jorge@astro.up.pt

3.1- Source of targets: SDSS, surveys of nearby cool stars, surveys of proper motion stars

3.2- Preparatory work on targets required?: yes, confirmation of metallicities using UVES+VLT will be performed

3.3- Target brightness: 15, 17, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 8

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +30

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: seeing, 2

4.2- Field-of-view: longslit

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 400 - 1000

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: CODEX

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 2, 4, N/A

7.2- Longest continuous observation time on a target or field: 0.5

7.3- Shortest integration time on a target or field: 1200

7.4- Total time: 24

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:

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my science case requires a resolving power of at least R = 80 000. The minimum spectral coverage should be from 510-520nm, but a coverage up to 1000nm will be useful to study other chemical elements in these cool stars.

9.3- Detailed description or other comments:
I""ve tried to use the exposure time calculator but it seems like it is too conservative, or perhaps I""ve made a mistake. The resulting exposure times were much higher than scaling the exposure times I""ve used for similar (yet brighter K dwarfs) with Keck. I""ve preferred to use the exposure times based on my previous Keck experience, but I guess much better results could be obtained, depending on the characteristics of the E-ELT high resolution spectrograph.

1.1- Project Title: The evolution of the black-hole mass - Bulge Luminosity - Sigma relationship using QSOs

1.2- Project Category: 2

1.3- Abstract:
We propose to use the HARMONI to measure bulge masses, effective radii, surface brightness and velocity dispersions of a large sample of QSOs. With will thus be able to make the first study of the fundamental plane of luminous quasar hosts and their evolution from z~2 through to the present day with sufficiently short exposures to facilitate statistical samples which will overcome the intrinsic scatter in the various relations. This will enable us to monitor the build-up of black holes, their host stellar masses and total halo masses over ~80% of the Universe.

1.4- Publication agreement: yes

2.1- PI: Matt Jarvis

2.2- CoIs: Ross McLure

2.3- Institute: University of Hertfordshire

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: M.J.Jarvis@herts.ac.uk

3.1- Source of targets: any of SDSS, VST, VISTA, DES, LSST, LOFAR, PanSTARRS

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 18.5, 19.5, Vegamag/arcsec2, K

3.4- Target size: extended source, 200, 3000

3.5- Number of targets: ~50-100

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: AGN

4.1- Spatial resolution: 100, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 800 - 2400

5.2- Spectral Resolution: 500-1000

6.1- Instrument: HARMONI

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 4, 10, N/A

7.2- Longest continuous observation time on a target or field: 6

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7.3- Shortest integration time on a target or field: 4

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 100

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, VLT/VLTI, SKA/SKAPF, other, N/A

9.2- Critical aspects / limiting factors for the science case:
The most crucial factor is signal to noise so throughput of the instrument is the crucial factor.

9.3- Detailed description or other comments:
It has now become well established that the nuclei of both active and quiescent galaxies harbour supermassive black-holes (eg. Magorrian et al. 1998). Furthermore, it has become clear that the mass of the central black-hole is directly proportional to that of the surrounding bulge, as traced by either the stellar velocity dispersion or bulge luminosity (e.g. Tremaine et al. 2002). These results demonstrate that the formation and evolution of supermassive black holes and their host galaxies must be intimately related. Moreover, given that the dominant mechanism for the build-up of black-hole mass is very likely accretion, it is now clear that the evolution of massive galaxies, supermassive black holes and quasars must be investigated together.

The locally observed correlations between black-hole mass and both velocity dispersion and bulge luminosity ($M_{bh}-\sigma$ and $M_{bh}-L_{bulge}$ relations) are now routinely used to estimate the black-hole masses of non-active galaxies, but neither can be trivially applied to AGN because of the luminous unresolved nuclear emission. However, many recent studies of active galaxies (AGN) have employed the virial method (e.g. Kaspi et al. 2000) to estimate the central black-hole masses. It is now common practice to estimate quasar black-hole masses based on only the FWHM of various broad-emission lines and the continuum luminosity (e.g. McLure & Dunlop 2002; McLure & Jarvis 2002; McLure & Dunlop 2004). Consequently, if studies of high-redshift quasars based on the virial estimator are to be regarded with any confidence, it is a minimum requirement that the virial estimator be shown to be consistent with other secondary black-hole mass indicators. Indeed, based largely on HST imaging data,
McLure & Dunlop (2002) have already demonstrated that the virial estimator and the $M_{bh}-L_{bulge}$ relation are consistent for AGN host-galaxies (quasars+Seyferts) at $z < 0.5$. In addition,

using long-slit spectroscopy, Nelson et al. (2004) have shown that low-redshift ($z < 0.1$) Seyfert galaxies have consistent stellar velocity dispersions and virial black-hole mass estimates. However, using Keck long-slit spectroscopy, Treu et al. (2004) found that Seyfert galaxies at $z \approx 0.3$ have significantly smaller velocity dispersions than suggested by their virial black-hole masses. This is potentially crucial because the masses of AGN hosts must have evolved significantly since $z \approx 0.3$, implying that the black holes may have fully formed before the host galaxy reaches its final mass. Further work on the evolution of the Mbh-Lbulge relation using both distant quasars (Peng et al. 2006) and radio galaxies and radio-loud quasars (McLure et al. 2006) has further strengthened this argument,
see also Treu et al. (2007) who also find similar results fo!
r low-redshift Seyfert galaxies. However, the stellar bulge luminosity is highly subject to evolutionary effects and a reliance on galaxy spectral models is required in order to interpret them properly, and importantly to compare galaxies at different redshifts. A much cleaner method of establishing whether there is evolution in the properties of the Mbh and the mass of the host galaxy comes from measuring the stellar velocity dispersion which does not rely on synthetic models.

Assuming that the velocity dispersion can be measured by binning up in an annulus which is beyond the unresolved nuclear emission, which even for a relatively poor AO correction would be achievable, it would be easily possible to determine the stellar velocity dispersion of the massive QSO host galaxies via fitting the absorption line complex of the Calcium triplet as it moves through the H- and K-band windows. Furthermore additional constraints could be made using the full stellar SED, although the relatively poor performance of the AO system at the bluer wavelength could limit its usefulness. At higher redshifts (i.e. $z \sim 2$) then it should be possible to measure the velocity dispersion of the QSO hosts using the whole rest-frame optical spectrum, which would be redshifted into the JHK-band windows.

Therefore, a successful measurement of the host-galaxy velocity dispersions will allow us to compare the Mbh−σ correlation against the virial mass estimate in luminous quasars for the first time. Using the IFU to unveil the underlying host-galaxy by observing the CaII triplet region the spatially unresolved nuclear spectrum will feature the permitted broad Hα and/or Hβ emission lines. This is potentially crucial for two reasons. Firstly, when extracting the stellar-velocity dispersions, the luminosity of the Hα/Hβ line can be used to subtract-off residual contamination of the host-galaxy spectra by scattered nuclear light. Secondly, and more importantly, because it is spatially unresolved, the broad lines can be used to accurately reconstruct the spatial point-spread function (PSF) from the 3D IFU datacube. Therefore, by subtracting out the nuclear contribution and then collapsing the 3D datacube in the spectral dimension, HARMONI observations offer the prospect of rec
onstructing a clean 2D image of the underlying host-galaxy. This reconstructed host-galaxy image will provide an accurate measurement of the bulge luminosity allowing us to compare the virial black-hole mass estimates with both the Mbh−σ and Mbh−Lbulge relations. At high redshift ($z>1$) the K-band samples the rest-frame light longward of the 4000A break, the bulge luminosity will also provide a reasonably accurate determination of the underlying bulge mass. The prospect of

reconstructing a nuclear-free image of the underlying host-galaxy from the 3D IFU datacube would represent a significant technical advance in AGN host-galaxy studies.

Finally, although imaging studies have suggested that the hosts of luminous quasars are predominantly bulge-dominated galaxies (e.g. Dunlop et al. 2003), it has previously been impossible to study their location on the fundamental plane. However, using the lowest spatial resolution configuration of HARMONI, the field-of-view is large enough to accurately determine the half-light radii and effective surface brightness of the quasar hosts from the reconstructed, nuclear-subtracted, 2D images. Together with the stellar-velocity dispersion measurements, these will provide all three of the fundamental plane parameters from a single observation. As well as being the first opportunity to investigate the location of quasar hosts on the fundamental plane, this also offers the prospect of constraining the host mass-to-light ratio for determining the bulge masses.

1.1- Project Title: Determining the upper stellar mass limit from resolved starburst clusters

1.2- Project Category: 3

1.3- Abstract:
Young, massive Milky Way star clusters host stars with initial masses up to ~150 Msun. The high-mass IMF is sampling limited: it is not clear whether the cut-off originates from poor sampling in 104 Msun stellar clusters, or from a fundamental limitation of forming more massive stars. Probing starburst clusters with 105-106 Msun provides the required sampling of the high-mass IMF. It is crucial that these clusters be resolved into their high-mass component to avoid confusion when estimating individual stellar masses.

1.4- Publication agreement: yes

2.1- PI: Andrea Stolte

2.2- CoIs: Wolfgang Brandner, Bernhard Brandl

2.3- Institute: I. Physikalisches Institut, Univ Cologne

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: astolte@ph1.uni-koeln.de

3.1- Source of targets: VLT, HST

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 15, 24, Vegamag, K

3.4- Target size: point source, N/A, N/A

3.5- Number of targets: > 50

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +90

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star cluster

4.1- Spatial resolution: diffraction, 3

4.2- Field-of-view: 30x30arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 0.0, 0

5.1- Wavelength range: 600 - 3500

5.2- Spectral Resolution: bbimaging

6.1- Instrument: MICADO, METIS

6.2- Desired special mode: precision photometry, uniform photometry < 2%

6.3- Desired AO mode: LTAO

7.1- Integration time per target or field and per setup: 0.2, 1.0, 1.15 AM, 3x3 pixel dist., pix size 10 mas K-L, 5 mas V

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7.2- Longest continuous observation time on a target or field: 0.1

7.3- Shortest integration time on a target or field: 0.1

7.4- Total time: 50

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
Near- to mid-IR imaging and spectroscopic (low-res) coverage is crucial to include clusters with visual extinction.

9.3- Detailed description or other comments:
Most likely instruments to use: MICADO JHK for optimal spatial resolution and sensitivity on young stars, penetration of local and foreground extinction. METIS: to estimate the number of excess objects and distinguish IR excess/disks from stellar fluxes, to derive the stellar photospheric luminosity and corresponding mass limits. Ideally, to improve resolution and ensure observation of photospheric flux in un-extincted regions,
optical high-resolution imaging would be helpful, but is not required to carry out the project. Low-resolution (few 1000) to obtain velocity dispersion measurements in the clusters and dynamical states, also provides spectral types of the brightest stars. NIR spectroscopy is required to constrain stellar evolution models in detail.

1.1- Project Title: Evolution of the mass-luminosity relationship for brown dwarfs and superJupiters

1.2- Project Category: 3

1.3- Abstract:
To date, more than 300 planets have been found orbiting other stars different from the Sun. The study of the transits of a few of them have allowed us to derive their physical properties, but a full characterization of extrasolar planets will require the direct detection of their light. We propose to perform a search for brown dwarf and superjupiters (1-10MJup) around Solar type and very low-mass stars in nearby young stellar associations and clusters (<1Gyr,<150pc), like Taurus, Scorpius, Pleiades and Hyades. Using near-infrared and high-contrast (10-3 - 10-5) instruments, like EPICS and HARMONY on the E-ELT, we will be able to detect and characterize the physical properties of superjupiters around stars at separations of a few AU, corresponding to angular separations larger than 30-100 mas. Given the relatively short periods of a few years, the dynamical characterization of their orbits will allow us to determine their masses and derive the dependence of their mass-luminosi
ty relations with age. All these observations will be fundamental to understand the formation and evolution of giant planets and planetary systems. In this sense, the Pleiades and Hyades clusters are unique to address these questions.

1.4- Publication agreement: yes

2.1- PI: V. J. S. Béjar

2.2- CoIs: R. Rebolo, M. R. Zapatero Osorio, D. Barrado y Navascués

2.3- Institute: N/A

2.4- Country of Employment: ES

2.5- Career Stage: postdoc

2.6- E-mail: vbejar@iac.es

3.1- Source of targets: e.g. VizieR, WEBDA, UKIDSS, 2MASS

3.2- Preparatory work on targets required?: yes, e.g. low and intermediate spectroscopy

3.3- Target brightness: 7, 27, Vegamag, J

3.4- Target size: point source

3.5- Number of targets: 300

3.6- Density of targets: N/A

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3.7- Target coordinates: RA:3:30 - 04:30;Dec:+22 - +27, RA:4:15 - 04:35;Dec:+12 - +24, RA:15:10 - 16:20;Dec:-15 - -30

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star cluster

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 2x2arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: J, H, K

5.2- Spectral Resolution: bbimaging

6.1- Instrument: EPICS, HARMONI

6.2- Desired special mode: coronography, contrast: 10-3 - 10-8

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.5, 1, Laser Tomography AO, airmass=1.15, pixel scale=5 mas/pix, S/N=10

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 600

7.4- Total time: 300

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30-50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

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8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: other, VLT,GTC

9.2- Critical aspects / limiting factors for the science case:
There are no critical aspects

9.3- Detailed description or other comments:
Since the discovery of the first extrasolar planet around a solar type star (Mayor & Queloz, 1995, Nature, 378, 355), more than 300 planets have been found around other stars, the majority of them using the radial velocity technique. The discovery of transiting extrasolar planets (Charbonneau et al. 2000, ApJ, 529, L45; Konacki et al. 2003, Nature, 427, 501) have allowed us to precisely measure their mass and radious, determine the direct light coming from the planet in a few cases (Charbonneau et al. 2000, ApJ, 529, L45; Konacki et al. 2003, Nature, 427, 501) and characterize their atmospheres (Tinetti et al. 2007, Nature, 448, 169; Swain et al. 2008, Nature, 452, 329).

However, it is only the direct detection of a extrasolar planet's light that allow the detailed study of its physical properties, like Luminosity, Teff or chemical composition, which are critical to understand the formation and evolution of planets. Recent discoveries of wide extrasolar planets by direct imaging (Chauvin et al. 2004, A&A, 425, L29; Kalas et al. 2008, Science, 322, 1345; Marois et al. 2008, Science, 322, 1348) open the possibility to make a detailed study of them. Unfortunately the age of these systems is not well known and the mass of the planets, given their large separations from their primaries (>24 AU), can only be obtained from theoretical models.

The determination of age and masses of substellar objects is fundamental because the properties of these objects evolve drastically with age as they progressively contract and cool down (Burrows et al. 2001, Rev. Mod. Phy., 73, 719). Dynamical masses of substellar objects are known for a few systems (Zapatero Osorio et al. 2004, Ap J 615, 958; Bouy et al. 2004, 423, 341; Liu et al. 2008, ApJ, 689, 436; Dupuy et al. 2009, ApJ, 692, 729) but only one eclipsing binary with well determined age is known (Stassun et al. 2006, Nature, 440, 311). The identification of similar binaries in open clusters and stellar associations of well known age, distance and metallicity combined with a full dynamical and spectroscopic characterization will be crucial for testing theoretical evolutionary models of these objects.

We propose to perform a search for brown dwarf and planet companions around stars in the nearest very young (1-10 Myr) stellar associations (e.g. Taurus, Scorpius) and young (100-600 Myr) star clusters (e.g. Pleiades, Hyades) using near-infrared imaging facilities at the E-ELT. These observations will allow us to determine the physical properties of substellar objects with masses up to a few Jupiter mass, i.e. the so called superjupiters. The astrometric and radial velocity characterization of these objects will allow us to determine their orbital parameters and dynamical masses. From these data we will be able to derive the mass-luminosity relations of brown dwarf and superjupiters for a given age and compare with evolutionary theoretical models. In addition, we will

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determine the frequency and separations of superjupiters around stars of different masses and ages, and hence, study their formation processes and possible migration mechanisms at these early stages (<1Gyr). The
se observations are not only very important to know how giant planets are formed, but joined to the studies of protoplanetary disks, they will be crucial to understand the formation and early evolution of rocky planets and our own Solar System.

Since superjupiters are intrinsically very faint even at these very young ages, we will require a large collecting area as provided by the E-ELT. For example a 5 MJup object at the distance and age of the Pleiades cluster (130pc, 120Myr) will have a J-band magnitude of 23, while at the Hyades (45pc, 600Myr), it will have J=26.5. For ages younger than 10Myr, they will be much easier to detect and they will have J-band magnitudes of 18-20 at 150pc (Taurus, Scorpius). The estimated Teff of these objects are between 2000-1000K for ages <10Myr and Teff<1000K for the older ones, and they are expected to emit most of their light in the near and mid-infrared. Because of the sensitivity to these objects and the higher spatial resolution, the near-infrared wavelength range, and the J-band in particular, is preferred.

We expect to detect these superjupiters at separations of a few AU and greater, where the bulk of these giant planets are predicted to be formed (see Lin & Ida 2009, ApJ, 691, 1322). An orbital separation of 5 AU, corresponding to a period of 10yr for a solar type stars, translates into an angular separation of 110 mas (18.5 λ/D at 1µm) at the distance of 45pc and 38 mas (6 λ/D at 1µm) at the distance of 130pc (It will therefore be possible to follow orbital motion and determine dynamical masses). In addition to a high spatial resolution, we require for this programme a high contrast capability like that provided by the E-ELT using LTAO and a coronograph. In order to detect a superjupiter orbiting a solar type star in the Pleiades (J~9.5) and Hyades (J~7), it is necessary to resolve contrasts of 10-5 - 10-8 at the separations mentioned above, while to detect them around a 0.1 MSol star, a contrast of 10-3 - 10-5 is required. Instruments proposed for E-ELT, like EPICS
(for star brighter than V=12) and HARMONY (for much fainter primaries) will provide the needed capabilities for this programme.

In summary, we propose to perform a search for superjupiters around Solar type and very low-mass stars in young nearby clusters (<1Gyr,<150pc) at separations of a few AU, using near-infrared and high-contrast facilities in the E-ELT. We will derive their frequency around stars of different masses, their physical properties, orbital parameters and the dependence of mass-luminosity relations with age, which will be crucial to understand the formation and evolution of giant planets and planetary systems.

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1.1- Project Title: Taxonomy of the formation of Low Mass Objects: from the Local Bubble to the Perseus Arm

1.2- Project Category: 3

1.3- Abstract:
One of the most important astrophysical phenomena which is needing a comprehensive explanation is star formation, specially in the low-mass range, down to substellar masses, specially in an environment as different as the Perseus Arm, located beyond 2 kpc, when compared with the Local Bubble. This E-ELT proposal deals with this issue and several specific questions: i) evolution of Young Stellar Objects, specially for Very Low Luminosity Objects, and those having also very low mass. ii) Protoplanetary disk properties (accretion, ices and grains) and evolution. iii) Multiplicity in very low-mass, very young objects. Observations done at different wavelengths and taken with different techniques would provide (together with the data in the literature) an uniform database, a requirement for accurate classification of Young Stellar Objects. Spectral features available such as H(alpha), Br(gamma), CaII IRT (stellar classification, accretion and age indicators) in the optical, and

on the other hand PAH, ices and silicates from the disk in the mid-IR will allow to link stellar and disk evolution. Multiplicity and disk morphology in young, embedded objects will be tackled with mid-IR imaging. Here we propose to create a platform of observational data, complemented with theoretical interpretation, on which a sound paradigm for the stellar and brown dwarf formation and early evolution can be built.

1.4- Publication agreement: no

2.1- PI: David Barrado y Navascués

2.2- CoIs: de gregorio

2.3- Institute: LAEX-CAB, Centro de Astrobiologia, INTA-CSIC

2.4- Country of Employment: ES

2.5- Career Stage: faculty

2.6- E-mail: barrado@laeff.inta.es

3.1- Source of targets: GTC, Spitzer, IRAM, Subaru, VLT, VISTA, UKIRT

3.2- Preparatory work on targets required?: yes, wide survey

3.3- Target brightness: 1e-5, 1e-3, mJy, J

3.4- Target size: point source

3.5- Number of targets: 300

3.6- Density of targets: N/A

3.7- Target coordinates: RA:20 - 6;Dec:-15 - +70

3.8- Moving target?: no

3.9- Variable target?: yes, N/A

3.10- Target type: star

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 600 - 20000, V, R, I, J, H, K, L, M, N, Q

5.2- Spectral Resolution: 300-500, 2000-3000, 10000-20000

6.1- Instrument: EAGLE, MICADO, HARMONI, METIS, OPTIMOS

6.2- Desired special mode: precision photometry, coronography, N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.1, 3, 0,8 arcsec, 1.15 AM

7.2- Longest continuous observation time on a target or field: 3

7.3- Shortest integration time on a target or field: 360

7.4- Total time: 300

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

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7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, VLT/VLTI, SKA/SKAPF, other, IRAM, GTC

9.2- Critical aspects / limiting factors for the science case:
No critical factor

9.3- Detailed description or other comments:
The first Class 0, very low luminosity protostar in Taurus were discovered by Andre et al. (1999). Later on, Kauffmann et al. (2005) presented an object with Lum<0.1 Lsun, which could be the first Class 0 substellar object. In this same association, about 1 Myr old, Class II (CTTs) and Class III (WTTs) objects can be found, with very different Spectral Energy Distribution, despite the fact they should be coeval. Spitzer observations have revealed that some of these Class III stars have transition disks (Calvet et al. 2005), which present a large cavity between the star and the internal edge of the disk. Nowadays, there is a significant number of coeval, low luminosity objects in several star forming regions which have very different properties. The classification by Lada et al. (1987) suggests that there is a monotonic evolution Class 0 to Class II phase in less than 1 Myr. However, the fact that a very well-known association such as Taurus contains Class 0, I , II and III objects argue against this simple scenario. We propose to revisit the problem with a holistic perspective, with a wide wavelength coverage. Moreover, we need to extent our detailed star formation studies away from the solar neighborhood. The Perseus Arm, located beyond 2 kpc, is an ideal hunting ground, which avoids the much larger confusion present in the galactic center direction.

Specific goals:

i) The central object.-
The spectral typing can be achieved with low-medium resolution in the optical. However, the presence of accretion might hinder the classification, since the excesses, together with veiling change both the spectral shape and the depth of the spectral features. Moreover, the classification is even more complicated for embedded objects, since they might be not detectable in the optical or even at near-IR the confusion with the medium might be very important. Mid-resolution spectra are required for a more sophisticated analysis, such as the surface gravity (and, hence, the true age), which can be estimated with several alkali doublets detectable at red and near-IR wavelength. Problems associated to veiling can be overcame using several of them at different bands.

Diagnostics.- Low- and med-res spectroscopy, covering 0.5-1.0 micron only for objects detected at visible wavelengths (OPTIMOS type). Low- and med-red spectroscopy in the ZJHK bands for the whole sample (HARMONI/EAGLE type).

ii) The inner disk and the interaction with the central object: accretion, activity, outflows.-
The optical and near-IR spectroscopy will allow to study lines such as H(alpha), Br(gamma), Pa (beta), HeI6678, CaII IRT, and so on, appear at very different bands, from the optical to the near-IR. Some among them allow to study activity and accreting related phenomena. A similar, complete study in the near-IR is needed, in order to measure accretion rates for obscured objects by envelopes and disks (since the inclination factor might play an important role). Forbidden lines such as [OI], [OII] and [SII] are indicative of the presence of outflows, which are very important to regulate the initial evolution of angular momentum. Rapid rotators will be detected.
Diagnostics.- Med- and high-res spectroscopy, covering 0.5-1.0 micron only for objects detected at visible wavelengths (OPTIMOS type). Med- and high-red spectroscopy in the JHK bands for the whole sample (HARMONI/EAGLE type).

iii) The disk/envelope as a whole.- As clearly shown by different theoretical models, disk evolution is complex issue, even more difficult to tackle if an envelope is taken into account. Different parts of an envelope or a disk can be observe at different wavelengths and produce distinct, complementary phenomena. The stellar photosphere is mainly reachable in the optical; the near-IR opens a window to the disk, for the nearest parts to the star, as we move to longer wavelength, we have access to cooler, more distant parts of the disk. Therefore, only a multiwavelength approach can provide a complete picture of YSO evolution, since any missing piece of the puzzle might be crucial. This analysis is essential to locate any object in a HR diagram and to start to understand its properties (disk mass and size, inclination, etc). We note that models such as Robitaille et al. (2007) are able to fit SEDs, but with a significant number of free parameters. Among them, the disk inter
nal radius and inclination are reliable. In few cases, others such as geometry (flare or flat disk) and the grain size (large or small) can be estimated (Pinte et al. 2008). However, in order to reduce the degeneracy of model fitting, as many as possible SED datapoints (photometry or spectroscopy) are required (Bouy et al. 2008, Huelamo et al. 2007).
Diagnostics.- Complete SED, from the optical to mm wavelengths, for the whole sample.

iv) Ices, PAH and silicates at 10 micron.-
Boogert et al. 2008 conducted a study in 41 low-mass YSO, which show prominent absorption features present at mid-IR. Most of them were attributed to absorption in the vibrational modes of molecules in ices. At the low temperatures of dense clouds and circum-protostellar environments atoms and molecules freeze out rapidly on dust grains. For slightly more evolved objects, broad emission features in the mid-IR start to appear due to grains, whose size seem to grow and to adopt crystalline structures (Apai et al. 2004). As an example, Sicilia-Aguilar has found in the Coronet cluster that about 70% of the members do not show silicate emission or have flat features which should correspond to large grains. This might contradict the results by Furlan et al. (2006), who

have been able to derive a classificatory scheme based on Taurus -ie, coeval- spectra. Finally, transition disks have been found and carefully studies using mid-IR IRS spectroscopy, at least in the case of Tau
rus (Calvet et al. 2005). Paradoxically, much older stars have similar properties. This is the case of the transition disks discovered in the 10 Myr cluster NGC7160, the age when stars are supposing to start assembling big planetesimals and Jupiter-like planets.
Diagnostics.- Low-res optical spectroscopy in the mid-IR (METIS-type instrument).

1.1- Project Title: Resolved Stellar Populations

1.2- Project Category: 2

1.3- Abstract:
The study of galaxy formation and evolution is one of the major goals of modern astrophysics. Much information on the star formation history (SFH) and the chemical and dynamical evolution of galaxies are imprinted in their stellar populations. Medium resolution (R~20,000) spectroscopy in the optical and infrared is a powerful approach to investigate the detailed chemical composition and kinematics of stellar populations in extragalactic stellar clusters and relatively nearby galaxies.

1.4- Publication agreement: yes

2.1- PI: Eline Tolstoy

2.2- CoIs: Livia Origlia

2.3- Institute: Kapteyn Astronomical Institute, Groningen

2.4- Country of Employment: NL

2.5- Career Stage: faculty

2.6- E-mail: etolstoy@astro.rug.nl

3.1- Source of targets: VLT, HST, JWST, ELT

3.2- Preparatory work on targets required?: yes, pre-imaging

3.3- Target brightness: 20, 28, Vegamag, I

3.4- Target size: point source

3.5- Number of targets: 1000

3.6- Density of targets: 1

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +90

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 50, 3

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 500 - 2500

5.2- Spectral Resolution: 5000-10000, 10000-20000

6.1- Instrument: HARMONI

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 100, N/A

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 3600

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7.4- Total time: 1000

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
optical wavelength with a reasonable throughput (PSF not so important, but light down the slit is)

9.3- Detailed description or other comments:
Until now sensitivity and resolution limitations have meant that detailed spectroscopic studies of individual stars have only been possible within the Local Group and mostly around our own Galaxy. The Local Group contains only two massive galaxies (spiral systems M31 and the Milky Way) and around 40 smaller, mostly dwarf, galaxies. This means that massive galaxies still await careful scrutiny. To make significant progress we need to study large numbers of resolved stars in a range of galaxy types and this requires us to look beyond the halo of the Milky Way and even the Local Group. The Virgo cluster is the real prize for studying elliptical galaxies. Virgo at an average distance of 17Mpc, with over 2000 member galaxies of all morphological types, is the nearest large cluster of galaxies. There are also a large variety of (late-type) spiral systems in nearby galaxy groups, such as Sculptor (in the south) or M81 (in the north) both around 2.5Mpc distance. There are also nearby
starburst galaxies such as NGC1569 and NGC1705, and compact (early-type) dwarf elliptical galaxies such as M32, NGC205, and NGC185 in the Local Group. There are faint low surface brightness systems, such as DDO154 (~4Mpc). There are two close by elliptical galaxies: CentaurusA at 3.5Mpc and NGC3379 at 10Mpc.
The basic requirements to make direct measurements of the chemo-dynamical properties of resolved stars as probes of the evolutionary history of a range of systems beyond the halo of the Milky Way are accurate velocity measurements (where accurate means a velocity resolution less than expected velocity dispersion) combined with metallicity indicators for samples covering their different components (e.g., thin disc, thick disc, halo, bulge). This technique has been known to accurately separate the different components of our Milky Way (e.g., Eggen, Lynden-Bell & Sandage 1962, ApJ, 136, 748; Venn et al. 2004, AJ, 128, 1177) and also more distant systems such as dwarf galaxies (e.g., Tolstoy et al. 2004, ApJL, 617, 119). These observations enable an accurate study of the current dynamical state and thus dark matter masses and distributions of these systems

as well as their chemical evolution (e.g., Battaglia 2007, PhD Thesis, Univ. of Groningen). Systematic and homogeneous spec
troscopic surveys aimed at measuring key chemical elements released by stars with different mass progenitors and hence on different time scales, have also a strong astrophysical impact in drawing the global picture of galaxy formation and evolution. Alpha elements are synthesized in type II supernovae (SN) with massive progenitors and released into the interstellar medium right from the initial onset of star formation. Iron-peak, C, N, and s-process elements are mainly produced in Type Ia SN and Asymptotic Giant Branch stars, with low-intermediate mass progenitors and released at later epochs (after ~1 Gyr). The [alpha/Fe] abundance ratio is thus a powerful tracer of the relative enrichment by type II and Ia SN at any given time in the SFH of a galaxy.
Most abundance work to date on resolved stellar populations has been done in the optical. But more will be learnt from CRIRES, for example. We can determine what can be done in the IR, e.g., CNO, alpha elements, Fe, Al, Na all have useful IR (atomic and molecular) lines. But the study of Li, atomic C lines and r & s-process elements will always require optical spectroscopy. Optical spectroscopy is also best suited to study resolved warm giants and Main Sequence stars in galactic environments not severely affected by extinction. The near infrared spectral region is best suited to study both resolved and integrated cool stellar populations in the nuclear region of galaxies, where extinction can be severe.

1.1- Project Title: A Spectroscopic Survey of Globular Clusters in Coma: Early Galaxy Formation and Dark Matter Content.

1.2- Project Category: 2

1.3- Abstract:
Spectroscopy of globular clusters (GCs) around external galaxies provides invaluable information on the main episodes of star formation in the Universe, as well as on the distribution of dark matter at large galactocentric distances. Unfortunately, there is a lack of spectroscopic studies of GCs in truly high-density environments where, according to detailed stellar population analysis and recent theories of galaxy formation, massive galaxies could form ~2 Gyr earlier. This proposal outlines how ELT/OPTIMOS would provide, for the first time, spectra for thousands of Coma GCs, thereby constraining the epoch of GC/galaxy formation and the baryonic and dark matter distribution throughout the cluster.

1.4- Publication agreement: yes

2.1- PI: A. J. Cenarro

2.2- CoIs: D. Carter (Liverpool John Moores University)

2.3- Institute: Instituto de Astrofisica de Canarias

2.4- Country of Employment: ES

2.5- Career Stage: postdoc

2.6- E-mail: cenarro@iac.es

3.1- Source of targets: HST (The HST/ACS Coma Cluster Treasury Survey; P.I. David Carter)

3.2- Preparatory work on targets required?: yes, Precise astrometry and photometry from HST/ACS. This data will soon be available (see

3.3- Target brightness: 23, 26, Vegamag, V

3.4- Target size: extended source, 6, 9

3.5- Number of targets: Thousands of

3.6- Density of targets: ~25 (up to 180)

3.7- Target coordinates: RA:12.93 - 13.02;Dec:+27.1 - +28.2

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star cluster

4.1- Spatial resolution: seeing, ~3

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: >100, 1x1arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: 380 - 580

5.2- Spectral Resolution: 2000-3000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 6, 8, 0.8"""" FWHM seeing, 1.15 airmass, and dark night

7.2- Longest continuous observation time on a target or field: 0.5

7.3- Shortest integration time on a target or field: 600

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: ~20

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, IR spectroscopy of some targets will be possible with NIRSpec

9.2- Critical aspects / limiting factors for the science case:
N/A

9.3- Detailed description or other comments:
1) Scientific rationale

Globular clusters (GCs) are the oldest stellar systems ever discovered. They are known to be fossils of the major star-forming episodes in the Universe, therefore being ideal systems to probe the earliest epochs of galaxy formation
(e.g. Kissler-Patig 2000, RvMA 13, 13; Brodie & Strader 2006, ARA&A 44, 193). Importantly, GCs can be studied in a
wide variety of galaxy types, as all galaxies brighter than M_V ~ -13 host GCs. They are numerous, from several tens in dwarf elliptical galaxies up to several thousands in massive ellipticals, and their

number densities remain high at large galactocentric distances (> 10 r_eff). For the above reasons, GCs are key to advance our understanding of the early
Universe: (i) as simple stellar populations (SSPs), their formation epoch (ages and metallicities) and formation time-scales (alpha-element abundance ratios) provide essential clues to constrain the role that the different galaxy formation and
evolution mechanisms (e.g.~major/minor mergers, accretions, monolithic collapse) could have in their host galaxies; (ii) GCs provide complementary information on galactic kinematics aside from the one derived from galactic stellar light and/or planetary nebulae (Romanowsy et al. 2009, AJ 137, 4956). They are ideal systems to constrain the baryonic and dark matter content of galaxies over a range in mass out to large galactocentric distances, which is crucial to test the current predictions of the Lambda-CDM cosmology.

Recent photometric studies over large samples of galaxies (e.g. Peng et al. 2006, ApJ 639, 95; Strader et al. 2006, AJ 132, 2333) confirm that the metallicity distributions of GCs are mostly bimodal -similarly to the Milky Way GC system, with a metal-rich (MR) and metal-poor (MP) population- and scale with galaxy mass. Unfortunately, since broad-band colours are strongly affected by the age-metallicity degeneracy (Worthey 1999, ASPC 192, 283), the above studies cannot provide accurate GC ages below Delta[log(age)]~0.25 (Carter et al. 2009, arXiv0905.0810). Aimed at understanding the origin of GC bimodality, optical spectroscopic studies of extragalactic GCs conducted at large telescopes have determined accurate GC ages, metallicities, and [alpha/Fe] abundance ratios on the basis of line-strength indices and SSP models for a wide variety of galaxy types (see Brodie & Strader 2006, ARA&A 44, 193). The fact that the vast majority of both MP and MR GCs in early-type galaxies seem
to be old (>10 Gyr; e.g. Strader et al. 2005, AJ 130, 1315; Cenarro et al. 2007, AJ 134, 391) has favoured the idea that most GCs formed at very high redshift. MP GCs are thought to form in the early Universe inside low-mass halos that, ultimately, would end up constituting more massive galaxy halos through accretion processes (e.g. Rhode et al. 2005, ApJ 630L, 21; Strader et al. 2005, AJ 130, 1315), whilst MR GCs could form slightly later along with the bulk of the field stars in massive early-type galaxies and spiral bulges (e.g. Forbes et al. 1997, AJ 113, 1652; Beasley et al. 2002, MNRAS 333, 383).

2) Why spectroscopy of GCs in Coma?

In practice, typical spectroscopic studies of GCs in 8-10m telescopes are limited to V < 22.5. Since GCs follow a universal log-normal luminosity function that peaks at M_V ~ -7.4 (V ~ 24 at the distance of Virgo), only the brightest objects in nearby galaxies (say < 25 Mpc) have been reasonably observed so far. All these galaxies are either in the field or in low-density galaxy groups/clusters, such as Virgo and Fornax. However, we still lack of spectroscopic studies of GCs in high-density
environments, where both observations and theory concur massive galaxies may have formed up to 2 Gyr earlier (at z ~ 5) than in the field (e.g. Thomas et al. 2005, ApJ 621, 673). To probe truly high-density environments we need to go to Coma, the richest galaxy cluster in the local Universe. However, at ~100 Mpc, the Coma GC systems are out of reach of 8-10m telescopes.

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The Coma GCs are ideal targets for the future EELT. By having a multiobject optical facility at EELT (e.g. OPTIMOS), typical
spectroscopic studies of GC systems can be extended out to galaxies in Coma. As such, it constitutes a unique window to study in detail the stellar populations of GCs which formed in very dense and dynamically relaxed (older) environments, as well as to test the different paths of GC formation. We therefore propose to carry out a extensive spectroscopic survey of GCs in the Coma cluster that will allow us to measure their stellar population properties (ages, metallicities, and [alpha/Fe] ratios) and kinematics, and compare with similar studies in Virgo/Fornax and isolated galaxies. If massive galaxies in rich clusters indeed formed earlier than in low density environments, we should find unequivocal signatures in the ages and metallicities of their GC systems, which in turn may depend on the host galaxy mass and its local environment within the cluster (e.g. Peng et al. 2008, ApJ 681, 197). This spectroscopic survey will also offer a unique opportunity to test the nature of f
ree-floating intracluster GCs (e.g. Yahagi & Bekki 2005, MNRAS 364L, 86; Williams et al. 2007, ApJ 654, 835). If they were the results of GCs formed in low-mass halos that have not been accreted yet, we would expect them to be very old and MP. The recent finding that ~20% of free-floating GCs in Coma are MR (Peng et al. in preparation) suggests the existence of highly efficient mechanisms of GC stripping, galaxy harassment and fly-by encounters within the cluster. In addition, the GC kinematics will put constraints on the amount and distribution of dark matter halos around Coma galaxies and throughout the cluster, a direct estimate to compare with the expectations for NFW Lambda-CDM halo density profiles.

The HST/ACS Coma Treasury Survey (Carter et al. 2008, ApJS 176, 424) has mapped the core and outskirts of the Coma cluster with 25 ACS pointings. Catalogs and GC selection are due for public release during 2009. This will constitute our reference GC database for the proposed spectroscopic follow-up, so no additional pre-imaging for GC selection is required for this project.

3) Technical observing requirements

At a distance of ~100 Mpc, the GC luminosity function in Coma peaks at V=27.7 (sigma ~1.5 mag; Harris et al. 2009, AJ 137, 3314). Using the available EELT Exposure Time Calculator we estimate that, in 8 h integration time, it will be possible to get reliable kinematics for GCs with V<26 (S/N > 7 per angstrom) and stellar populations for GCs with V<25 (S/N > 18 per angstrom). In a sense, EELT will allow to do in Coma the same science that it is being done in Virgo and Fornax from 8-10m class telescopes. For this project, it is not required neither AO nor high spectral resolution (seeing-limited optics and R=2500 suffices for both kinematics and stellar population analysis). Using typical GC number densities in Coma galaxies from Harris et al. (2009, AJ 137, 3314), we expect, on average, ~600 GCs with V<26 within a 5"X5" FoV (OPTIMOS), and up to ~180 GCs per square arcmin in the densest regions of Coma. A high multiplex is therefore required.

1.1- Project Title: Constraining reionisation with Lyman-alpha emitters in the young Universe

1.2- Project Category: 2

1.3- Abstract:
How and when reionisation happened in the young Universe is today one of the large, unanswered questions in cosmology. The type of galaxies called Lyman-alpha emitters, detected through their bright emission in the Lyman-alpha line, are one of the most promising probes of the reionisation era. Here we propose to confirm a sample of Lyman-alpha emitting candidate galaxies, found in narrow-band imaging surveys at other telescopes. The goal with this program is to put a strong constraint on exactly when reionisation occurred, and possibly on what type of galaxy was involved in this transition.

1.4- Publication agreement: yes

2.1- PI: Kim K. Nilsson

2.2- CoIs: Johan P.U. Fynbo, the ELVIS team

2.3- Institute: Space Telescope European Coordinating Facility

2.4- Country of Employment: ESO

2.5- Career Stage: postdoc

2.6- E-mail: knilsson@eso.org

3.1- Source of targets: VISTA

3.2- Preparatory work on targets required?: yes, assumes completion of the ELVIS/Ultra-VISTA survey

3.3- Target brightness: 24.1, 24.1, ABmag, J

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: 0.02

3.7- Target coordinates: RA:10 - 10;Dec:02 - 02

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3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: seeing, N/A

4.2- Field-of-view: 30x30arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A, N/A

5.1- Wavelength range: J, H, K

5.2- Spectral Resolution: 1000-2000

6.1- Instrument: HARMONI

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 1, single line detection, scaled with X-shooter NIR ETC

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

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8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: other, VISTA

9.2- Critical aspects / limiting factors for the science case:
Wavelength range, exposure time per target.

9.3- Detailed description or other comments:
The ELVIS (Emission Line galaxies with VISTA Survey, part of the Ultra-VISTA survey, see also Nilsson et al. 2007) will in five years create a catalogue of thousands of emission line galaxies in the COSMOS field, of which the majority will be H-alpha emitters, some oxygen emitters and some will be z = 8.8 Lyman-alpha emitters (LAEs). With these LAEs it will be possible to constrain the level of ionised gas at this redshift and thus put a constraint on when reionisation happened. Before the ELT, it will be difficult to do follow-up spectroscopy on these candidates, and only the best will be observed. With the ELT, even the weakest emission line detected in the narrow-band survey will be detected in only one hour of observing and it will then be possible to follow up on all potential LAE candidates, as well as other emitters with unusual characteristics. It will also be possible to search for signs of Pop III stars, through the He II line or the continuum slope.

Target brightness is in the VISTA narrow-band.

1.1- Project Title: The dark nature of ultra-compact dwarf galaxies

1.2- Project Category: 2

1.3- Abstract:
Ultra-compact dwarf galaxies (UCDs) have recently been established as a new kind of hot stellar systems. With masses in the range 106 to 108 M_sun and half-light radii of 10-100 pc, UCDs show properties in between those of globular clusters (GCs) and early-type dwarf galaxies. They follow a mass-size relation and their mass-to-light ratios are about twice as large as those of GCs with comparable metallicities. It is speculated whether the elevated M/L values are due to dark matter or a non-canonical stellar initial mass function. So far, due to their remoteness and their compactness, no spatially resolved information could be gathered for UCDs. The high spatial resolution and collecting power of the E-ELT is crucial to bring light into the dark nature of these enigmatic objects.

1.4- Publication agreement: yes

2.1- PI: Michael Hilker

2.2- CoIs: N/A

2.3- Institute: ESO/Garching

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: mhilker@eso.org

3.1- Source of targets: VLT

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 18.5, 21.5, Vegamag, V

3.4- Target size: extended source, 100, 1000

3.5- Number of targets: 30

3.6- Density of targets: 3

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star cluster

4.1- Spatial resolution: 50, 3

4.2- Field-of-view: 2x2arcsec

4.3- Multiplexity and pick-off FoV: 3600, slitlet

4.4- Plate scale stability: N/A

5.1- Wavelength range: 550 - 900, I

5.2- Spectral Resolution: 1000-2000, 10000-20000

6.1- Instrument: HARMONI, SIMPLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: LTAO

7.1- Integration time per target or field and per setup: 0.5, 1.0, 0.8

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 60

7.4- Total time: 30

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 0.5

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
The science case strongly relies on a high spatial resolution combined with a high spectral resolution. Since the targets have apparent visual magnitudes of the order $19<V<21$, AO assistance from laser guide stars is needed.

9.3- Detailed description or other comments:
Most of the ultra-compact dwarf galaxies (UCDs) known to date are predominantly metal-rich and reside in the cores of nearby galaxy clusters. The best studied environments are the Fornax and Virgo galaxy clusters. Due to their remoteness and their compactness (half-light radii of 10-100 pc), UCDs cannot be resolved into singles stars (or even spatially resolved) with currently existing telescopes/instruments. Their metallicities, alpha abundances, ages and internal kinematics so far have to be deduced from integrated spectral properties and multi-wavelengths imaging.

In order to unveil the nature of UCDs, i.e. whether they contain dark matter or whether they possess multiple stellar populations, spatially resolved spectra are needed, preferentially from an integral field unit. Whereas the stellar populations can be constraint in the optical from low to medium resolution spectroscopy, a high spectral resolution (corresponding to a radial velocit accuracy of ±5 km/s) is necessary to unveil the internal kinematical structure of UCDs (rotation, velocity dispersion profile, etc.). Since the surface brightness of UCDs rapidly drops in their outer parts, a binning in rings is foreseen to keep the integration time reasonable.

1.1- Project Title: Globular clusters as key tracers of dark matter around giant ellipticals and their formation history

1.2- Project Category: 2

1.3- Abstract:

Giant elliptical galaxies possess systems of thousands of globular clusters (GCs) that reach galactocentric distances of several effective radii. Thus, they can be used as kinematical probes of the gravitational potential of their host galaxies which is supposed to be dark matter dominated in the outskirts. In nearby galaxy clusters, the typical luminosity of GCs is about V=24-25 mag. So far, only the brightest GCs (V<22 mag) were covered by spectroscopic surveys on 8-metre class telescopes. Since the luminosity function of GCs is steeply rising towards fainter magnitudes, radial velocities of thousands of GCs can be obtained with a few pointings of a wide-field multi-object spectrograph on E-ELT. This would enable us to study the velocity distribution of GC sub-populations (metal-poor and metal-trich) around gEs in great detail (higher moments, rotation, anisotropy, etc.).

1.4- Publication agreement: yes

2.1- PI: Michael Hilker

2.2- CoIs: N/A

2.3- Institute: ESO/Garching

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: mhilker@eso.org

3.1- Source of targets: VLT, Gemini, CTIO

3.2- Preparatory work on targets required?: yes, pre-imaging, wide 2-colour imaging

3.3- Target brightness: 22, 25, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: >1000

3.6- Density of targets: 10-50

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star cluster

4.1- Spatial resolution: seeing, 3

4.2- Field-of-view: 10x10arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 550 - 900, R

5.2- Spectral Resolution: 1000-2000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

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7.1- Integration time per target or field and per setup: 0.2, 2, seeing 0.8" in V, airmass 1.2, grey time

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: 60

7.4- Total time: 20

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 0.75

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
This science case relies on optical multi-object spectroscopy in a relatively wide field (10x10 arcmin) combined with a low spectral resolution (<=1000).

9.3- Detailed description or other comments:
The (central) giant ellipticals (gEs) in galaxy clusters are regarded as the end-products of hierarchical galaxy formation. Although large photometric and spectroscopic surveys have revealed the gross properties of brightest cluster galaxies over a fair redshift range, their detailed assembly history still is widely unknown. The rich globular cluster (GC) systems of gEs in nearby galaxy clusters provide us with the ideal test particles for constraining the mass and shape of their dark matter halos - by using GCs as kinematical tracers -, as well as for studying their main star formation epochs - by investigating the properties of metal-poor and metal-rich GC sub-populations. Only few large kinematical data sets of GCs around gEs have been acquired so far due to the apparent faintness of the GCs. More data are needed to fully exploit this powerful tracer population and gain a complete picture of gE formation.
The collecting power of the E-ELT combined with a relatively wide field (10x10 arcmin) would enable us to multiply the radial velocity measurements of GCs by a factor of 3-4, i.e. getting thousands of kinematical probes, thanks to the rapidly increasing number of GCs towards fainter magnitudes (the typical GC has a absolute luminosity of M_V=-7.5 mag, which corresponds

to V=24 mag at the distance of the most nearby gEs).
With thousands of kinematical data points in hand the velocity distribution of GCs around gEs can be studied in detail, i.e. higher moments can be obtained and the mass-anisotropy degeneracy alleviated, in particular by comparing the distribution and kinematics of metal-poor and metal-rich GCs. Moreover, chemical abundances and ages can be estimated for a large sample of GCs via line index measurements, and finally the kinematics of chemically distinct sub-populations of the GC systems can be used to constrain the formation history of gEs.

1.1- Project Title: Dwarf spheroidal galaxies in the Perseus Cluster

1.2- Project Category: 2

1.3- Abstract:
We propose to use the E-ELT equipped with an optical multi-object integral-field spectroscope to obtain detailed maps of the stellar kinematics and the stellar population properties (mean age and metallicity, star-formation histories) for a large sample of dwarf spheroidal galaxies (dSph) in the Perseus Cluster. This project builds on our HST/ACS/WFPC2 survey of the Perseus dSphs. Using dynamical modeling, we will determine the spatial dark-matter distribution in these dwarfs. We will compare the observed stellar populations properties with numerical simulations in order to test theories for dwarf galaxy evolution and the interplay between internal (star formation, supernova feedback) and external (interactions, ram-pressure stripping) influences.

1.4- Publication agreement: yes

2.1- PI: Sven De Rijcke

2.2- CoIs: C. Conselice (Nottingham, UK), S. Penny (Nottingham, UK), S. Valcke (Gent, Belgium), M. Koleva (IAC, Spain), P. Prugniel (CRAL, France)

2.3- Institute: Gent University

2.4- Country of Employment: BE

2.5- Career Stage: postdoc

2.6- E-mail: sven.derijcke@UGent.be

3.1- Source of targets: HST/ACS and HST/WFPC2

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 18, 22, ABmag, V

3.4- Target size: extended source, 500, 1500

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: RA:03 - 03;Dec:41 - 41

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: 250, 20

4.2- Field-of-view: 10x10arcmin

4.3- Multiplexity and pick-off FoV: 10, 5x5arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: 350 - 750

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: other, Multi-object Integral-field Spectrograph with deployable IFUs, covering the optical age and metallicity sensitive absorption lines

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 3, 4, N/A

7.2- Longest continuous observation time on a target or field: 4

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7.3- Shortest integration time on a target or field: 3

7.4- Total time: 50

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: other, HST

9.2- Critical aspects / limiting factors for the science case:
both the multi-object and the IFU aspect of the observations are critical. With a multi-object spectrograph, large samples of dwarf galaxies can be observed in dense environments such as galaxy clusters. The IFU would allow us to derive 2D information (kinematics, stellar populations) which is crucial for a proper comparison with numerical simulations. The multi-object aspect saves valuable observing time; the IFU aspect is science driven. Coverage of the optical absorption lines that contain age and metallicity information (the Balmer lines and the Ca, Fe, and Mg lines) and the emission lines linked to star formation between 350 and 750 nm is crucial to unravel the star-formation histories of faint galaxies in nearby clusters.

9.3- Detailed description or other comments:
DWARF SPHEROIDALS : INTRODUCTION

Dwarf spheroidal galaxies (dSphs) are faint stellar systems ($M_V > -14$ mag) with smooth elliptical isophotes. They show a strong predilection for high-density environments, residing not more than a few hundred kiloparsecs away from massive galaxies and in dense groups and clusters of galaxies (Mateo 1998; Grebel, Gallagher & Harbeck 2003). This very pronounced morphology density-relation shows that the environment plays a crucial role in the evolution of dwarf galaxies. Indeed, dwarf galaxies, due to their low mass, should be very sensitive to their surroundings through gravitational interactions (Moore et al. 1998; Mastropietro et al. 2005), ram-pressure stripping (Mori & Burkert 2000) or both processes acting simultaneously (Mayer et al. 2006) and to supernova feedback (Valcke
et al. 2008; Stinson et al. 2009). These effects are expected to dramatically affect the morphologies and star-formation histories (SFHs) of dwarf galaxies. Therefore, observations of the internal kinematics and stellar-population characteristics of low-mass galaxies are crucial to improve our understanding of galaxy formation and evolution in general.

In the course of a survey of the Perseus Cluster using HST/ACS and HST/WFPC2, we have obtained detailed photometry of a sample of dSphs down to an absolute V-band magnitude of M_V=-12 mag (De Rijcke et al. 2009; Penny et al. 2009). The Perseus Cluster (Abell 426) is one of the richest nearby galaxy clusters and, as such, constitutes a galaxy environment that is markedly different from the Local Group or the Virgo and Fornax Clusters and comparable in galaxy density to the Coma Cluster. It also hosts the peculiar and X-ray bright central galaxy NGC 1275 (Conselice et al. 2001). Clearly, this is a very extreme environment, bringing out the details of how the environment influences dwarf galaxy evolution.

DARK MATTER : SURVIVING THE DENSE CLUSTER ENVIRONMENT

Using a novel photometric method, we estimated the mass-to-light ratios of the Perseus dSphs studied with HST. We found the mass-to-light ratios of these dwarfs to be from a few tens up to a few hundreds, in solar units, comparable to those of the Local Group dSphs (Mateo 1998; Lokas 2002; Kleyna et al. 2005; De Rijcke et al. 2006; Lewis et al. 2007; Mateo, Olszewski & Walker 2008; Penny et al. 2008). This high M/L suggests the presence of copious amounts of dark matter that help protect the embedded stellar body of the dSph against the tidal forces of the massive host galaxy or of the host galaxy cluster or group.

Our photometric M/L estimates of the Perseus dSphs need to be confirmed with estimates based on stellar kinematics. Low surface brightnesses, low metallicities (weak absorption lines) and small internal velocities (narrow lines) conspire to make obtaining the required high-S/N, high-resolution spectra with the currently available facilities impossible. The E-ELT, equipped with an optical multi-object integral-field spectrograph, would be excellently suited to study the dark-matter content of sufficiently large samples of dwarf galaxies in a wide variety of environments.

SCALING RELATIONS : THE FUNDAMENTAL PLANE AND ITS PROJECTIONS

Spheroidal galaxies (bright elliptical galaxies, intermediate-luminosity dwarf ellipticals, and faint dwarf spheroidals) follow the same, continuous scaling relations in diagrams correlating photometric and kinematical parameters (Graham & Guzman 2003; De Rijcke et al. 2005, 2009; Matkovic & Guzman 2005; Janz & Lisker 2008; Misgeld 2009). The slopes of these scaling relations change quite abruptly at certain key luminosities.

At M_V=-19 mag, bright ellipticals give way to dwarf ellipticals. This transition can be explained by galaxy evolution models (Yoshii & Arimoto 1987; De Rijcke et al. 2005; Cody et al. 2009) that include the effects of supernova feedback induced mass-loss. At M_V=-14 mag, the separation between dwarf spheroidals and dwarf ellipticals, again scaling relations change slope (Janz & Lisker 2008; De Rijcke et al. 2009, Misgeld 2009). Based on detailed N-body/SPH simulations of the formation and evolution of dwarf spheroidal galaxies, this slope change has been interpreted as a consequence of the shifting balance between gravity (pulling gas towards the galaxy center) and supernova feedback (blowing gas outwards) in dwarf galaxies with gasping SFHs (Smecker-Hane et al. 1996; Valcke et al. 2008; Stinson et al. 2009; Revaz et al. 2009; Tolstoy, Hill & Tosi 2009).

Data on the internal kinematics and stellar population characteristics (age, metallicity) of Local Group dSphs have revealed chemically
distinct, spatially segregated stellar populations in some of them (Tolstoy et al. 2004; McConnachie et al. 2007). These findings need to
be confirmed by spectroscopic observations of samples of dSphs larger than can be provided by the Local Group. Going to dSphs in nearby clusters (e.g. Coma, Perseus, Virgo, ...) also allows us to study the impact of the environment of their evolution by correlating the
stellar-population properties (age, metallicity, SFH) with cluster galaxy density or galaxy position within a cluster (Koleva et al. 2009).

IMMEDIATE GOAL

The main goal of this proposal is to observe a complete sample of dwarf galaxies in the Perseus cluster, drawn amongs others from our
HST/ACS/WFPC2 Perseus Cluster survey, using integral-field (multi-object) spectroscopy (IFS). The integral-field observations will enable us to study both the kinematics and stellar populations of the targeted dwarfs in two dimensions. From the 2D kinematics, robust estimates for the total amount and the spatial distribution of dark matter can be derived via dynamical modeling (De Rijcke et al. 2006). The 2D distribution of the stellar population properties (e.g. mean age and metallicity, SFH) extracted from the spectra using cutting-edge techniques such as full-spectrum fitting (Koleva et al. 2009), will give us unprecedented insights into the past evolution of dwarf galaxies. These observational results can be compared directly with numerical simulations in order to test theories for (dwarf) galaxy evolution and
to drastically improve the currently used description of star formation, AGN feedback, supernova feedback, etc.

The multi-object capability is crucial to allow us to cover the hundreds of dwarf galaxies present in the Perseus Cluster within a realistic time-frame. Not only this program, aimed at the Perseus dwarfs, will benefit from such a facility. It would evidently also be of great value to other projects studying galaxy evolution in dense environments.

1.1- Project Title: Tracking the first galaxies and cosmic reionisation from redshift 5 to 13

1.2- Project Category: 2

1.3- Abstract:
We propose a deep very high multiplex spectroscopic survey with OPTIMOS-EVE to target large samples of faint distant galaxies to measure their Lya line and other spectroscopic UV restframe features. Our targets will be continuum selected sources previously imaged at visible and near-IR wavelengths with facilities such as VLT, WFC3/HST, and the JWST. The observations will provide unprecedented observational constraints to determine the Lya properties and hence the ionisation state of the IGM from redshift 5 to 13. Simultaneously such a program will also determine the properties of these first galaxies – most likely the principal sources of reionisation – including their ISM, outflows, stellar populations etc.

1.4- Publication agreement: no

2.1- PI: Daniel Schaerer

2.2- CoIs: OPTIMOS_EVE Science Team

2.3- Institute: Geneva Observatory

2.4- Country of Employment: CH

2.5- Career Stage: faculty

2.6- E-mail: daniel.schaerer@unige.ch

3.1- Source of targets: VLT, VISTA, HST, JWST

3.2- Preparatory work on targets required?: yes, deep imaging surveys (foreseen/planned)

3.3- Target brightness: 26, 30, ABmag, J

3.4- Target size: point source

3.5- Number of targets: 300

3.6- Density of targets: up to ~100

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: seeing, >~2

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 800 - 1700

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 20, ~40, standard conditions, science exposure, no overheads

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 480

7.5- Percentage of the total time sufficient to obtain scientifically useful results: ~50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, N/A

9.2- Critical aspects / limiting factors for the science case:

A high multiplex capacity, appropriate to the high expected number density of targets, is of particular importance and great interest, especially for reasons of efficiency. The science case can, however, also be carried out with a lower multiplex.

9.3- Detailed description or other comments:
After the Big Bang, the Universe cooled, and 380000 years its temperature was low
enough for the hydrogen-dominated IGM that pervades the Universe to become neutral. Today the IGM is fully ionised, heated by the integrated ultraviolet emission from galaxies and AGN. Exactly how and when the IGM turned from neutral to fully ionised is a matter of great debate. Furthermore, the sources of reionisation have so far remained elusive, probably due to their faintness.
The quest for these sources, which produce the UV radiation field that re-ionises the IGM,
is therefore intimately related to the search for the first, most distant galaxies.
Tracking the first galaxies and understanding cosmic reionisation is a fundamental
objective where the E-ELT should lead to significant breaktroughs.

As shown by many authors the evolution of the Lya emitter luminosity function (LF(Lya)) with redshift
can be used to derive constraints on the volume weighted neutral hydrogen fraction in the IGM. This technique has e.g. been applied by Kashikawa et al. (2006) to the LF of Lya emitters found with the SUBARU telescope at z=5.7 and 6.5; Ota et al. (2008) have just started to extend it
to z=7 Lya emitters.

Since the LF(Lya) method is sensitive to a larger neutral hydrogen fraction than the Gunn-Peterson test, it is one of the most promising methods to constrain the reionisation history of the Universe. However, the current estimates are subject to considerable uncertainties and most importantly the samples are limited to z<= 6.5. The main uncertainties are due to 1) very small samples of Lya emitters, 2) a small fraction of spectroscopically confirmed Lya emitters, 3) a very limited knowledge
of the source properties such as their star formation rate (SFR), SF history and age, their outflow velocities
etc., and 4) simplifying assumptions in the models used for the interpretation of the data.
Thanks to its unique performances the E-ELT will allow us to eliminate the first three limitations. The
knowledge gained from these observations, in particular the derived source properties, will also be taken into account in the interpretation, for which already very sophisticated codes exist (e.g. Gnedin
& Prada 2004, Iliev et al. 2008 and others). This will allow us to chart cosmic reionisation with unprecedented precision beyond z~6 and probably up to redshift~13, into the Dark Ages.

To achieve this goal we need (i) to determine reliable Lya LFs at different redshifts, (ii) to measure the

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Lya line profiles with sufficient resolution, and (iii) to determine as far as possible other properties of
the sources from spectroscopy in the continuum (ISM kinematics, accurate source redshift etc.) and deep imaging (e.g. UV LF, ages, SF histories, clustering properties).

Flux limits of ~1.e-19 erg s^−1 cm^−2 , a factor 40 deeper than those of the current z~6.5 samples, will be reached over an unprecedented wavelength, i.e. Lya redshift range. At such depths, corresponding
approximately to UV continuum magnitudes 28–30 magAB, the expected source density is high (~3−100
arcmin-2 (Delta z = 1)^−1; see e.g. Choudhury & Ferrara 2007, Richard et al. 2009), and perfectly suited
to the high multiplex of OPTIMOS-EVE.
Lya line profiles will be measured with resolutions R~ 5000, appropriate for the
observed line widths and ultimately required to separate the effect of the IGM transmission
(i.e. the ionisation state of the IGM) from radiation transfer effects in the host galaxy and its close environment, such as galactic winds, known to alter the Lya line profile (see e.g. Santos 2004, Verhamme et al. 2006). The presence of galaxy winds and their properties
(outflow velocity and others) will further be constrained with OPTIMOS-EVE by measurements of interstellar absorption lines and their relative velocities with respect to Lya and to stellar features, extending the techniques well known from current LBG samples (cf. Shapley et al. 2003) to fainter magnitudes. Determining properties such as the UV LF, clustering properties, stellar ages and star formation histories of these high redshift galaxies from imaging is also important to examine how much of the LF(Lya) evolution is due to galaxy evolution (cf. Dijkstra et al. 2007, Ota et al. 2008), and to constrain the sizes of their surrounding HII regions, which also affect the Lya transmission (see e.g. Furlanetto et al. 2006).

In summary, ultra-deep spectroscopy with OPTIMOS-EVE of faint continuum selected sources previously
imaged at visible and near-IR wavelengths with facilities such as VLT, WFC3/HST, and the JWST will provide all the required observational constraints to thoroughly determine the Lya properties
and hence the ionisation state of the IGM from redshift 5 to 13. Simultaneously such a program will also determine the proper ties of these first galaxies – most likely the principal sources of reionisation –
including their ISM, outflows, stellar populations etc.

More precisely OPTIMOS-EVE will allow us to:
* Measure Lya line fluxes typically up to a factor 40 deeper than current samples at z~6.5 in blank fields, ~40 times deeper than searches for Lya emission from z~7–8.5 lensed galaxies, and > 100 times deeper than the current searches at z~8–10 (Stark et al. 2007).
* Extend Lya searches up to z~13, and carry out spectroscopy of galaxies down to ~30 mag, presumably

the dominant population of reionisation sources, with a very high multiplex, unachievable with other
planned E-ELT instruments and perfectly suited to the expected source density.
* Reach an effective Lya transmission f_eff of 10% for very faint objects (mAB = 30) and correspondingly lower values for brighter objects. Even 1 (10) % transmission will be reachable for objects with mAB = 30 (32) for sources behind lensing clusters benefiting from gravitational magnifcation of a factor 10.

Taken together this unique information will allow us to accurately determine the H ionisation fraction
in the IGM and its evolution with redshift, hence to measure the cosmic reionisation history, and to determine important properties of the first galaxies in the Universe.

The targeted depth is 1.e-19 erg s^−1 cm^−2 at 5 sigma, requiring ~40h science exposure.
For each target redshift 2-3 wavelength settings centered on Lya and redward will be obtained.
To trace the redshift evolution, several redshift intervals z_i will be targetted.
For each z_i up to 300-600 rest-frame UV spectra of unprecedented depths will be obtained in ~120h. Four redshift intervals (centered at z~5, 7, 9, 12) could be covered with 480h, providing a truly exceptional sample of high-z galaxy spectra.

1.1- Project Title: Survey for Companions of Jupiter Trojan Asteroids

1.2- Project Category: 3

1.3- Abstract:
The origin and evolution of the Jupiter Trojans is extremely diagnostic of the evolution of the early Solar System. Estimating their physical properties is limited to remote observation, but close study of any binary systems allows a unique insight into their masses and densities. Similarly, the fraction which have companions and the systems"""""""""" properties constrain those evolution of Jupiter Trojans during the early Solar System.

1.4- Publication agreement: yes

2.1- PI: Kevin J. Walsh

2.2- CoIs: N/A

2.3- Institute: Observatoire de la Cote d''Azur

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2.4- Country of Employment: FR

2.5- Career Stage: postdoc

2.6- E-mail: kwalsh@oca.eu

3.1- Source of targets: SDSS

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 20, 27, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 200

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: yes, 12

3.9- Variable target?: no

3.10- Target type: solar system body

4.1- Spatial resolution: diffraction, 4

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: B, V, R, I, J

5.2- Spectral Resolution: bbimaging

6.1- Instrument: MICADO

6.2- Desired special mode: precision astrometry, N/A

6.3- Desired AO mode: best

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7.1- Integration time per target or field and per setup: .05, 1, N/A

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 30

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, Basics....

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
Spatial resolution is the key for this project. JWST will be great for characterization of Jupiter Trojans, but spatial resolution will not be sufficient to go substantially beyond current ground based AO surveys.

9.3- Detailed description or other comments:
The origin and evolution of the Jupiter Trojans is extremely diagnostic of the evolution of the early Solar System. This large popuation are consistently low albedo D-type objects which reside near the Lagrangian points located 60 degrees leading and trailing Jupiter''''''''''''''''s orbit at similar semi-major axes. Different models of Solar System evolution have them forming in place near Jupiter, or alternatively being captured Kuiper Belt objects captured during planet migration (see Morbidelli et al. 2005). A more detailed physical characterization, including binary fraction, binary properties, mass and densities will help place their origin in the Solar System providing a key constraint for planet migration models.

Estimating the physical properties of Jupiter Trojans is limited to remote observation. Photometric and spectroscopic studies can characterize the surfaces, estimating taxonomies and mineralogies. The detection and characterization of any binary systems allows a determination of the combined mass based on Newton''''''''''''''''s third law. Based on relative sizes of the binary components and size estimates from multi-wavelength observations accurate sizes can be determined. This allows an estimate on the density of the asteroid, a property which can otherwise only be measured via spacecraft missions. Combining the density estimate and mineralogical information a characterization of the internal structure of the body can be made, estimating its porosity or void space and infering its collisional history.

Similarly, the fraction of Trojans which have companions and those systems"""""""""" properties constrain the evolution of the entire population during the early Solar System. Binary formation mechanisms vary, from collisions in the Main Belt to dynamical capture mechanisms among the Kuiper Belt. Each mechanism creates binary systems with specific properties and, specifically, capture mechanisms are extremely sensitive to the initial population of bodies during formation. Thus a simple fraction of binaries in a population can imply past evolution, and detailed properties can be strongly diagnostic of where in the Solar System the population was formed and details about its evolution.

Spatial resolution is the major limiting factor in companion searches of Jupiter Trojans. With current technology, companions closer than 0.07 arcseconds are undetectable, and only the largest 10""""""""""s of the Jupiter Trojans are suitably bright to studied. Future large aperture telescopes with vastly improved spatial resolution surveying many more suitable targets are ideal instruments to carry out this survey and vastly improve limits on the known population of Jupiter Trojan companions. Future space based telescopes will provide valuable surface characterization, but ground-based large-aperture telescopes have proven to be the ideal tool to search for close companions.

1.1- Project Title: Rapid Reponse Observation of Gamma-Ray Bursts

1.2- Project Category: 1

1.3- Abstract:

Gamma-ray Bursts are the brightest sources of light on the sky at any redshift for a short period. Provision of a rapid-response mode (RRM) at the ELT would access the light enabling a study of the detailed physical conditions with the GRB host galaxy. Multiple spectra would constrain conditions in the host. High-spatial resolution imaging of GRB hosts would greatly strengthen constraints on the progenitor. Many of the proposed ELT instruments would be suitable for GRB studies assuming a RRM mode is available.

1.4- Publication agreement: yes

2.1- PI: Professor Paul O"Brien

2.2- CoIs: Professor Nial Tanvir, Dr Rhaana Starling, Dr Klaas Wiersema

2.3- Institute: University of Leicester

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: pto@star.le.ac.uk

3.1- Source of targets: Swift, SVOM, EXIST, other GRB monitoring facilities

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 12, 22, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: 25

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 2 per hour

3.10- Target type: GRB

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: longslit

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: B, V, R, I, J, H, K, L, M, U

5.2- Spectral Resolution: bbimaging, 3000-5000, 20000-50000

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6.1- Instrument: EAGLE, MICADO, HARMONI, METIS, OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: LTAO

7.1- Integration time per target or field and per setup: 1, 4, average seeing and sky background

7.2- Longest continuous observation time on a target or field: 4

7.3- Shortest integration time on a target or field: 1800

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: yes, the sources fade rapidly, standard processing with data available for real-time decision making

8.2- Would you welcome remote observing capabilities?: yes, Ability to see automatic pipeline data and make decisions on further observations

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, 10

8.4- Is it Target-of-Opportunity like?: yes, 10

9.1- Synergy with other programmes: ALMA, JWST, VLT/VLTI, SKA/SKAPF, N/A

9.2- Critical aspects / limiting factors for the science case:
The most crucial aspect is rapid response. As each target is different, the capability to decide on instrument use in real-time would be highly desirable. (e.g. switching from imaging to spectroscopy, changing wavelength range depending on redshift).

9.3- Detailed description or other comments:
Over the last decade the advent of rapid response photometry and spectroscopy has revolutionised the study of GRB host galaxies. The ESO VLT facility has led the way on this providing a Rapid-Response-Mode (RRM) capability (few minutes) which has enabled the gathering of data within a few minutes of the GRB location being found. The provision of accurate positions by the Swift satellite (accurate to a few arc-seconds within moments) has allowed for identification of unique

optical/IR counterparts to the fading X-ray source. Where bright enough, a spectrum can be obtained along with an optical/IR location. This capability is now taken for granted and is clearly the way forward for future facilities, including the ELT. Future GRB missions (such as SVOM and EXIST) will provide locations sufficient for rapid follow-up, particularly when combined with data from ground-based robotic facilities. Thus it is highly likely suitable GRB targets will be available for ELT.

Having a much larger telescope combined with a modern AO system will advance the subject in many ways. For example: (a) faster spectroscopy enabling higher time-resolution when using modest resolution gratings; (b) high spectral-resolution observations of bright targets; (c) high spatial-resolution imaging of GRB locations to constrain the progenitor. Early data permit rapid identification of the most interesting targets for further follow-up. A significant fraction of GRBs remain unidentified at present. These sources may be highly reddened, unusually faint or at high redshift. GRBs can be detected out to redshift 15-20 in gamma-rays. A facility such as ELT can located the IR/mid-IR counterparts to such objects which may well be the brightest "first light" sources on the sky.

At all redshift GRBs are the brightest sources of light. For example, the recently discovered GRB090523 at redshift 8.2 was at K~20 when identified (Tanvir et al., 2009, GCN9219). The intrinsic spectra of GRBs are simple power-laws greatly simplifying the identification of spectral features due to the host or intervening material. This enables, particularly at high redshift, a study of galaxies in more detail then available through objects selected in other ways.. Even in the ELT era GRBs may be the only viable route to obtain a high-quality spectroscopic probe of the very highest redshift galaxies. GRBs also fade away allowing subsequent uncontaminated observations of the host galaxy light. The transient, beamed GRB light does not effect its host in the way a QSO does, for example, and thus they provide a more pristine view of the intrinsic properties of the galaxy. Galaxy selection using gamma-rays allows for a more complete sample of host types as it relatively unbiased against heavily enshrouded systems and small, faint galaxies, which may be common in the early Universe.

With an ELT-sized telescope it will be possible to extend the use of spectroscopy, obtaining high-quality spectra sufficient for measuring metallicity and dynamics for host galaxies and extending time-resolved spectroscopy to fainter targets. For the latter technique, the UV radiation from a GRB changes the ionisation state of the surrounding

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gas. This can be tracked using fine-structure and metastable lines (Vreeswijk et al., 2007, A&A, 468, 83) and constrains the location and physical properties of absorbing gas in the host galaxy.

The exact localisation of a GRB on its host galaxy provides information on the progenitor. For long-duration bursts the putative progenitor is a massive star whose location should correlate strongly with regions of high star-formation. For low redshift long bursts the SN can be studied. For short bursts a variety of progenitors have been proposed mostly involving compact-object binaries. Some of these may be given a dynamical kick of several hundred kilometres per second at formation and may thus be observed offset from their host galaxy by the time the GRB occurs. For the nearest GRBs it should be possible to localise to a particular star cluster or (at very low redshift) a globular cluster.

Many of the instruments proposed for the ELT would be suitable for the study of GRBs. Estimating exposure times is problematic due to the wide range in observed magnitudes so those given on the form are for illustration only. For the brightest sources high-resolution spectroscopy is possible (say R=50000) while for faint sources low to moderate-resolution would be used (R=5000). Imaging would be possible to very faint magnitudes (R=29 or so) to localise the burst. The target numbers have been estimated at 25 for 4 hours each but the required time will vary with the particular target. Monitoring is likely but with a sampling pattern that depends on source brightness and behaviour. As wide a wavelength range as possible is good for SED and redshift determination. For faint targets the availability of AO would greatly shorten required exposure times for these point sources.

1.1- Project Title: Direct imaging of exoplanets around nearby main-sequence stars

1.2- Project Category: 3

1.3- Abstract:

Exoplanets search and study is one of the key goals for the astronomy of the next decade. Yet the direct observation of exoplanets remains challenging given the very high contrasts to deal with. N band direct imaging observations beneficiate of more favourable contrast ratii than shorter

wavelengths. We propose a survey of a selected sample of nearby (d<20 pc) main-sequence (F0-M5) stars. We show that given the simulated performances of the ELT-METIS instrument will 1) image self-luminous giant exoplanets down to a minimum limiting mass of ~2 Mj at a distance of 1.2 arcsec 2) be a well-suited instrument to directly image 1Mj warm exoplanets placed on 0.1- 1 AU orbits.

1.4- Publication agreement: yes

2.1- PI: E. Pantin

2.2- CoIs: W.Brandner, B.Brandl, C.Cavarroc

2.3- Institute: CE Saclay

2.4- Country of Employment: FR

2.5- Career Stage: faculty

2.6- E-mail: eric.pantin@cea.fr

3.1- Source of targets: VizieR

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 4, 13, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-80 - +25

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 50, 3?

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 1, 3600

5.1- Wavelength range: N

5.2- Spectral Resolution: nbimaging

6.1- Instrument: METIS

6.2- Desired special mode: coronography, minimum residual jitter (<5 mas) is a must

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: 0.8, 1.2, seeing, thermal background...

7.2- Longest continuous observation time on a target or field: 1.2

7.3- Shortest integration time on a target or field: 3000

7.4- Total time: 120

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, to make decisions in real time concerning coronagraphic performances

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
coronagraphy; differential imaging would allow to gain a significant factor of performances also

9.3- Detailed description or other comments:
Since the announcement of the first exoplanet identified around 51 Peg by radial velocity variations (Mayor & Queloz 1995) almost 350 exoplanets have been discovered. The study of exoplanets is now one of the most active research areas in astronomy. Yet the direct detection of exoplanets

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around other stars remains challenging. For our solar system, the contrast between Jupiter and the Sun is one to 500 million in the visual (V-band) and one to 2 billion in the near-infrared (J-band). The situation improves considerably in the mid-infrared to contrasts of one to 20 million in the M-band and one to 2 million at 11.3 μm (N-band), respectively. Observations at longer wavelength are also accompanied by a well behaved point spread function with the Strehl ratio delivered by the E-ELT AO system increasing from ≈65% in the H-band, to 80% in the L-band, and to 93% at a wavelength of 11 μm according to simulations. Mid-infrared studies of exoplanets promise to be particularly rew
arding as this wavelength region encompasses a plethora of spectral lines and band structures from the multitude of molecules present in planetary atmospheres.

We have simulated the performances of the ELT/METIS instrument in the N-band at 10.65 and 11.3 μm. A standard turbulent atmosphere model followed by 84x84 actuators ELT-like AO system has been considered. We assume that optical seeing would vary between 0.7 and 0.8 arcsec over a timescale of 1 hour integration time. Taking into account non-corrected static aberration errors also a non common path residuals, the wavefront errors are in the range 430-480 nm and the strehl ratii in the range 0.92-0.94. Fig.1 (left panel) displays the relative rejection levels of a primary star as a function of the angular distance at a wavelength of 11.3 um. Direct imaging; coronagraphic imaging using an achromatized 4 quadrants phase mask (4QPM) and differential imaging (DI) modes are considered; we consider also the possibility of mixing the DI and the 4QPM coronagraphy. Not only the 4QPM coronagraphy is essential to avoid any spurious saturation effects at the level of the detector but also
attenuates the star profile by factors in the range 2-10. Since the differential imaging is not part of the baseline instrument, only the sequential PSF subtraction in the 4QPM observing mode is able to provide the 10-5-10-4 rejection levels required to observe a >1 Gyr old giant exoplanet around a main-sequence star at separations in the range 0.05-1.0 arcsec i.e. at orbital distances larger than 0.5 AU for planetary systems closer than 15 pc. Fig. 1 (right planel)assumes a 10 pc away planetary system and displays the residual levels expressed in point source detection limit as a function of the distance to the star for different instrument configuration/modes. We have overplotted the fluxes at 11.3 um of gas giant exoplanets integrated over a filter (assuming Burrows et al.,97 models) having a R=20 spectral bandwidth at a set of chosen distances from the star. While ~3 to 10 Mj self_luminous giant planets are observable at distances of 10 to 2 AU respectively, irradiated 1
Mj giants, given their higher effective temperatures in the!
range 200-400 K (Sudarsky et al., 2003) are brighter (1-10 mJy) and emit most of their flux in the range 5 to 15 um. This type of exoplanets constitute a clear niche for the ELT/METIS instrument. Up to now, very little is know concerning the chemical composition and the structure of giant exoplanets. SPITZER narrow band imaging has provided some clues on the chemical composition and the atmospheric structure of of hot Jupiter exoplanet HD189733b (Tinetti et al., 2007) but a comprehensive study as a function of the orbital separation and planet mass is still required to improve our knowledge on exoplanetary systems. Narrow-band imaging between 8 and 13.5 um of self-luminous and irradiated planets will provide a unique tool to study the atmospheric content and structure of these exoplanets.

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We propose to make a volume-limited (d < 20 pc) survey of F0 to M5 type stars older than ~1 Gyr in the solar neighbourhood. At the time that METIS will observe we expect (based on current planet detecitonstatistics) that more than 100 planetary systems (over more than 700 stars) will have been discovered by the VLT/SPHERE instrument within 20 pc. Since we need about 1 hour of observing time per target we will establish a prioritary list based on SPHERE results.

References:

- Sudarsky, D., Burrows, A. and Hubeny, I., 2003, ApJ, 588, 1121
- Burrows, A., et al., 1997, ApJ, 491, 856
- Léger et al. 2004, Icarus 169, 499
- Mayor M., Queloz, D. 1995, Nature 378, 355
- Tinetti, G., et al., 2007, Nature, 448, 169

1.1- Project Title: Dwarf Galaxies in the Coma Cluster: probing the faint end of the luminosity function in dense environments.

1.2- Project Category: 2

1.3- Abstract:

We propose to use integral-field (multi-object) spectroscopy on E-ELT to obtain high-spatial resolution maps of the stellar kinematics, absorption line strengths and ionized gas properties for a complete sample of dwarf galaxies in the Coma Cluster, drawn from the HST/ACS Coma Treasury Survey. These observations, and in particular the two-dimensional perspective they provide, will allow us to study the presence of kinematic substructures, the internal variation of metallicity and age, and the connection of the stellar (and gas) kinematics with the local metal enrichment in these galaxies. The results, combined with dynamical models, will allow us to recover the internal stellar population and mass distributions in dwarf galaxies, and hence also to investigate their location in the Fundamental Plane of giant ellipticals. This will help us understand the nature and origin of dwarfs, which, given their mere dominance in clusters as well as their importance as potential building

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blocks of giant ellipticals, is key in drawing a complete picture of galaxy formation and evolution.

1.4- Publication agreement: yes

2.1- PI: Jesus Falcon-Barroso

2.2- CoIs: M. Koleva, A. Bosseli, S. De Riejke, J. Gorgas, R. Guzman, R.F. Peletier, Ph. Prugniel, A. Vazdekis

2.3- Institute: Instituto de Astrofisica de Canarias

2.4- Country of Employment: ES

2.5- Career Stage: postdoc

2.6- E-mail: jfalcon@iac.es

3.1- Source of targets: HST/ACS Coma Treasury Survey

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 17, 25, Vegamag, I

3.4- Target size: extended source, 5000, 10000

3.5- Number of targets: 370

3.6- Density of targets: 3

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy cluster

4.1- Spatial resolution: 250, 2

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

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5.1- Wavelength range: 350 - 700

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: other, Multi-object, Integral-field Spectrograph (10 deployable IFUs, 10arcsec x 10arcsec per IFU). The closest from the proposed instrumentation is OPTIMOS (if it offers an IFU mode).

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 4, scaled from VIMOS IFU ETC and after some spatial binning (5x5 spaxels) with seeing: 0.8 arcsec , airmass:1.6 and lunar phase: 3 days from new moon

7.2- Longest continuous observation time on a target or field: 4

7.3- Shortest integration time on a target or field: 1

7.4- Total time: 150

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: other, HST

9.2- Critical aspects / limiting factors for the science case:
The availability of the requested instrumentation (deployable IFUs) is key to make the observations of the full sample viable. In case of single IFU the number of targets will get significantly reduced.

9.3- Detailed description or other comments:
Dwarf galaxies (dGs) are small, low-luminosity galaxies which constitute the dominant population of galaxies. While early-type dGs (i.e. dwarf ellipticals, dEs) are mostly found in clusters and

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groups of galaxies, star-forming (late-type) dGs are predominantly found in the field (Dressler et al. 1980; Binggeli et al. 1988). Indeed, dwarf galaxies alone outnumber high luminosity galaxies by a factor of six in the Local Group (Mateo 1998), and they represent more than 50% of the galaxies in the Virgo cluster (Sandage et al. 1985). This very pronounced morphology density-relation for dwarf galaxies shows that the environment plays a very important role in their evolution. Being small and fragile they are a unique tool to study galaxy-to-galaxy and galaxy-intergalactic medium interactions.

As potential building blocks of massive galaxies in hierarchical frameworks of galaxy formation, dGs may provide important clues on the main processes involved in galaxy assembling and evolution. Unfortunately, the origin of dGs is still a matter of debate with various scenarios for their origin being proposed: (1) They might be primordial objects formed from density fluctuations in which some of them might have expelled their gas in early stages of their evolution because of supernova explosions (e.g. Mori & Yoshii 1999). (2) dGs could be the by-product of late-type disky galaxies that entered the cluster ~5 Gyr ago and evolved into a hot spheroid because of internal dynamical processes (Conselice et al. 2001). Under this scenario, dGs might still keep some memory of their origin. In fact, there exists a growing number of evidences for the existence of stellar disks, bars, spiral structures, and kinematically decoupled cores in the central regions of dGs (e.g. de Rijcke et a
l. 2003, 2004; Thomas et al. 2006; Chilingarian et al. 2007). Tidal harassment within the cluster can also account for these substructures (Dressler et al. 1980). (3) Tidal origin,
where gas-rich dwarf galaxies are formed from material liberated during galaxy collisions and/or mergers (Okazaki & Taniguchi 2000). Despite their relevance to draw a complete picture of galaxy formation and evolution, the efforts to understand the nature of dGs as well as their possible connection with the more massive classical ellipticals, are still in their infancy. The relation between early and late type dwarfs is not fully understood either. While there is observational evidence in favour for dIrrs to be the progenitors of dEs (e.g. light profiles, rotation, SFHs, gas and dust content), there are other properties (metallicity gradients, globular cluster frequency, metallicity-luminosity relation) that require explanation.

At present, with the current observational facilities, we have been able to study the star formation histories (SFHs) of dwarf galaxies only in sparse environments (e.g. the Local Group) and slightly denser clusters (e.g. Virgo, Fornax), essentially limited by their distance. Very little is known about the properties of this class of objects in dense environments. In this respect, the Coma Cluster (the densest, nearby cluster) offers an unique opportunity to explore the complex nature of these systems in an extremely harsh environment, where interactions between the galaxies and the surrounding medium are more acute. The advent of the E-ELT will allow us to overcome the distance limitations (and therefore low-luminosity regimes) and to explore the nature of dGs with the same level of detail of their nearby counterparts.

The main goal of the proposed project is to observe a complete sample of dwarf galaxies in Coma cluster, drawn from the HST/ACS Coma Cluster Treasury Survey, using integral-field (multi-object) spectroscopy (IFS). The ACS survey represents the most complete sample of galaxies in Coma down to MI=-10 mag, reaching the faintest galaxy levels ever observed on the cluster. The

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integral-field observations will enable us to study both kinematics and stellar populations of dGs in two dimensions, allowing for an unprecedented view of their mass distribution and star formation history. The high-spatial resolution and in particular the two-dimensional capability of the integral-field spectrograph will be crucial to accurately identify and characterize any substructure present in the central regions of dGs, as well as essential to recover the internal dynamics. More specifically, the IFS data will allow us to study the different formation scenarios for these systems, by: (1) establishing
the nature and extent of
any kinematically decoupled components in two dimension; (2) mapping ages and metallicities across the galaxies; (3) determining the mass distribution in dwarfs and the influence of dark matter; (4) ultimately understanding the connection between the SFH and the stellar kinematics in these galaxies. In addition, this will enable us also to investigate their location in the Fundamental Plane of giant ellipticals and establish their connection with their larger counterparts.

While the availability of a single IFU would still allow the completion of part of this program, it is the multi-object capabilities what will set the difference with any other project of this kind ever done and allow us to observe the full set of 370 dwarf galaxies in the Coma cluster. The proposed instrumentation will be of great value not only for this project, but for any other study of other kind of galaxies in clusters. The total time required for full program under this conditions (10 IFUs) will amount to 150 hours. In the worse case scenario of a single IFU, the strategy would change to observe a representative subset of galaxies (~50) on the same amount of time.

The two-dimensional spectroscopic data, together with available ancillary multi-wavelength photometric and long-slit spectroscopic observations, will thus provide, in an unique way, the opportunity to address key questions like: (1) Does the dE family represent the low-luminosity extension of the classical Es? (Gorgas et al. 1997, Binggeli & Jerjen 1998, Graham & Guzman 2003). (2) Are dEs in clusters primordial members or the result of environmental effects? (Moore et al. 1998, Conselice et al. 2003). (3) And finally, is there a dichotomy within the family of dEs (as suggested by their kinematical - Pedraz et al. 2002, Geha et al. 2003 - and stellar population properties - Michielsen et al. 2003)?

1.1- Project Title: AGB stars in Local Group Galaxies

1.2- Project Category: 3

1.3- Abstract:
We propose to obtain high-resolution (R>40,000) optical and near-infrared
spectra of Asymptotic Giant Branch (AGB) stars in Local Group Galaxies. The main

objective of this project is to determine their s-process element and CNO isotopic abundances, and to investigate the dependence with other stellar parameters such as luminosity, stellar mass and metallicity with an unprecedent detail. These observations will improve our understanding of the nucleosynthesis processes ocurring within AGB stars as a function of metallicity and stellar mass, imposing important observational constraints on the current AGB nucleosynthesis models. These results will be of great interest to many different areas in astrophysics.

1.4- Publication agreement: yes

2.1- PI: D. A. Garcia-Hernandez

2.2- CoIs: A. Manchado, C. Abia, B. Plez, M. Lugaro, A. I. Karakas, M. van Raai, I. Dominguez, F. D"Antona, P. Garcia-Lario, O. Straniero, S. Cristallo, D. L. Lambert

2.3- Institute: Instituto de Astrofisica de Canarias

2.4- Country of Employment: ES

2.5- Career Stage: postdoc

2.6- E-mail: agarcia@iac.es

3.1- Source of targets: The Spitzer Space Telescope

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 19, 22, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, N/A per millennium

3.10- Target type: star

4.1- Spatial resolution: seeing, 2-3

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A, N/A

5.1- Wavelength range: 470 - 950, H, K

5.2- Spectral Resolution: 20000-50000

6.1- Instrument: CODEX, SIMPLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.2, 9, R=40,000, seeing=0.8", airmass=1.15, spectral type=M5V and 300 mas on the sky

7.2- Longest continuous observation time on a target or field: 9

7.3- Shortest integration time on a target or field: 720

7.4- Total time: 400

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 25

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: yes, we would need to estimate the integration times to reach the desired S/N (>50) in
view of the star''s brightness, N/A

8.2- Would you welcome remote observing capabilities?: yes, check the data (e.g., S/N) in real-time

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

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9.2- Critical aspects / limiting factors for the science case:
High-resolution (R>40,000) in the optical and near-IR ranges is needed

9.3- Detailed description or other comments:
Low- and intermediate-mass stars (between 0.8 and 8 Msun) end their lives with a phase of strong mass loss and experience thermal pulses on the Asymptotic Giant Branch (AGB; e.g., Herwig 2005, ARA&A, 43, 435). AGB stars account for the cosmic origin of roughly half of all elements heavier than Fe and are the main source of long-term gas return and dust input into the interstellar medium (e.g., Boyer et al. 2009, ApJ, 697, 1993), being an important driver of chemical evolution in galaxies. Thus, AGB stars constitute excellent laboratories to test stellar evolution and nucleosynthesis theories. Their particular internal structure - an inert degenerate CO core surrounded by two (He and H) burning shells - allow two important processes to occur in them. First is the so-called "third dredge-up" (3DUP), a mixing mechanism in which the convective envelope may penetrate the He intershell after each thermal instability (thermal pulse, TP). The other process is the synthesis of elements heavier than iron via the slow neutron capture process. Neutrons are released by alpha-captures onto 13C and/or 22Ne, and are subsequently captured by iron-peak nuclei. The repeated operation of TPs and 3DUP episodes enriches the stellar envelope in the newly synthesized elements (basically, carbon and s-process elements such as Rb, Zr, Sr, Ba, La, etc.). The 3DUP transforms the star into a carbon star, if the carbon added into the envelope is enough to increase the C/O ratio above unity. The envelope becomes enriched with the ashes of the above nucleosynthesis processes which eventually can be detected spectroscopically.

According to our current understanding, low-mass AGB stars (<4-5 Msun) can turn C-rich and s-process rich. However, higher mass AGB stars remain O-rich, depending on Z, due to the high temperatures reached at the bottom of their convective envelopes, the 12C added into the envelope is burned into 13C and 14N through the CN cycle (the so-called "Hot Bottom Burning" process, HBB). HBB models predict the production of 7Li and 14N, low values for the 12C/13C ratio, together with an almost complete destruction of 18O and large excesses in 17O (e.g., Forestini & Charbonnel 1997, A&AS, 123, 241). In addition, these massive O-rich AGB stars reach higher temperatures during the TP phase and neutrons are mainly released by the 22Ne neutron source (Lugaro & van Raai 2008, JPhG, 35, 014007). In contrast, the 13C neutron source, which produces a completely different s-process nucleosynthesis pattern is efficiently activated in lower mass C-rich AGB stars. The relative abundance of Rb to other nearby s-process elements such as Zr (i.e., the [Rb/Zr] ratio) is very sensitive to the neutron density owing to branchings in the s-process path at 85Kr and 86Rb (e.g., van Raai et al. 2008, AIP, 1001, 146). Since the 22Ne neutron source produces much higher neutron densities than the 13C neutron source, the [Rb/Zr] ratio is a powerful discriminant of the operation of the 22Ne vs. the 13C neutron source

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and, as such, a good indicator of the progenitor stellar mass in AGB stars.

In summary, high mass (>4-5 Msun) AGB stars form very different elements and isotopes than lower mass AGB stars and Supernovae as a consequence of the combined effects of HBB and 22Ne s-process nucleosynthesis. This general scenario is strongly modulated by metallicity as predicted by the current theoretical models. Indeed, the above mass limits critically depend on the initial metallicity of the stars, a low metallicity increasing both the 3DUP efficiency and the temperature at the base of the convective envelope, thus shifting the mass range of C- and O-rich AGB stars to lower masses.

Current AGB nucleosynthesis models are subject to important uncertainties depending on e.g. the choice of mass loss, treatment of convection, reaction rates, and they need to be confronted with observations. Until now, observational constraints of AGB models have come mainly from observations of galactic AGB stars with [Fe/H]~0.0 (e.g., Busso et al. 2001, ApJ, 559, 1117; Abia et al. 2002, ApJ, 519, 817; Garcia-Hernandez et al. 2006, Sci, 314, 1751). These studies are however, hampered by the uncertain luminosities of the stars. At lower metallicities, the observations (R<20,000) rely mainly on a few AGB stars in the Magellanic Clouds (e.g., Plez et al. 1993, ApJ, 418, 812). From the above, it is evident that abundance studies in single (C-rich and O-rich) AGB stars at metallicity other than solar are mandatory in order to test the AGB nucleosynthesis models. However, present instrumentation (8-10 meter class telescopes) only permits observations of the brightest AGB stars (V<17-18 and HK<12-13) in the nearest galaxies such as the MCs. In contrast to our own Galaxy, Local Group galaxies cover a large range of metallicities and their distances (and so the stars''s luminosity) are well known. In addition, thanks to the Spitzer Space Telescope, an important number of AGB stars are being identified in low-metallicity Local Group Galaxies (e.g., dwarf irregulars such as Leo A, Sextans A and spirals like M31 and M33) (see e.g., Boyer et al. 2009, ApJ, 697, 1993).

The large collecting area of the E-ELT will permit us to do high-resolution (R>40,000) spectroscopic observations in the optical and near-infrared ranges (from 400 to 2500 nm) in AGB stars in Local Group Galaxies. The s-process nucleosynthesis pattern (i.e., the [Rb/Zr] ratio) can be extracted from optical spectra while CNO elemental and isotopic abundances can be measured in the near-infrared range. These observations will be crucial in order to understand the relationship between AGB stellar nucleosynthesis and other stellar parameters like metallicity, luminosity, stellar mass, etc. or the star formation history in these nearby galaxies with an unprecedented detail. This will undoubtedly be of interest not only to many different areas in astrophysics (such as stellar evolution and nucleosynthesis, anomalous abundances of giants in globular clusters, galaxy formation and evolution, and the overall

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nucleosynthesis of heavy elements in galaxies, with their implications on the chemical evolution models, etc.), but also to other disciplines, such as the chemical composition of some Solar System meteoritic samples, like stardust grains, which show the imprint of AGB star nucleosynthesis (e.g., Lugaro et al. 2003, ApJ, 593, 486).

1.1- Project Title: Exploring Atmospheric Phenomena on the Giant Planets from E-ELT

1.2- Project Category: 4

1.3- Abstract:
Infrared imaging and spectroscopy of the giant planets of our solar system from E-ELT could reveal a myriad of new dynamical and meteorological features, and provide compositional constraints on giant planet formation and evolution as a paradigm for studying exoplanetary systems. Mid-infrared imaging capabilities would be exploited to study wind fields, convective instabilities and small-scale structures on Jupiter and Saturn at an unprecedented spatial resolution. Furthermore, thermal observations of the faint discs of Uranus and Neptune would dramatically enhance our understanding of the ice giants to a level comparable with present studies of Jupiter and Saturn.

1.4- Publication agreement: yes

2.1- PI: Leigh N. Fletcher

2.2- CoIs: Glenn S. Orton

2.3- Institute: N/A

2.4- Country of Employment: UK

2.5- Career Stage: postdoc

2.6- E-mail: fletcher@jpl.nasa.gov

3.1- Source of targets: Solar system objects previously observed using VLT.

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 7.7, -2.8, Vegamag, V

3.4- Target size: extended source, 2000, 40000

3.5- Number of targets: 4

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: yes, TBD

3.9- Variable target?: no

3.10- Target type: solar system body

4.1- Spatial resolution: seeing, TBD

4.2- Field-of-view: 30x30arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 1000 - 5000, 7000 - 14000, 17000 - 25000

5.2- Spectral Resolution: nbimaging, 500-1000

6.1- Instrument: MICADO, METIS, other, Thermal Imaging and Spectroscopy in the 7-25 micron region.

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.1, 2, chosen target - Jupiter requires very short times, Neptune requires much longer integrations.

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 5-20

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

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7.6- Are the observations time critical?: yes, of the rotation of the giant planets, certain features are only visible for small periods (e.g. 5 hours for Jupiter/Saturn)

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, 60

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: other, Extension of the science capabilities of previous spacecraft missions.

9.2- Critical aspects / limiting factors for the science case:
We explain below the importance of studying the gas giant atmospheres in the thermal-infrared, and the key new results which could be realised using E-ELT. However, it is important to note that descriptions of the temperature and dynamically-active tropospheres of the gas giants relies on observations in the 17-25 micron region where opacity is dominated by well-mixed hydrogen and helium. This would require extending the range of currently proposed instrumentation beyond 13 microns and operating the telescope effectively in the Q-band. This could be limited by the difficulties in chopping and nodding (the usual technique for removal of the background of water vapour emission in the Q-band). Some alternative means of background removal would need to be developed to satisfy science requirements in this range.

The telescope would require some technique for nodding and chopping for the successful removal of background emission and instrumental effects. Furthermore, improvements in detector sensitivity would be desirable, particularly for Uranus towards shorter wavelengths, to begin understanding clouds and structures within the deep atmosphere. We envisage three different observational strategies: (1) Unique one-off observations to acquire spectral imaging cubes and/or high resolution spectroscopy for derivation of temperature, composition, cloud properties and dynamics at a particular epoch; (2) Target of opportinunity-type observations for rapidly evolving phenomena (e.g. plumes, storms, vortices and eruptions) at spatial resolutions never-before possible; and (3) Regular-repeat observations of a particular feature to search for tracers of horizontal motions (winds) at wavelengths which were previously inaccessible.

9.3- Detailed description or other comments:
The role of the E-ELT will be significant in the exploration of the outer planets, both in terms of discovery-class observations (probing spatial resolutions and spectral ranges previously inaccessible) and extending/supporting the capabilities of future spacecraft missions. The infrared spectra of the four giant planets of our solar system provide windows into the dynamic phenomena (waves, vortices, belts and zones) in their tropospheres and stratospheres; the cloud properties and

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gaseous composition and the resulting interaction of the atmospheres with seasonal variations in solar energy deposition; and the bulk composition and the various constraints imposed on the origin and evolution of our solar system.

One of the principal advantages of the E-ELT would be in the mid-infrared and longer wavelengths, where even 8- to 10-metre telescopes are still diffraction limited in their spatial resolution. For example, the spatial resolution of the IRTF in mapping Jupiter's stratospheric temperature field at 7.8 microns is diffraction-limited to no better than 2500 km and Jupiter's tropospheric temperature field at 18 microns no better than 5700 km, length scales that are considerably larger than the scales over which convective events, atmospheric turbulence and instabilities and vortex interactions take place. For the VLT and other ~8-metre telescopes, these values become 920 km in the stratosphere and 2100 km in the troposphere, commensurate with the radius of deformation.

For a 30-metre telescope, these values shrink to 250 km in the stratosphere and 570 km in the troposphere, small enough to detect structure within not only large vortices, such as the Great Red Spot, but also in smaller ones, and to characterize the thermal and compositional properties of small-scale, short-lived storms across the planet. Such observations are not possible at thermal wavelengths at the present time, and are currently only resolved by visible imaging by Hubble Space Telescope visible and near-infrared instruments and wide-angle imaging of orbiting spacecraft. This resolution is competitive with the expected spatial resolutions of notional infrared instruments on future missions to the outer planets, such as the Europa-Jupiter System Mission (2020+).

For Saturn, similar resolution improvements, down to 550 km in the stratosphere and 1260 km in the troposphere, would allow resolution of the temperature and compositional fields within Saturn's polar hot spots (Dyudina et al 2008, Fletcher et al. 2008) and possibly associated with storms which have been detected in the visible and near-infrared in reflected sunlight but not in the thermal. For some instances, then, such ground-based observations might well improve spacecraft-instrument spatial resolution, although only for Earth-facing geometries.

Surpassing diffraction-limited resolutions will allow, for the first time, it will be possible to use tracers (bright and dark discrete features) observed in the thermal-IR to trace the dynamic winds associated with the belt/zone structures and vortices. As thermal wavelengths are sensitive to a range of different altitudes, we can study how the winds vary with depth, to constrain models for the depths of the winds into Jupiter and Saturn to answer long-standing questions about the circulation of giant planet tropospheres.

For the small and thermally faint disks of Uranus and Neptune, improvements in both spatial resolution and sensitivity are possible with giant-telescope observations. The IRTF cannot resolve either planet in the mid-infrared. Diffraction-limited resolution is 0.3 arcsec at 7.8 microns and 0.6 arcsec at 18 microns for an 8-metre telescope vs. 0.07 arcsec and 0.16 arcsec, respectively, for a 30-metre telescope. The former are nominally sufficient to resolve the 3.8-arcsec disk of Uranus and the 2.4-arcsec disk of Neptune (e.g. Orton et al. 2007), but with few resolution elements.

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Observations using a 30-metre telescope, on the other hand, can resolve thermal emission from Neptune with about the same resolution as the 3-metre IRTF can resolve it in Saturn at the same wavelength, or emission from Uranus with the same resolution as an 8-metre telescope can resolve it in Saturn. Observations of the belt/zone structures, discrete cloud and convective events and seasonal asymmetries
on Uranus and Neptune would be of a sufficient quality for a quantitative comparison of the dynamics and composition of the gas giants and ice giants, which has been previously limited by the difficulties in observing the faint disks of the ice giants.

Finally, some of the most interesting dynamical phenomena on Jupiter and Saturn have been investigated via spatially resolved imaging at 5 microns, a window between the absorption of hydrogen and methane which permits emission of flux from the deep interiors of the planets, silhouetting higher level clouds. Capabilities at 5 microns from E-ELT for similar imaging and spectroscopy on Uranus and Neptune could reveal a plethora of meteorological phenomena that haven't been observed before.

In general, it would determine the extent of similarities or differences between meteorological phenomena among the entire range of outer planets, providing important constraints on the increasing number of atmospheric models for exoplanetary systems. The myriad of phenomena in our own solar system will serve as a paradigm for the understanding of planets elsewhere in our galaxy.

1.1- Project Title: Star formation history in late type galaxies in Virgo

1.2- Project Category: 2

1.3- Abstract:

We propose to investigate the star formation history (SFH) of 10 galaxies in the Virgo cluster by photometry of the resolved stars in the central part of the galaxies. Stellar counts in selected boxes of the CMD will provide the mass transformed into stars in a wide age range. The comparison of the SFH in various regions of the galaxies and among galaxies with different properties will allow us to derive fundamental information on the processes of galaxy formation.

1.4- Publication agreement: yes

2.1- PI: Laura Greggio

2.2- CoIs: Renato Falomo, Luigi Bedin

2.3- Institute: INAF - Osservatorio di Padova

2.4- Country of Employment: IT

2.5- Career Stage: faculty

2.6- E-mail: laura.greggio@oapd.inaf.it

3.1- Source of targets: VizieR

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 21, 28, Vegamag, J

3.4- Target size: point source

3.5- Number of targets: 10

3.6- Density of targets: 1000000

3.7- Target coordinates: RA:12 - 13;Dec:10 - +15

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 1x1arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 900 - 2200

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5.2- Spectral Resolution: bbimaging

6.1- Instrument: MICADO

6.2- Desired special mode: precision photometry, N/A

6.3- Desired AO mode: MCAO

7.1- Integration time per target or field and per setup: 4, 5, diffraction limit quality

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 40

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
image quality close to diffraction limit

9.3- Detailed description or other comments:
One of the key issues in modern astronomy concerns the history of Star Formation (SF) in the universe. Direct observations of galaxies up to high redshift can
be used to map the SF history (SFH), but since the integrated galaxy light is dominated by the most recent stellar generations, the information on the underlying older stellar population is severely limited. A similar problem affects the analysis of the spectral energy distribution of galaxies, from which only luminosity averaged ages and metallicities can be derived.
In the last 20 years a very effective technique to derive the SFH in

external galaxies has been developed, which compares observed Color-Magnitude Diagram (CMDs) with corresponding theoretical simulations (the synthetic CMD method).

The nearest rich cluster of galaxies (the Virgo cluster) offers the possibility to apply this method to a sample of galaxies with different morphology and luminosity, such that the SFH can be compared. Because of the distance of the cluster (DM = 31) only the bright portion of the CMD is accessible. This science case therefore focuses on deriving the SFH by studying the intrinsically brightest portion of the CMD. The synthetic CMD method builds on the concept that, if one considers a cell on the CMD, the number of stars falling in it is proportional to the total mass transformed into stars in the SF episode which populates the considered cell, via a factor which is given by stellar evolution theory. By counting the stars in cells over the CMD, one can reconstruct the mass transformed into stars in different age bins, which is equivalent to the SFH. We designed four boxes on the (J,J-K) CMD at magnitudes brighter than M(J)=-3, M(K)=-4 which sample well defined age ranges: the Red Supergiant (RSG) box populated by stars younger than 50 Myr; the Blue Supergiant (BSG) box with stars from 50 to 100 Myr old; the Asymptotic Giant Branch (AGB) box with stars from 100 Myr to 1.5 Gyr old; and the Red Giant Branch (RGB) box, with stars older than about 2 Gyr (see MICADO Phase A Scientific Analysis Report, document E-TRE-MIC-561-0007). According to stellar evolution, and adopting Salpeter IMF and a constant SF rate over 12 Gyr, in the RSG, BSG, AGB and RGB boxes there should be, on average, about 2, 0.4, 1 and 77 counts per Million Mo of stars formed in the corresponding age ranges. Therefore, by performing simple star counts in these wide boxes, one can estimate the average SFH over the whole Hubble time.

We propose to study the SFH in 10 late type galaxies in the Virgo Cluster. Besides the variety of morphological types among its members, Virgo also offers the opportunity of investigating on the SFH in the cluster environment, to be compared with that of field galaxies. In addition, due to its large distance, typical size of the core of galaxies fit well within the Micado FoV, thus allowing us to cense the SFH where most of the mass is. The critical issues in this kind of study are photometric accuracy and crowding effects. The effect of the former is mitigated by the adoption of relatively big boxes on the CMD for the star counts, since photometric errors, as well as uncertainties in the stellar evolution background and color-temperature transformation, will reshuffle most of the stars within the box, with little loss from the sides. Crowding effects will instead be avoided by examining regions of relatively low surface brightness. The impact of crowding on this study can in fact be evaluated as a function of surface brightness, given the resolution elements of the instrumental set up. In this respect, the superior spatial resolution of a diffraction limited E-ELT with respect to other instruments, including JWST, implies that stars will be resolved in regions of much higher surface brightness.

To assess quantitatively the feasibility of this science case we have produced simulated images in J and Ks for a stellar population formed at a constant star formation rate over 12 Gyr, with a Salpeter IMF. The metallicity increase with age, with a trend similar to what characterizes our galaxy disc. We assumed: a surface brightness of 21 mag/square arcsec in the B band; the Maory PSF with 0.6 arcsec seeing and 6 LGS; a pixel size of 3 mas; and 5h of exposure time in both filters.

The simulated images have been reduced with a standard DAOPHOT-ALLSTAR package, and the output magnitudes compared to the input ones. The results show that the photometric accuracy and the completeness are suitable for the success of this project.

1.1- Project Title: Detecting Earth-like planets around very nearby stars

1.2- Project Category: 4

1.3- Abstract:
There are numerous stars within 5 pc, including a handful similar to the Sun, where a habitable Earth-like planet can be sought. E-ELT offers the prospect of direct imaging detection, and follow-up spectroscopy to see if there are biomarkers such as abundant atmospheric oxygen. In an decade when space missions such as DARWIN and TPF are on indefinite technical hold, detecting Earth analogues with E-ELT is a strong science driver, fascinating to scientists and public alike.

1.4- Publication agreement: yes

2.1- PI: J S Greaves

2.2- CoIs: N/A

2.3- Institute: University of St Andrews

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: jsg5@st-andrews.ac.uk

3.1- Source of targets: nearby stars catalogues (all main sequence stars to type M ~complete to 5 pc)

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 25, 27, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 50

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: exoplanet

4.1- Spatial resolution: 5, 200

4.2- Field-of-view: 1x1arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: V

5.2- Spectral Resolution: bbimaging

6.1- Instrument: EPICS

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6.2- Desired special mode: coronography, N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 4, 20, 5mas scale; V = 25 for G2 host, 27 for M5 host

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 800

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 90

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, local regional centre with helpdesk

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, complementary data out to mid-IR possible for planets of cool stars

9.2- Critical aspects / limiting factors for the science case:
Need coronograph plus AO to clear out light of stars, including spider effects, speckles; multi-wavelength imaging to identify semi-static speckles. Need to get usable data very close to star: habitable zone of M-star at 5 pc as small as 20 mas.

9.3- Detailed description or other comments:
N/A

1.1- Project Title: The central structure and supermassive black holes in nearby galaxies

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1.2- Project Category: 2

1.3- Abstract:
We want to use the superior spatial resolution and sensitivity of MICADO to explore the central regions of nearby galaxies, focusing particularly on the presence and effects that Supermassive black holes have in these objects. We can study the details of central rings, disks, clusters or binary black holes formed in these regions. If spectroscopical capabilities are made available for MICADO, this will greatly enhance the science output of this project since detailed kinematical studies can be carried out for nearby galaxies, but we can also obtain good black hole size estimates for galaxies up to z~0.35.

1.4- Publication agreement: yes

2.1- PI: Ralf Bender

2.2- CoIs: Roberto Saglia

2.3- Institute: USM, MPE

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: bender@mpe.mpg.de

3.1- Source of targets: NED, SDSS

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 20, 25, Vegamag, J

3.4- Target size: extended source, 5, 20

3.5- Number of targets: 15-30

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

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3.10- Target type: galaxy

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 10, 1200

5.1- Wavelength range: J, H, K

5.2- Spectral Resolution: 2000-3000

6.1- Instrument: MICADO

6.2- Desired special mode: precision astrometry, N/A

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: 10, 30, 1.15 airmass

7.2- Longest continuous observation time on a target or field: 6

7.3- Shortest integration time on a target or field: 1200

7.4- Total time: ~200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, not necessary, but welcome

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, N/A

9.2- Critical aspects / limiting factors for the science case:

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The most critical aspect for this science case is the astrometric accuracy (i.e. spatial resolution and plate scale stability)

9.3- Detailed description or other comments:
In the past decade HST observations of local early-type galaxies have shown that they posses two types of cores, correlated with absolute luminosity, kinematic anisotropy and isophote shapes of the galaxy. Early-type galaxies, with Mag_B <~-21, have well resolved, so-called cuspy cores, while fainter ellipticals and bulges have power-law centers that appear unresolved at the distance of Virgo with HST-resolution (Lauer et al. 2007, ApJ-664-L226). Supermassive black holes have been detected in these galaxies, which are expected to have a destructive influence and produce cores (Merritt et al. 2007, ApJ-671-53). Higher resolution imaging can resolve such power-law cores, and measure their core radii. MICADO at the ELT, with optimal AO in the K band, will achieve 0.01 arcsec resolution and detect core radii down to one pc at the distance of Virgo. Sensitivity is not an issue, the increase in collecting area with respect to HST will easily compensate the decreased size of the res
olution element. Using MICADO to image the nuclei of galaxies closer than Virgo will allow the detection of rings and disks like those seen in the Milky Way and M31 (Bender et al. 2005, ApJ-631-280; 2009, ApJ in press) and also extremely compact bar-type structures as those found in NGC 3706. For example, the blue nuclear disk detected in M31 would be resolvable out to a distance of 7 Mpc, while eccentric nuclei will be detected at twice this distance or even in Virgo. Additional J or H band imaging will measure color gradients to constrain the stellar populations of the nuclear components. For nearby galaxies, it should be possible to resolve single red supergiants that might be present in such circumnuclear disks. For example, assuming a distance of 4.3 Mpc for Cen A (distance modulus of 28.4) and the presence of a central disk of blue stars similar to M31, 5-10 supergiants will be resolved in that disk (plus a background population of dozens of old supergiants along the l
ine-of-sight), the disk would have an area ~0.05 square arcs!
ec. Both types of stars are bright enough that their colors can be used to distinguish the two populations (Mag_J from -3 to -5, J-H=1 for the former, 0.5 for the latter type). Assuming an astrometric position measured with a precision better than 1 mas (1/3 of a pixel), or 0.02 pc in Cen A, for the red supergiants, the motion of a star moving at 2000 km/s can be detected with a baseline of 10 years. Mergers of ellipticals and early-type spirals imply mergers of central black holes. Dynamical friction quickly leads to the formation of a compact black hole binary, but the timescale over which this binary merges into a single black hole is highly uncertain. Indications for binary black holes have been found in a few cases at large distances (like OJ 287, Valtonen et al. 2008, Nature-452-851) but a systematic high resolution survey of nearby galaxy nuclei could produce interesting candidates. Also, the resolution and light collecting power of an ELT may allow to detect flares in
nearby galaxy nuclei similar to the ones observed in the Milky Way (Trippe et al. 2007, MNRAS-375-764), a polarimetry option could be interesting in these cases. The'Christmas Tree' mode will allow imaging with smaller pixels (2 mas) for an 8"x8" field of view. The programs sketched above can profit from smaller pixels, enhancing the PSF sampling and possibly allowing better astrometric performances, and do not suffer from the smaller field of view. The larger scale (4 mas pixels) does not improve the scientific output. The availability of a long-slit grism spectroscopy

mode through the'Christmas Tree' would greatly enhance the science output of MICADO. The determination of radial velocities of resolved stars (in M31 or up to Cen A) together with astrometric data would allow a complete reconstruction of the orbits, as it has been done for the Galactic center. Similarly, radial velocities of resolved stars in Galactic globular clusters might allow the mass deter

mination of intermediate mass black holes. Moreover, stellar!

kinematics of the (unresolved) centers of galaxies could be measured. A spectral resolution of R~3000 for a 0.01 arcsec wide slit (instr ~40 km/s, ~20 km/s per pixel in the 2 mas pixel configuration) is needed to avoid the sky lines in the K band and resolve the typical velocity dispersions at the centers of (spiral or low-luminosity) galaxies. Spectral dithering, similar to that available for SINFONI, would allow to measure velocity dispersions as low as 20 km/s. At the moment, there are few direct measurements of low-mass black holes, and these are are limited to local galaxies. MICADO will be able to spatially resolve the dynamical influence of "seed black holes"in local inactive bulge-less or dwarf galaxies (using the rest-frame CO band heads in the K-band out to ~50 Mpc) and the supermassive ones of inactive massive ellipticals out to redshift z~0.35 (using rest-frame H-band). Assuming comparable sensitivities to SINFONI, the increase in area of E-ELT compared to th

e VLT compensates 25% of the flux reduction due to the increased resolution in case of constant surface brightness. From our SINFONI experience (Nowak et al. 2007, MNRAS-379-909), we expect to reach high-enough spectral signal-to-noise ratios to derive stellar kinematics with integration times of the order of 10 hours for local dwarf ellipticals or low-luminosity bulges. For the case of local bright ellipticals, where SINFONI observations require ~8 hours exposure time, several nights integrations would be needed to compensate for the distance of z~0.35 objects. Note that these science cases exploit the observed K band, where the maximum Strehl ratio is achieved. The availability of a larger spectral range at the same spectral resolution ('linear' alignment of the detectors) adds to the science results by increasing the effective spectral signal-to-noise ratio only if the achievable Strehl ratio (overall spatial resolution) at shorter wavelength is above 20%. This will be probably true only for the H band, therefore the present !

science cases would profit from an H+K simultaneous coverage, but not from further extensions to shorter wavelengths.

1.1- Project Title: Fast cadence, high-resolution spectroscopy of stellar activity phenomena

1.2- Project Category: 3

1.3- Abstract:

We propose to observe fast-cadence time series of high-resolution spectra of bright, highly active stars. The E-ELT will obtain such spectra with an unprecedented time resolution and a low noise

level. Analysing the evolution of line profiles in such spectra will allow to study stellar activity phenomena based on information that in some respects rivals up-to-date solar observations. This will lead to a deeper understanding of the energy production and propagation mechanisms in the atmospheres of highly active stars.

1.4- Publication agreement: yes

2.1- PI: Uwe Wolter

2.2- CoIs: Jürgen H.M.M. Schmitt

2.3- Institute: Hamburger Sternwarte

2.4- Country of Employment: DE

2.5- Career Stage: postdoc

2.6- E-mail: uwolter@hs.uni-hamburg.de

3.1- Source of targets: VizieR

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 7.0, 10.0, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 5

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 6 per min

3.10- Target type: star

4.1- Spatial resolution: 250, 1

4.2- Field-of-view: 2x2arcsec

4.3- Multiplexity and pick-off FoV: N/A

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4.4- Plate scale stability: N/A

5.1- Wavelength range: 350 - 800

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: CODEX

6.2- Desired special mode: high time-resolution, time-resolution better than 10 sec

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.003, 0.003, N/A

7.2- Longest continuous observation time on a target or field: 9

7.3- Shortest integration time on a target or field: 10

7.4- Total time: 18

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: yes, they are potentially simultaneous e.g. with space-based X-ray observations

8.1- Does the execution of observations require real-time decisions?: yes, strong stellar flares may require reduced exposure times, exposure time adapation to avoid overexposure

8.2- Would you welcome remote observing capabilities?: yes, real time quicklook pipeline reduction

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
A spectral resolution >60000 is required as well as fast read-out options of the CCDs.

9.3- Detailed description or other comments:
The observational layout of R>60000, exposure times of about 10 sec and a S/N of about 200 or better is motivated by the following requirements: (a) Resolving weak spectral line profile features

to better than about 5 km/s. (b) These line profile changes, as expected from the Sun, tentatively occur on sub-minute time scales which need to be sufficiently sampled.

1.1- Project Title: Imaging the circumstellar environment of massive protostars

1.2- Project Category: 3

1.3- Abstract:
In star formation, massive stars have remained the most elusive and least understood objects. The major obstacles are rapid formation, large distances and high extinctions which has made it almost impossible to obtain direct imaging of the inner few hundred AU of massive protostars. This is the region where the complex strucuture and interaction exists between, star, disk, bipolar cavity, hypercompact HII regions and envelope. The unique spatial and spectral resolution capabilities offered by E-ELT can resolve most long standing issues in massive star formation by directly imaging the inner few 100 AU region of massive protostars.

1.4- Publication agreement: yes

2.1- PI: Nanda Kumar

2.2- CoIs: N/A

2.3- Institute: Centro de Astrofísica da Universidade do Porto

2.4- Country of Employment: PT

2.5- Career Stage: postdoc

2.6- E-mail: nanda@astro.up.pt

3.1- Source of targets: Spitzer, VLT, VISTA, IRSA-IPAC, Vizier

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 12, 20, Vegamag, K

3.4- Target size: extended source, 10, 100

3.5- Number of targets: few hundreds

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: N/A

4.1- Spatial resolution: 10, 20

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 1000 - 10000, K, L, M, N, Q

5.2- Spectral Resolution: bbimaging, nbimaging, 100-300, 300-500, 500-1000, 1000-2000, 2000-3000, 3000-5000, 5000-10000, 10000-20000, 20000-50000, 50000-100000

6.1- Instrument: EAGLE, MICADO

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.5, 10, Imaging or Spectroscopy. High Resolution Spectroscopy can take up to a nights observing.

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: no

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8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
IFU imaging at K and L bands and Imaging capabilities at 10micron should not be compromised

9.3- Detailed description or other comments:
In the VLT-ERA we have been able to obtain images of disks and envelopes around low mass protostellar objects in the near-infrared wavelengths (Duchene et al, 2007, A&A, 476, 229). The circumstellar environment of a massive star in formation is much more complex than that of a low mass star, owing to intense UV radiation that produces compact HII regions close to the star. The diversity of theoretical scenarios in this regard is a result of ideas to effectively dissipate the intense UV radiation and accrete matter to build the mass of the star (See Zinnecker & Yorke, 2007, ARAA, 45, 481). It is hardly necessary to emphasise that massive star formation can be addressed through relatively direct observations, only in the E-ELT or NGST ERA.

Recent studies of massive star formation using the Spitzer Space Telescope have revealed large samples of infrared counterparts of the massive protostellar candidates (Kumar & Grave, 2007, A&A, 472, 155; Grave & Kumar, 2009, A&A, 498, 147) that were otherwise studied in the far-infrared or millimeter bands with poor spatial resolutions. The near/mid-infrared counterparts of massive protostars appear point like with a spatial resolution of 0.5”-1” for a typical distance of 3kpc, translating to a projected size of 3000AU. Much of the complex structures and interactions occur within this spatial scale. The disk, compact HII region and the inner bipolar cavity where the radiation is thought to escape, are all located within a spatial scale interior to 3000AU. Diffraction limited observations (0.6”) with 8m class telescope at 24micron can just resolve the large scale envelopes in the massive protostellar sources (de Wit et al., 2009, A&A, 494, 157). Similarly, at 2micron, 8
m telescope diffraction limited images have shown silhoutte disks (Chini et al. 2004, Nature, 429, 155).

The E-ELT offers a diffraction limited spatial resolution of ~10mas at ~2micron for a 40m telescope.
This implies a spatial resolution of ~35AU at typical distances of 3000AU. Similarly at 10micron the diffraction limit is ~70mas yielding ~200AU spatial resolution at 3kpc. Additionally, a 40m telescope provides a high sensitivity, probing the highly extincted dense cores inside which massive protostars form. These unique abilities of an E-ELT can solve most long standing issues in our understanding of massive star formation.

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IFU Imaging with Eagle:

The physical components such as star, disk, bipolar cavity/jet/outflow and compact HII regions have significant emission at 2microns and all have specific spectral properties owing to different physical conditions. Similarly, they can emit different emission lines, mostly that of hydrogen and helium. Hydrogen emission lines available in the 2-4 micron bands range vibrational-rotational lines arising due to shocks and flourescence, and recombination lines arising in the ionised regions. Helium, Nitrogen and Carbon lines arise in the stellar photosphere and are tracers of photospheres at high temperatures (e.g: Martin-Hernandez et al, A&A, 405, 175).

With an instrument such as EAGLE, that can provide high contrast imaging in emission lines and continuum, it will be possible for the first time to conduct imaging observations to identify and study the various components such as disk, bipolar cavities, envelopes and hyper-compact ionised regions. IFU imaging is essential since the various physical structures will have different physical conditions giving rise to different emission lines or have different continuum properties. Most of the so called point sources at 0.5”-1” level identified by exisiting 4m-8m class telescopes will be resolved at the near-infrared diffraction limit of a 40m telescope allowing detailed studies of these structures.

Mid-infrared imaging and spectroscopy:

Much has been learnt from the experience with Spitzer Space Telescope infrared imaging and spectroscopy about the utility of the mid-infrared bands. Apart from providing a giant leap in probing high extinctions, the mid-infrared bands from 3-10micron provide access to several pure rotational H2 emission lines tracing shocked and flouresced regions. These bands also contains several Polycyclic Aromatic Hydrocarbon emission lines that is a good tracer of the radiation field and small particles. High spatial resolution and sensitive imaging and spectroscopic observations in these bands will primarily trace the large scale envelopes and cocoons in full detail. Such imaging observations can effectively examine the density profiles of envelopes (e.g: de Wit et al. 2009, A&A, 494, 157), multiplicity and fragmentation issues in massive stars and stability of rotating large scale structures.

A 40m class ground based telescopes best advantage is the high resolution spectroscopy with R~100000 leading to a few meters spectral resolution using emission lines in the mid-infrared band. This ability will not be possible with space facilities, and is the only way to understand the full kinematics of the disk, envelope and compact HII regions close to the massive protostar. The bright H2 lines will complement the ability of high spectral resolution in these bands.

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1.1- Project Title: The redshift z = 2 Universe

1.2- Project Category: 2

1.3- Abstract:
Historically only the most local galaxies were possible to study, and today, in the era of very high redshift surveys it has become obvious that we have two pieces of the galaxy evolution puzzle but little understanding how they fit together. The redshift slice between z = 1.5 - 2.5 includes the peak of star formation, as well as AGN activity, but it is also very difficult to detect galaxies in this range declining atmospheric and optical throughput. We here propose to use OPTIMOS to search for galaxies in this range, thereby laying down the final piece of the puzzle.

1.4- Publication agreement: yes

2.1- PI: Kim K. Nilsson

2.2- CoIs: N/A

2.3- Institute: Space Telescope European Coordinating Facility

2.4- Country of Employment: ESO

2.5- Career Stage: postdoc

2.6- E-mail: knilsson@eso.org

3.1- Source of targets: N/A

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 20, 29, ABmag, B

3.4- Target size: point source

3.5- Number of targets: 8000

3.6- Density of targets: 1.6

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +90

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: 100, N/A

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: 10000, fiber

4.4- Plate scale stability: N/A, N/A

5.1- Wavelength range: 300 - 600

5.2- Spectral Resolution: 1000-2000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 5, 5, enough time to reach 0.1 Msol/yr in SFR (in either continuum or Lyman-alpha)

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 25

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: other, WSO-UV

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9.2- Critical aspects / limiting factors for the science case:
Wavelength range must reach below 400 nm.

9.3- Detailed description or other comments:
For the first several thousands of years of astronomy, only the very most local Universe could be studied by eye or with simple telescopes. Following technological advances, we have for almost 50 years now also been able to look farther into space, to larger redshifts and have today collected very large samples of redshift three, and beyond, galaxies. However, due to the atmospheric cut-off and difficulties in sending UV telescopes into space, our knowledge of the redshift slice between z ~ 3 and the local Universe is not great. With a blue sensitive instrument on the ELT, this could rapidly change. The proposal submitted here is a suggestion of an observing proposal for this purpose. The conditions are modelled on trying to reach a star formation rate of 0.1 Msol/yr/galaxy in either the Lyman-alpha emission or the UV. Reaching these fluxes would be an improvement of at least a factor of ten compared to present day surveys (see e.g. Reddy et al. 2006, Nilsson et al. 2009), re sulting in presumably a factor of ten more sources over the same area. These galaxies would be flux limited, thus providing a complete sample of z ~ 2 galaxies. From the observations and follow-up on the sample, an unprecedented understanding of galaxy evolution would be accomplished, including detailed information about mass evolution, star formation rate densities, metallicity evolution, dust properties etc. Even though some of this science can be done already with the WSO-UV telescope (if launched), the ELT can do it faster and with greater resolution, as well as do spectroscopy in the range 300 - 400 nm, corresponding to z = 1.5 - 2 for the Lyman-alpha line.

1.1- Project Title: The Physics of Galaxy Evolution from Stellar Archaeology

1.2- Project Category: 2

1.3- Abstract:
Valuable insights into galaxy evolution can be gleaned from studies of resolved stellar populations in the local Universe. Deep photometric surveys have provided tracers of the star-formation histories in galaxies from 0.8-16 Mpc, but without robust chemical abundances and stellar kinematics from spectroscopy their sub-structures and assembly histories will remain hidden from us. We propose an E-ELT Large Programme to obtain calcium triplet spectroscopy of the evolved stellar populations in the five low-mass spirals in the Sculptor Group (2-4 Mpc), providing crucial new test cases for galaxy evolution models.

1.4- Publication agreement: yes

2.1- PI: Chris Evans

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2.2- CoIs: Annette Ferguson, Michael Barker, Matt Lehnert, Jean-Gabriel Cuby, Mathieu Puech, Simon Morris, & the EAGLE team

2.3- Institute: UK Astronomy Technology Centre

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: chris.evans@stfc.ac.uk

3.1- Source of targets: HST, VLT, JWST, VISTA

3.2- Preparatory work on targets required?: yes, additional ground/space-based imaging

3.3- Target brightness: 22.5, 25, Vegamag, I

3.4- Target size: point source

3.5- Number of targets: 20

3.6- Density of targets: 1000-30000

3.7- Target coordinates: RA:23.5 - 1;Dec:-40 - -20

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 75, 2

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: 20, 2x2arcsec

4.4- Plate scale stability: 1, 1800

5.1- Wavelength range: I

5.2- Spectral Resolution: 10000-20000

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6.1- Instrument: EAGLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: MOAO

7.1- Integration time per target or field and per setup: 10, 15, dark night, airmass=1, seeing=0.8, paranal background

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 1800

7.4- Total time: 240

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20% (i.e. one galaxy)

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, JWST, HST (after SM4), VISTA & VLT

9.2- Critical aspects / limiting factors for the science case:
Multiplex, spectral resolution

9.3- Detailed description or other comments:
Recent discoveries of disrupted satellite galaxies have demonstrated that our evolutionary picture of the Milky Way is far from complete, let alone our understanding of galaxies elsewhere in the Universe. Deep imaging from ground-based telescopes and the HST has yielded colour-magnitude diagrams (CMDs) with unprecedented fidelity, providing new and exciting views of the outer regions of galaxies beyond the Milky Way for the first time, e.g. in M31 and M33. From comparison with stellar evolutionary models, these high-quality CMDs are used to provide star-formation and chemical-enrichment histories for the targeted regions in these external galaxies, providing a probe of their past evolution and, in particular, their merger/interaction histories. There is increasing evidence for the accretion of numerous low-mass satellite galaxies in the assembly of

the present-day Milky Way. Do we see evidence for similar processes at work in other large galaxies? Moreover, what are the as
sembly histories in galaxies with very different morphological types, such as massive ellipticals, large metal-poor irregulars, and lower-mass, late-type spirals like M33?

Photometric methods are immensely powerful when applied to extragalactic stellar populations, but only via precise chemical abundances and stellar kinematics can we break the age-metallicity degeneracy, while also disentangling the populations associated with different structures, i.e. follow-up spectroscopy is required. Over the past decade the Calcium Triplet (CaT, spanning 0.85-0.87 microns) has become a ubiquitous diagnostic of stellar metallicities and radial velocities. However, existing telescopes are already at their limits in pursuit of CaT spectra of the evolved populations in external galaxies at distances greater than ~300 kpc, e.g. Keck-DEIMOS observations in M31 struggled to yield useful signal-to-noise at I > 21.5.

With its large primary aperture and excellent angular resolution across a large patrol field, the E-ELT will be the facility that unlocks stellar spectroscopy in the broad range of galaxies in the Local Volume, from the edge of the Local Group, out towards the Virgo Cluster. This will bring the huge benefit of a much larger sample of galaxies with which to compare theoretical models of galaxy evolution, spanning a much wider range of galaxy morphologies and metallicities compared to those in the Local Group. In stark contrast to high-redshift cases, E-ELT targets for CaT spectroscopy are readily available. For example, the HST GHOSTS Survey has targeted deep imaging in 27 galaxies in the Local Volume, with ground-based programmes also underway.

There are a wealth of compelling and ground-breaking targets for E-ELT observations, including:
- NGC 3109 and Sextans A (both at 1.3 Mpc) with sub-SMC metallicities.
- The spiral-dominated Sculptor Group at 2-4 Mpc.
- The M83/NGC 5128 (Centaurus A) grouping at ~4.5 Mpc.
- NGC 3379, the nearest normal elliptical (at 10.8 Mpc).
- The Virgo Cluster of galaxies at 16-17 Mpc, the nearest massive cluster.

For the purposes of the DRSP, we select our highest priority programme – the formation and evolution of galaxies in the Sculptor Group, which comprises five spirals (NGC 55, 247, 253, 300, 7793) and numerous smaller dwarf irregulars. Distance estimates over the past decade have revealed that this “group” is actually two distinct components, at approximately 1.9 Mpc (NGC 55/300) and 3.6 Mpc (NGC 247/253/7793). These five spirals represents the most immediate opportunity to study the star-formation history and mass assembly of spirals beyond the limited sample available at present, i.e. the Milky Way, M31 and M33. Their masses are in the range 1.5-8 x 1010 M_sun, putting them on a par with M33 – it is exactly these late-type, low-mass, small bulge (or even bulge-less) spirals which are the systems that theoretical N-body/semi-analytic simulations struggle hardest to reproduce.

We propose spectroscopy of stars in the upper red giant branch (RGB), spanning M_I = –4 (at the tip of the RGB) to approx. M_I = –2, i.e. 22.5 < I < 24.5 in NGC 55 and 300, and down to I ~ 24.5 (i.e. M_I ~ –3) in the others. For good velocity precision (± a few km/s) at signal-to-noise >10, combined with robust estimates of metallicity, we require a spectral resolving power of R~10,000, with a spectral coverage of at least 0.05 microns centred on the CaT.

Fields would be observed along the major and minor axes of each galaxy, sampling the stellar population across different spiral structures and the halos. The largest target galaxies are NGC 55 and 253, with semi-major axes greater than 10 arcminutes, i.e. multiple pointings are required given the notional E-ELT 5 arcminute patrol field. As the targets are HST (or ground-based) follow-up, an angular resolution of ~75 milliarcseconds is required, balancing improved sensitivity and sufficient resolution in the denser parts of the disks, against the challenges of AO correction in the 0.8-1.0 micron regime. IFU observations will assist with local background subtraction, and will deliver multiple stars per IFU. With 20 IFUs, we can observe in excess of 40-60 stars/pointing. MOAO sensitivity calculations using the Puech et al. simulation code lead to 10 hrs/pointing for NGC 55/300 (5 and 4 pointings, respectively), and 15 hrs/pointing for NGC247/253/7793 (3, 4, and 3 pointings), yi
elding >1,000 stars, with a total exposure time of 240 hrs.

Recent simulations predict that stellar radial mixing (also called radial ‘churning’, or orbit switching) due to perturbations from transient spiral density waves plays a large role in shaping the age and metallicity gradients – this dynamical process could have huge implications for stellar archaeology, as it may modify, or even erase, the original gradients. Ages and metallicities will be derived for each star to enable the gradients of these properties across each galaxy to be investigated, while also inspecting the results for evidence of sub-structure. In the outer halo fields we will also test the prediction that halo stellar metallicity is thought to scale with the halo stellar mass. Of course, this DRSP proposal is for a broad survey of the overall properties of each galaxy – were interesting sub-structures found in their halos, subsequent, more focused E-ELT observations would follow.

1.1- Project Title: Nuclear activity in nearby galaxies

1.2- Project Category: 2

1.3- Abstract:

Dust enshrouded activity can ideally be studied by mid-infrared (MIR) observations. In order to explore the AGN versus star forming origin of the nuclear MIR emission of galaxies, observations of high spatial resolution are required. VISIR data provide evidence that, up to 100Mpc, AGN and SB can well be separated but further out (500 Mpc, z <0.1) the ELT resolution is required. In this

proposal we wish to apply the MIR surface brightness as a quantitative measure at a distance scale which is not applicable to 10m class telescope and at a sensitivity required for in-active spirals.

1.4- Publication agreement: yes

2.1- PI: Ralf Siebenmorgen

2.2- CoIs: Martin Haas, Endrik Kruegel

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: rsiebenm@eso.org

3.1- Source of targets: NED: Albrecht et al., AA 462, 575

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 0.1, 1000, mJy, N

3.4- Target size: extended source, 50, 9000

3.5- Number of targets: 300

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: 50, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 10, 0.01

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5.1- Wavelength range: 11000 - 11500, N

5.2- Spectral Resolution: nbimaging

6.1- Instrument: METIS

6.2- Desired special mode: precision photometry, N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1/10, 1/2, Paranal with seeing <1arcsec and low pwv conditions

7.2- Longest continuous observation time on a target or field: 0.5

7.3- Shortest integration time on a target or field: 180

7.4- Total time: 75

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: yes, observations can be aborted when target is detected and it is clear that it is either resolved or unresolved, RTD on chopp/nodding corrected co-added frames

8.2- Would you welcome remote observing capabilities?: yes, RTD

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
good PSF stability of chopping and nodding corrected image

9.3- Detailed description or other comments:
Dust enshrouded activity can ideally be studied by mid-infrared (MIR) observations. In order to explore the AGN versus star forming origin of the nuclear MIR emission of galaxies, observations of high spatial resolution are required. Pilot observations with VISIR at the VLT,

reaching 0.35"""""""""" spatial resolution (FWHM) of a sample of 36 nearby galaxies with a variety of optically classified nuclear activity have shown that MIR imaging can be used as a diagnostic tool to investigate the nature of the active galactic nucleus which is either AGN or starburst driven. Further for in-active spirals no active core is found at the MIR sensitivity of a 10m class telescope. Sixteen out of 17 black hole driven active galactic nuclei (AGN) are detected as point sources, 10 starbursts (SBs) are found to be extended with structured emission up to a few arcsec and 9 quiet spirals were undetected with low upper limits. The morphology of the resolved SB nuclei follows that seen at radio frequencies. The compactness of AGN and the extent of the SB nuclei is consistent with predictions from radiative transfer models and with MIR spectra of lower spatial resolution. The nuclear MIR surface brightness can be explored as a quantitative measure of activity type with a 10m class telescopes; while AGN and SB cannot be distinguished with MIR data from 4m class telescopes. VISIR data provide evidence that, up to a distance of 100 Mpc, AGN and SB can well be separated by means of MIR surface brightness when using 8m class telescopes and further out up to 500 Mpc (z <0.1) when using METIS mounted at the ELT. In this proposal we wish to apply the MIR surface brightness as a quantitative measure at a distance scale which is not applicable at a 10m class or smaller telescope and to confirm present findings for the objects closer in (<100Mpc).

1.1- Project Title: Young Jupiters in Nearby Associations

1.2- Project Category: 3

1.3- Abstract:

A significant population of young stars exists in the solar neighbourhood. Recently, several southern, loose, young associations could be identified. They comprise a sample of about 300 young stars, with ages between 10 and 100 Myrs, grouped into 9 kinematically defined associations, with distances between 30pc and 100pc. These stars represent a prime sample of targets to observe planets just after formation.
Because these systems are simultaneously nearby (closer than the most nearby star forming regions) and young, the sensitivity and spatial resolution provided by the ELT-METIS instrument will allow to detect Jupiter-mass planets in a solar-system like configuration.

1.4- Publication agreement: yes

2.1- PI: M.Sterzik

2.2- CoIs: C.Torres, G.Quast, R.de la Reza, N. Huelamo, C. Melo, E. Pantin, R. Siebenmorgen, W. Brandner

2.3- Institute: ESO Chile

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: msterzik@eso.org

3.1- Source of targets: RASS (rosat all sky survey)

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 8, 15, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 300

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-80 - +30

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 50, 3

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

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4.4- Plate scale stability: 1, 1000

5.1- Wavelength range: N

5.2- Spectral Resolution: nbimaging

6.1- Instrument: METIS

6.2- Desired special mode: coronography, N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.5, 1.0, airmass, thermal background, seeing

7.2- Longest continuous observation time on a target or field: 1.2

7.3- Shortest integration time on a target or field: 0.5

7.4- Total time: 400

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
Coronagraphy mode is essential. Differential imaging would help a lot.

9.3- Detailed description or other comments:
Planets are believed to be assembled during early stages of star formation, and formed by material stemming from protoplanetary disks. The existence of a multitude of "hot Jupiters" found with precision radial velocity surveys can best be explained by migration mechanisms through dynamical interaction of planets with disk material, and indirectly proves their formation in these early stages.

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Young, nearby stars represent a highly promising hunting ground for the direct imaging of substellar objects, because of advantages gained through high spatial resolution (vicinity) and enhanced sensitivity (younger objects are in general brighter, and the contrast in a star-planetary mass companion system more favourable at younger ages, see Burrows et al 1997).

Meanwhile, the existence of several young associations in the solar neighborhood has been established following detailed spectroscopical and kinematical analysis of coronally active X-ray sources in the ROSAT all-sky survey. The most extensive survey performed so far, the Search for Associations Containing Young Stars (SACY) revealed more than 300 late-type stars with typical ages between 10 and 100 Myrs in the southern hemisphere.
These stars can be kinematically associated and grouped into nine associations, having typical distances between 30pc and 100pc from the sun (Torres et al. 2006, 2008), comprising the prominent TW Hydra, Tucana-Horologium and beta Pictoris associations, as well as other newly identified associations.

A few young brown dwarfs, and giant extrasolar planets, have already been directly imaged using high contrast imaging techniques with current generation adaptive optics techniques at 8-10m class telescopes, e.g. the planetary mass companion around the brown dwarf 2M1207334 in the TW Hydra association (Chauvin et al 2005), probing the wider orbital ranges (>10""""s A.U), and higher planetary companion masses (>5Mjupiter).
Interestingly, the AO surveys conducted up to date show that massive giant planets (and brown dwarf companions) at wide separations, accessible with current instrumentation, are relatively rare (see eg Apai et al, 2008; Nielsen et al, 2008), and the giant planet population is probably confined to inner regions (<15 A.U.), resembling more a solar-system type configuration.

METIS at an ELT opens a new parameter space to study young Jupiter-mass gas-giants in solar-system type configuration, i.e. probing the interesting separations between 1 and 10 A.U. from the central source.
The diagram attached demonstrates the ability of METIS to detect the atmospheres of 1-10Mj gas-giant planets.
Using DI and coronagraphic techniques it will be possible to image and characterize Jupiter mass planets at distances of ~5 A.U. from their host star for the youngest (10Myr) and closest (50pc) stars in the sample (sample size approx 100 sources, see Fig.1).
More massive planets can be detected even further in.

1.1- Project Title: Multiplicity of very low luminosity objects

1.2- Project Category: 3

1.3- Abstract:
One of the most important astrophysical phenomena which is needing a comprehensive explanation is star formation, specially in the very low-mass range, down to substellar masses. This proposal deals multiplicity in solar-type stars and low-mass objects, very young objects, which are embbeded and present very strong extinctions at optical and even at near-infrared wavelenghths. The multiplicity of the youngest stellar and substellar objects is directly linked to their formation process, and therefore represents one of the most critical parameters to constrain theories of star formation. Therefore, we propose to systematically study a sample of Class 0/I and II objects in nearby star forming regions.

1.4- Publication agreement: yes

2.1- PI: D. Barrado

2.2- CoIs: N. Huelamo, E. Pantin

2.3- Institute: INTA, Spain

2.4- Country of Employment: ES

2.5- Career Stage: faculty

2.6- E-mail: barrado@laeff.inta.es

3.1- Source of targets: VLT, VISTA, ALMA, SDSS, VizieR

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 6, 17, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: 500

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-80 - +30

3.8- Moving target?: no

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3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 50, 3

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 5, 1000

5.1- Wavelength range: L, M, N

5.2- Spectral Resolution: nbimaging

6.1- Instrument: METIS

6.2- Desired special mode: coronography, N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.1, 0.3, seeing, airmass, thermal background

7.2- Longest continuous observation time on a target or field: 0.3

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 250

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, VLT/VLTI, N/A

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9.2- Critical aspects / limiting factors for the science case:
Coronagraphic capabilities in L, M, N bands are mandatory.

9.3- Detailed description or other comments:
New instrumentation and observational windows open-up new possibilities and provide a new crucial view to old, unsolved problems. One of the most important astrophysical themes which is needing a comprehensive explanation is star formation, specially in very low-mass range. One key observable is multiplicity in very young objects.

Giant molecular clouds are the birth place of new generations of stars, due to their colapse and fragmentaion into small cores which eventually migh lead to the formation of stars of different masses. However, these cores might split into several fragments of equal or different masses, each of one can become a star. This process might depend on the initial conditions, and can be tested by the study of several star forming regions with different enviromental properties: from very sparse such as taurus to very massive and compact as the Trapezium. Few years ago, Andre et al. (1999) discovered the first Class 0, very low luminosity protostar in Taurus. Later on, Kauffmann et al. (2005) presented an object with Lum < 0.1 L(sun), which could be the first Class 0 substellar object. The formation of this type of object is not clear.

The role of Spitzer: setting the stage for a comprehensive protostellar taxonomy.
The Spitzer Space Observatory has done a superb job in stellar formation studies and a number of papers dealing with mid-IR spectroscopy have been published, mainly concentrated on Taurus members (see Calvet et al. 2005; Kessler-Silacci et al. 2006; Furlan et al. 2006, 2008). Some non-homogeneous analysis has been carried out on few Serpens and IC1396A members (Reach et al. 2009, Booegert et al. 2008), among others. Moreover, a significant number of Class 0-II low-mass objects located in different, nearby star forming regions are accessible with new, sensitive ground-based instrumentation Spitzer has produced a very comprehensive photometric database covering the range 3.6-24 micron with IRAC and MIPS. However, Spitzer has the handicap of the \underline {lack of spatial resolution}.

The role of E-ELT/METIS:
METIS will have a superb sensitivity and will provide an exceptional spatial resolution, which will be able to detect faint companions at subarcsec (few AU for the closest star formations).

The goal: multiplicity in protostars at the solar-type and low-mass regime.-
The multiplicity of the youngest stellar and substellar objects is directly linked to their formation process, and therefore represents one of the most critical parameters to constrain theories of star formation. The multiplicity of late-type protostars has been studied in several works based on observations in the near-, mid-IR, and radio wavelength (e.g. Reipurth et al. 2000, Haisch et al. 2004, Duchene et al. 2004, 2007, Connelley et al. 2008). Most of these works show that Class I YSO show a similar binary fraction and binary separation distribution beyond 100 AU as T Tauri stars. However, it is still not clear if multiplicity is environment dependent. Further, little is known about the multiplicity of very low-mass stars and proto-BDs at the earliest phases of their evolution.

Do they behave like proto-T Tauri stars? The youngest BDs studied so far have ages of 1-5 Myr (e.g. Bouy et al 2006; Ahmic et al 2007; Joergens et al. 2008). BD binaries among them show a tr end towards small separations ($<$30AU), although wide pairs (100-150 AU separations) have been detected in some Star Forming Regions (Luhman 2004; Bouy et al. 2006). With this proposal we plan to study the multiplicity properties of the youngest very low-mass stellar and substellar objects in order to establish the multiplicity fraction in different Star Forming Regions. METIS, with its unprecedented sensitivity and spatial resolution, offers a unique opportunity to answer this question. Moreover, its coronagraph will offer a unique opportunity in order to reach very high contrast between the primary and faint secondaries, even allowing the detection of substellar companions "in the making".
Diagnostics.-
L and M provide superb sensitivity and spatial resolution
(0.02 arcsec for a 42m telescope) and will allow
to detect very faint and close companions.
The N-band data is nedeed to study the multiplicity
of the youngest and deeply embedded objects that can
still be too faint in L and M.

1.1- Project Title: Luminous and Ultraluminous Infrared Galaxies up to z=3

1.2- Project Category: 2

1.3- Abstract:
We propose to study the internal physical and dynamical structure of a representative sample of about 60 Luminous and Ultraluminous Infrared Galaxies ((U)LIRGs) up to a redshift of 3. Local (U)LIRGs are ideal astrophysical laboratories to study the processes governing the formation and evolution of galaxies (interactions/mergers, star and AGN formation, enrichment of IGM, etc) . In addition their contribution to the total SFR density increases steadily from z~0 up to z~3, forming at least half of the newly born stars by z~1.5. The spectral range, angular resolution, sensitivity, and IFS capability of HARMONI makes it ideal for this program.

1.4- Publication agreement: yes

2.1- PI: Santiago Arribas

2.2- CoIs: Luis Colina

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2.3- Institute: IEM- CSIC

2.4- Country of Employment: ES

2.5- Career Stage: faculty

2.6- E-mail: arribas@damir.iem.csic.es

3.1- Source of targets: Spitzer

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 21, 23, Vegamag, K

3.4- Target size: extended source, 200, 5000

3.5- Number of targets: 60

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 500 - 2500

5.2- Spectral Resolution: 5000-10000, 10000-20000

6.1- Instrument: HARMONI

6.2- Desired special mode: N/A

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6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 2, 6, 2 exp. / object (for 4 and 40 mas spaxel scales), and z~0 and z~2.5 objects

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 240

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 25

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
IFS capability, several spaxel scales in the range 4-40 mas to optimise knot and diffusse emission detection, the optical and near infrared spectral coverage (500-2500 nm), and sensitivity are important for this program.

9.3- Detailed description or other comments:
Thanks to recent efforts focussed on obtaining and analyzing large surveys, observational constrains on the integrated properties of galaxies such as luminosity functions, stellar masses, sizes, spectral energy distributions, etc., as well as their evolution with redshift, have drastically improved. In addition to those integrated properties, a complete picture of galaxy formation and evolution should explain the internal structure of galaxies (i.e., internal kinematics, internal stellar population gradients, dust distribution, ionization structure, nuclear properties and effects, interaction with the IGM, etc.). Such a detailed studies should explain how the different physical processes involved are interrelated, and which are the ultimate causes of the integrated physical properties.

>From an observational point of view these studies require two-dimensional spectroscopy (i.e. 3D data), which can now be obtained with integral Field Spectrographs (IFS). Most of IFS studies have been based on local samples of galaxies (e.g. the SAURON project; de Zeeuw et al. 2002,

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MNRAS, 329, 513 and references therein; Colina et al., 2005, ApJ, 621, 725), though recent work also includes high-z objects (e.g., Puech et al. 2007, A&A, 466, 83; Law et al. 2007, ApJ, 669, 929; Genzel et al. 2008, ApJ, 687, 59, and referentes therin). However, current limitations in sensitivity and angular resolution make the studies of the internal structure of high-z galaxy populations difficult, and the observation of comprehensive samples (i.e., not just individuals at the tip of the luminosity function) will require larger aperture telescopes, and higher angular resolution than those currently available. In fact. an instrument like HARMONI installed in the ELT has a the two key ingri
dients (i.e. sensitivity, and angular resolution) to overcome these limitations and revolutionize this field.

In the context of the formation and evolution of galaxies, some galaxy populations are of particular interest. That is the case of luminous and ultraluminous infrared galaxies (LIRGs, with infrared luminosity L_IR = L[8−1000 μm] = 1011−1012 Lsolar, and ULIRGs, LIR > 1012 Lsolar, respectively). Locally they can be considered as ideal astrophysical laboratories to study the physical processes governing the formation and evolution of galaxies, such as the star and AGN formation, galaxy interactions and mergers, the enrichment of the IGM, etc. In fact, ULIRGs and LIRGs have large amounts of gas and dust, and are undergoing an intense star formation in their (circum)nuclear regions (e.g. Scoville et al. 2000, AJ, 119, 991 and references therein). This starburst activity is believed to be their major energy reservoir, although AGN activity may also be present (Genzel et al. 1998, ApJ, 498, 579). In many cases (especially for ULIRGs) these objects show clear signs of int
eractions and mergers. Several authors have also suggested that, as the end product of the merger, moderate-mass (0.1−1 m∗) ellipticals are formed (Dasyra et al. 2006, ApJ, 651, 835; Genzel et al. 2001, ApJ, 563, 527). In addition local (U)LIRGs may be the counterpart of important high-z populations or, at least, share many of the processes that govern their evolution. In fact, recent Spitzer cosmological surveys have found that the majority of IR-selected galaxies at $1 < z < 3$ are (U)LIRGs (e.g. Pérez-González et al. 2005, ApJ, 630, 82). The contribution from (U)LIRGs to the total SFR density increases steadily from z~0 up to z~3, forming at least half of the newly born stars by z~1.5. Ultraluminous infrared galaxies play a rapidly increasing role for z>~1.3.

We aimed at studying the internal physical and dynamical 2D structure of this important galaxy class up to a redshift of 3. At low redshift (i.e. $z<1$) we will observe the rest frame optical and near-infrared spectral range. The near infrared is a rich region of the spectrum where the different phases of the interstellar medium as well as the stellar populations can be traced by several emission and absorption lines. This is even more important for (U)LIRGs where due to the large amounts of dust and gas extinction effects play the additional role of blocking our view in the optical. Moreover, the starbursts in (U)LIRGs are concentrated in general in the central regions of these galaxies, within a 1 kpc radius (about 1" to 2" angular size) of the nucleus. Therefore, HARMONI with its extreme high angular resolution (4 mas per spaxel) will allow to investigate the physical processes in these regions up to distances of 200 Mpc with linear resolutions of 1 to 10 pc. At higher
redshifts (say, $1 < z < 3$) the exquisite angular resolution and powerful sensitivity of HARMONI will allow us to study at this important galaxy class with a level of detail similar to the one now

carried out with local samples, and using the rest-frame optical diagnostic lines. Among others, specific goals of these studies are:
(1) To detect nuclear disks or rings. Rotational motions in the nuclear regions of these galaxies will be identified detecting the standard spider-like pattern in the 2D velocity field of the warm ionized gas, molecular gas, and the stellar component.
(2) To detect non-rotational flows such as starburst-driven superwinds, tidally induced motions in tidal tails, or nuclear gas inflows. The origin of non-rotational flows at the kpc scale is established identifying 2D rotational velocity deviations associated with stellar tidal tails, massive nuclear and extranuclear star-forming regions, or nuclear dust lanes.
(3) To establish the dynamical mass of the host galaxies. Independent estimates of the dynamical mass of the galaxies is obtained from several different tracers such as the nuclear velocity dispersion of the ionized gas, the molecular gas and the stellar component, and from the rotational velocity field, if it dominates the velocity structure.
(4) To quantify the 2D structure of the internal dust absorption. This can be estimated from the hydrogen recombination lines.
(5) To characterize star-forming regions. The spatial distribution, mass, and contribution to the total bolometric luminosity of the starbursts is established from the 2D distribution and extinction corrected flux of the hydrogen emission lines. Also, the stellar populations will be studied using stellar libraries.
(6) To identify the presence of extended shock-induced ionization. Extended shocks will be identified in extranuclear regions characterized by a LINER-like spectrum, and a high velocity dispersion (Monreal-Ibero et al. 2006, ApJ, 637, 138).
(7) To investigate the presence of dust-obscured AGNs. For local objects the presence of dust-obscured AGNs can be identified through the coronal lines like [SiVI] (e.g. Bedregal et al. 2009, ApJ, 698, 1852).
(8) To identify the formation of ellipticals in advanced mergers. The combination of central velocity dispersion measurements with the corresponding effective radius and surface brightness allows to establish whether advanced mergers are evolving into normal ellipticals at these redshifts.
(9) To investigate the presence of candidates to Tidal Dwarf Galaxies (TDG). The kinematic and structural properties of high surface brightness Ha regions allow to identify candidates to TDGs formed during the the merging process (Monreal-Ibero et al. 2007, A&A, 472, 421).

Explanatory comments/remarks

For optimal observations of both, the extended diffuse emission and the knots of star formation, different instrument spaxel scales are required. HARMONI allows the observer to change the scale by a factor of 10 (i.e. from 4 to 40 mas) which is ideal to optimize this type of observations.

The given target brightness refers to the continuum for z~2.6 objects. Considering that typical EW of Halpha can be as large as 100 A, a gain of 5 magnitudes gain in this line with respect to the continuum is expected.

The spatial resolution and FoV were selected for the 4mas case (highest possible angular resolution), but the 40 mas is also important for studying extranuclear diffusse emission. A larger FoV (e.g. 5" x 10") is also important for the nearby (large) objects.

The desired AO option will depend on the spaxel scale selected: LTAO for 4mas , GLAO for 40mas.

Total time: assuming 20 objects at z~ 0 (2h /obj), 20 objects at z~1 (4 h/obj), 20 objects at z~ 2.5 (6 h/obj)

1.1- Project Title: Star formation by submm large area continuum mapping

1.2- Project Category: 3

1.3- Abstract:

The ability to map star forming region in the submm dust continuum has provided extremely valuable insights into local star formation (in low mass clusters up to 150pc and high-mass star formation within 500pc). A submm image with the ELT would allow to study clusters at similar depth and resolution throughout the Galaxy where the resolution of Herschel is by large insufficient. Questions are: What is the minimum mass of a star? What is the difference between high and low mass star formations? What are the lifetimes of the different phases of star formation?

1.4- Publication agreement: yes

2.1- PI: Ralf Siebenmorgen

2.2- CoIs: N/A

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: rsiebenm@eso.org

3.1- Source of targets: simbad

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 1, 1000, mJy, Q

3.4- Target size: point source

3.5- Number of targets: 1

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star cluster

4.1- Spatial resolution: seeing, 2

4.2- Field-of-view: 2x2arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 10, 1

5.1- Wavelength range: 350000 - 850000

5.2- Spectral Resolution: bbimaging

6.1- Instrument: other, SCELT

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 300, 400, PWV of less than 1mm

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7.2- Longest continuous observation time on a target or field: 0.01

7.3- Shortest integration time on a target or field: 10

7.4- Total time: 400

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, RTD

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, herschel, APEX, SCUBA-2, JWST, Spiitzer, ISO

9.2- Critical aspects / limiting factors for the science case:
ELT site shall have typically have low PWV; for example PVW of less than 1mm; day time observations could be possible.

9.3- Detailed description or other comments:
Star formation by submm large area continuum mapping

The ability to map star forming region in the submm dust continuum has provided extremely valuable insights into local star formation (in low mass clusters up to 150pc and high-mass star formation within 500pc). This is illustrated for example by the SCUBA map of rho Ophiuchus (Johnstone et al. 200) where 55 cores down to masses of 0.02Msun are detected. A submm image with the ELT would allow to study clusters at similar depth and resolution throughout the Galaxy where the resolution of Herschel is by large insufficient. We need to extend these local studies to understand star formation in the Galactic context. The combination of sensitivity (a submm camera at the ELT is in the continuum 25 times more sensitive than ALMA) together with mapping speed (wide fields with a submm imager with a field of view of 2 arcmin at the ELT is million times faster than the mapping speed of ALMA) of a submm camera at the ELT will allow for the first time surveys of clusters as far as the Galactic Centre. The deepest studies of Brown Dwarfs in the nearby Trapezium cluster indicate a mean stellar separation of 0.04pc (Lucas et al. 2004); this would correspond to 1arcsec at the GC. Cluster sizes of several arcmin could be mapped to 1mJy at 10sigma which corresponds to 10 times the mass of Jupiter at this distance.

Some key questions are: How do very lowest mass stars form? What is the minimum mass of a star? How do binary stars form and is it caused by turbulent fragmentation ? What is the difference between high and low mass star formation process? Over what mass range does the mean mass function of cloud clumps trace the initial mass function of stars? What are the lifetimes of the different phases of star formation?

1.1- Project Title: Census of the Galaxy plane: submm continuum survey

1.2- Project Category: 3

1.3- Abstract:

A submm Galacic Plane survey in the submm continuum will give a true census of the star forming cloud population and the total mass of the Galaxy. Today there is better knowledge about dense clouds in Andromeda than about those clouds in the Milky Way. The best available Galactic Plane survey in the submm is at 8arcmin resolution in CO (Dame et al. 2000) but there is no survey in the dust continuum, which, however, is a much better tracer of the mass. A ELT GP survey at 350, 450, 850mic of 200deg x 3deg down to 1mJy cannot be done by Herschel, ALMA or SCUBA2 caused by confusion limits and time constrains.

1.4- Publication agreement: yes

2.1- PI: Ralf Siebenmorgen

2.2- CoIs: N/A

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: rsiebenm@eso.org

3.1- Source of targets: simbad

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 1, 1000, mJy, Q

3.4- Target size: point source

3.5- Number of targets: 1

3.6- Density of targets: N/A

3.7- Target coordinates: l:0 - 360;b:-3 - +3

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star cluster

4.1- Spatial resolution: seeing, 2

4.2- Field-of-view: 2x2arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 10, 1

5.1- Wavelength range: 350000 - 850000

5.2- Spectral Resolution: bbimaging

6.1- Instrument: other, SCELT

6.2- Desired special mode: N/A

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6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1/100, 1/10, pwv < 1mm

7.2- Longest continuous observation time on a target or field: 0.01

7.3- Shortest integration time on a target or field: 10

7.4- Total time: 400

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, RTD

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, herschel, APEX, SCUBA-2, JWST, Spiitzer, ISO

9.2- Critical aspects / limiting factors for the science case:
ELT site shall have typical low pwv (e.g.: <1mm)

9.3- Detailed description or other comments:
Census of the Galaxy plane: submm survey

A submm Galacic Plane survey in the submm continuum will give a true census of the star forming cloud population and the total mass of the Galaxy. Today there is better knowledge about dense clouds in Andromeda than about those clouds in the Milky Way. The best available Galactic Plane survey in the submm is at 8arcmin resolution in CO (Dame et al. 2000) but there is no survey in the dust continuum, which, however, is a much better tracer of the mass. A ELT GP survey at 350, 450, 850mic of 200deg x 3deg down to 1mJy cannot be done by Herschel, ALMA or SCUBA2 caused by confusion limits and time constrains.
rsiebenm@pc014642$ m GCsurvey.drsp
Census of the Galaxy plane: submm continuum survey

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At present there is no survey of the entire Galactic Plane in the submm continuum. The best available data are the 8arcmin resolution maps of optically thick CO emission (Dame et al. 2000).

Compared to CO the dust is a much better and unbiased tracer of the total mass. A submm Galacic Plane survey will give a true census of the star forming cloud population and the total mass of the Galaxy. Today we have better observations and therefore knowledge about dense clouds in Andromeda than about those clouds in the Milky Way. SCUBA-2 at JCMT will be able to trace dust down to several tens of mJy in some sections of the plane. However with a submm camera at the ELT a 200deg times 3deg Galactic Plane survey simultaneously at 350, 450 and 850 mic and at a 1 sigma depth of 1 mJy could be observed in 400hours.

Such a survey depth is not possible wit Herschel which has a 8 arcsec resolution at 500mic and the anticipated depth of the ELT survey already outperforms the confusion limit of a 15m telescope. If one would like to perform such a survey with SCUBA2 down to the confusion limit of JCMT it would cost 1000 years of observing time so it cannot be done with ALMA as well.

1.1- Project Title: MID-IR Characterization of exoplanet atmospheres in the solar neighbourhood

1.2- Project Category: 3

1.3- Abstract:

Mid-IR studies open a direct window into exoplanet atmospheres. We propose to measure the flux emitted by exoplanets in the LMN-bands using METIS. Our sample will be based on giant exoplanets directly detected by VLT/SPHERE and JWST at shorter wavelengths, and on suitable exoplanets detected by astrometry with VLTI/PRIMA and GRAVITY. Direct and coronagraphic imaging will reveal their integrated flux in various bands. Low-resolution spectroscopy aims at detecting molecular bands, and hence at identifying individual chemical species. Comparison with atmospheric models reveals chemical composition and temperature structure of their atmospheres. Multi-epoch monitoring will reveal weather patterns and seasonal changes.

1.4- Publication agreement: yes

2.1- PI: Wolfgang Brandner

2.2- CoIs: Sebastian Daemgen, Kerstin Geissler, Markus Janson, Eric Patin, Carolin Schnupp, Carolin Bergfors

2.3- Institute: Max-Planck-Institute for Astromony

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: brandner@mpia.de

3.1- Source of targets: VLT, VLTI, JWST

3.2- Preparatory work on targets required?: yes, VLT/NACO 4-micron coronagraphy of target stars, VLTI/PRIMA & GRAVITY astrometry of subsample (suitable binaries)

3.3- Target brightness: 5, 12, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: 50

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +90

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: exoplanet

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 0.1, 120

5.1- Wavelength range: L, M, N

5.2- Spectral Resolution: bbimaging, nbimaging, 100-300

6.1- Instrument: METIS

6.2- Desired special mode: N/A, coronography, high centroding accuracy / small residual tip-tilt required (better than 0.1 FWHM) over ~1000s

6.3- Desired AO mode: XAO

7.1- Integration time per target or field and per setup: 1, 4, <0.8" seeing, airmass < 1.6

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: 1

7.4- Total time: 500

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, remote monitoring to assess data quality

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A, JWST, VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
small residual tip-tilt (better than 0.1 FWHM) in JMN bands over ~1000s to optimize observing efficiency

9.3- Detailed description or other comments:
While in the visible and near-IR exoplanets can be detected by the light they reflect from their host star, in the mid-IR we can study their intrinsic thermal emission. Gravitational settling of condensates from higher, and hence in general cooler atmospheric layers should result in cloud layer formation at various atmospheric levels, similar to what is observed in giant planets in the solar system.

The atmospheres of giant exoplanets should thus be vertically stratified with chemically differentiated cloud layers. Jupiter with a temperature of 165 K at the 1 bar level has the following main cloud layers: (i) at the top level are clouds of ammonia, NH4HS, and water. At subsequently lower atmospheric levels (higher pressure) follow cloud layers composed of (ii) sulfide and alkali halide, (iii) silicate and iron, and (iv) refractory ceramics such as perovskite and corundum. In exoplanets, we expect a similar sequence of cloud layers, which with increasing exoplanet temperature should be stripped off from the top, i.e., exoplanets somewhat warmer than Jupiter should loose their ammonia and NH4HS cloud layers first, and reveal more of the lower level cloud layers. In addition to the cloud layers, the relative abundances of CH4 and CO define the infrared opacities in a giant planet"s outer atmosphere. Temperature gradients between day- and night-time hemisphere, as well as e
xcess heat tracing back to the formation drive Jupiter"s powerful zonal weather system, which becomes apparent in lighter zones of upwellings and darker belts of downdrafts. Wind shear leads to the formation of weather patterns, which manifest themselves most strongly in giant storm systems. As molecular opacities are a strong function of wavelength, observations at different wavelengths across the LMN bands will enable us to probe different cloud layers, and hence different pressure and temperature levels in an exoplanet atmosphere. Such observations, combined with atmospheric models, also facilitate the detection of chemical non-equilibrium conditions and temperature inversions in giant exoplanet atmospheres. Thus mid-IR studies enable us to probe the chemical composition and the physical structure of exoplanet atmospheres.

Our sample consists of giant exoplanets orbiting stars in the solar neighbourhood. We will follow-up all exoplanets directly detected by VLT/SPHERE, and JWST/NIRCAM at shorter wavelengths (typically H-band), and a subset of the exoplanets detected by astrometry with VLTI/PRIMA and GRAVITY. The proposed mid-IR characterisation of giant exoplanets in the solar neighbourhood is also very much complementary to the E-ELT/EPICS survey. For quite a few of the astrometrically selected exoplanets in our sample, H-band fluxes as determined by EPICS will provide an additional important constraint in our modeling of the atmospheric properties. Of all nearby exoplanets detected by astrometry, the METIS sample will focus on planets at sufficiently large angular separations from their host star (typically at several 10 to 100mas), on the more massive exoplanets, and on those orbiting younger host stars.

Direct and coronagraphic imaging in LMN-band will reveal both astrometric information (separation and position angle of the exoplanet with respect to its host star as a function of time) as well as the integrated flux of the exoplanet. The astrometric information will enable us to improve the determination of the orbit of the planet around its host star, and also yield an improved mass estimate for the exoplanet. Low-resolution spectroscopy will reveal molecular bands, and hence enable us to identify individual chemical species in the exoplanet atmosphere. Comparison with atmospheric models will reveal not only the chemical composition, but also the pressure-temperature structure of the exoplanet atmospheres. This should also reveal the presence of temperature inversions, as, e.g., has been observed in Jupiter"s atmosphere, or just recently in the atmosphere of the transiting giant exoplanet TrES-4b (Knutson et al. 2009). The modeling and improved mass estimates should also enable us to estimate the average density of the giant exoplanets, and hence investigate if they might have formed directly out of a gaseous proto-planetary disk by graviational instability (lower density) or by core-accretion (higher density due to the presence of a central rocky core). Finally, multi-epoch monitoring of the ~10 brightest exoplanets with a signal-to-noise ratio better than 20 in the most suitable spectral bands will reveal global weather patterns and seasonal changes at the 5% level.

We expect the initial sample to consist of 50 giant exoplanets orbiting stars within 25 pc of the Sun. Typical integration times in the imaging modes should be of the order of 1 to 4 hr per target and set-up (band), hence about 400 hr in total is required to cover LMN-bands. Spectroscopic follow-up and multi-epoch astrometric and photometric monitoring of the ~10 brightest exoplanets, such as the ~1 Jupiter mass planet orbiting Eps Eridani (Hatzes et al. 2000), or the ~6.5 Jupiter mass planet orbiting VB 10 (Pravdo & Shaklan 2009) are expected to require 100 hr of integration time, adding up to a total of 500 hr.

1.1- Project Title: The cosmic history of super-massive Black hole growth

1.2- Project Category: 2

1.3- Abstract:
The evolution of galaxies needs the study of both their stellar component and of the growth of the super-massive black holes (SMBH) in their centres. During their accreting phases, SMBH show up as luminous AGN and regulate both star formation and further growth by accretion. Mapping the co-evolution of stars and SMBH in galaxies at redshifts z~6-10 is key to understanding galaxy evolution, and a goal of many large facilities in the next decade. Here we propose to use the E-ELT and IXO in conjunction to unveil young growing SMBH in the form of mini-QSOs in that critical redshift range.

1.4- Publication agreement: yes

2.1- PI: X. Barcons

2.2- CoIs: J. Aird, W.N. Brandt, F.J. Carrera, A. Comastri, A. Fernandez-Soto, K. Nandra, A. Ruiz, Y. Ueda

2.3- Institute: Instituto de Física de Cantabria (CSIC-UC)

2.4- Country of Employment: ES

2.5- Career Stage: faculty

2.6- E-mail: barcons@ifca.unican.es

3.1- Source of targets: IXO (International X-ray Observatory), a NASA/ESA/JAXA science mission, with estimated launch date around 2020.

3.2- Preparatory work on targets required?: yes, Astrometry and photometry with 8-10m class telescopes (GTC, VLT, Subaru) in various optical/NIR bands, most importantly J

3.3- Target brightness: 24, 26.5, ABmag, J

3.4- Target size: extended source, 100, 2000

3.5- Number of targets: Thousands

3.6- Density of targets: 4

3.7- Target coordinates: l:0 - 360;b:-90 - -20, l:0 - 360;b:20 - 90

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: AGN

4.1- Spatial resolution: seeing, 3

4.2- Field-of-view: fiber

4.3- Multiplexity and pick-off FoV: 100, fiber

4.4- Plate scale stability: N/A

5.1- Wavelength range: J

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

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7.1- Integration time per target or field and per setup: 2, 8, 0.8 arcsec seeing

7.2- Longest continuous observation time on a target or field: 0.5

7.3- Shortest integration time on a target or field: 1800

7.4- Total time: 1600

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, IR spectroscopy of the faintest targets should be done with NIRSpec

9.2- Critical aspects / limiting factors for the science case:
Field of view, multiplexing capability and wavelength coverage should not be smaller than assumed baseline.

9.3- Detailed description or other comments:
One of the main themes in extragalactic astronomy for the next decade will be the evolution of galaxies over cosmic time. Observing starlight from early galaxies is among the key goals of the E-ELT (and other ELTs) and JWST, whilst ALMA will be able to observe the cold phase of their interstellar medium. Besides stars and gas, a third component in galaxies is recognised to have a large impact on galaxy evolution: Super-Massive Black Holes (SMBH) in galaxy centres. SMBH have been unveiled at low-z by the kinematics of galaxies in their innermost regions; the SMBH binding energy is 30-100 times that of the galaxy bulge. However, the growth of these SMBH, most likely dominated by accretion and occasional mergers, has surely had an enormous impact on the way galaxies have grown across cosmic time. SMBH-driven feedback, in terms of both radiative and mechanical energy being deposited on scales comparable to those of the whole galaxy, is thought to regulate both star formation an
d accretion.

Our current understanding is that the first stars that formed were rather massive and short-lived. Some of them ended with black holes of a few 10s of Msun, the seeds of the 106 -109 Msun SMBH that we see in today's galaxy centres. Although light from those first black holes in the first galaxies will not be easily detectable by any of the currently planned large facilities within the ASTRONET roadmap, our goal in this proposal is to see them in their childhood in the form of mini-QSOs. The current frontier in AGN searches around z~6-7 reveals the existence of very luminous and massive SMBH at these early epochs, implying rapid, maybe episodic, Eddington-limited growth in early epochs.

X-rays are unique signposts of accreting SMBH; they are robust against galaxian (star) light and also against obscuration. An efficient search and subsequent study of growing SMBH needs to involve X-ray observations in a leading role. While X-ray observations are needed to detect these AGN, they are alone insufficient as we also need to confirm their redshifts.

In this programme we plan to unveil the overall population of growing SMBH (i.e., not limited to luminous unobscured objects) at z~6-10, by combining the use of IXO (International X-ray Observatory) with the E-ELT and in some cases with JWST. IXO is an X-ray observatory class mission, currently under study by ESA, NASA and JAXA, and with expected launch date around 2020. One of the most important and demanding goals for IXO is to be able to detect the X-ray emission from growing SMBH at those redshifts (see "The Growth of Super-massive black holes across cosmic time" under the ixo.gsfc.nasa.gov white paper list). This results in a limiting sensitivity of just below 10-17 erg/cm2/s in the 0.5-2 keV band, a factor of more than 10 below the deepest current X-ray surveys. IXO will deliver that capacity when the E-ELT is up and running.

Immediate goal

A reference programme to characterize the entire growing SMBH population has been devised, which will combine shallow (2 deg2), medium (1 deg2) and two deep (1 Ms each, totalling 0.18 deg2) IXO exposures. The shallow and medium exposures might be obtained from the serendipitous content of other IXO observations (the IXO instrument in use for this purpose WFI has a FOV ~18′ x 18′), but at least the deep surveys will target well studied areas of cosmological interest available (COSMOS, Subaru Deep Survey, Extended Groth Strip, CDFS, VVDS, etc). A total of 170, 90, 50, 25 and 15 AGN are expected at z~6, 7, 8, 9 and 10 respectively under conservative hypotheses. These searches will not only reveal the most extreme objects: a significant fraction of those AGN will be of low luminosity, corresponding to small SMBH of mass 106 -107 Msun accreting at 0.1-1 times their Eddington limit.

Hunting and characterising the growing SMBH population will need a coordinated use of IXO with E-ELT spectroscopy, and even JWST or ALMA, to measure the redshift and hopefully obtain a spectral classification, by measuring emission line widths (broad/unobscured or narrow/obscured AGN). For the shallower fields, other facilities that will come up on line within the next decade, like LSST, will also be of great help. Obtaining a large fraction of the redshifts for the faintest X-ray sources, and finding their spectral type, is the immediate goal of this programme. Further information on the physical nature of these sources will come from the multi-wavelength coverage of the areas under study (especially the deep surveys), through their Spectral Energy Distribution.

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Technical description and feasibility
At our main target redshifts z~6-10, the J-band will be our work horse. Down to an X-ray flux ~10-17 erg/cm2/s, IXO will find about 4 X-ray sources per square arcmin, so multiplexing is critical. The positional accuracy (95% confidence) delivered by IXO will be around 1-1.5 arcsec in radius. Using best AGN SEDs, we expect a JAB ~26.5 magnitude for such a faint AGN. Existing deep J-band galaxy counts predict that within an error circle of the faintest X-ray sources only 0.1-0.4 spurious galaxies down to that magnitude will be found, so identification will be possible.

We have used reference values for the OPTMOS/EVE fibre-fed spectrometer. The fibres can be arranged in 300 “single-object IFUs” (consisting of 7 fibres, appropriate for those sources where there is only one candidate counterpart), but also in 15 “small-IFUs” covering a region of 2 x 3 arcsec each, appropriate for sources with > 1 candidate counterpart, all over a 7 arcmin diameter FOV. The MOS version of this instrument will also be appropriate. It is very important that the wavelength coverage stays at no less than 2500 Å, to ensure efficient identification of spectral features.

The continuum sensitivity of OPTIMOS/EVE will be around JAB~25.7 for an 8 hour exposure, so it will be appropriate for sources down to 2 10-17 erg/cm2/s. The unresolved line sensitivity quoted for EVE of 10-19 erg/cm2/s would be appropriate for all our targets (we expect the emission lines, typically Ly-alpha, SiIV, CIV and CIII], to be 100 to 1000 times brighter than this for unobscured AGN, but weaker for obscured AGN), but unfortunately they will be largely resolved at the 5000-10000 resolution that is needed to avoid OH lines, so the real line sensitivity will be likely lower. An estimate of the observational strategy and required exposure time is shown under http://venus.ifca.unican.es/~barcons/SMBHGrowth_exptime.pdf.

For objects escaping our E-ELT spectroscopy, we will need to use JWST/Nirspec (but note the reduced FOV of 3.4′ x 3.4′ in this case) and for particular objects, using ALMA/Band 6 to cover the [CII] fine-structure line at 157.74 microns will be also contemplated.

1.1- Project Title: Kinematics of isolated dwarf galaxies of the Local Group: probing the structure of Dark Matter haloes in their pristine status

1.2- Project Category: 2

1.3- Abstract:
We propose to obtain R~5000-10000 spectra of hundreds of RGB stars belonging to two dwarf spheroidal galaxies lying at the extreme outskirts of the Local

Group, to measure their radial velocity with accuracy of 1-2 km/s. This will allow to characterize at best the structure and the mass distribution of the Dark Matter halo of these galaxies, providing a unique insight into DM halos that are expected to be essentialy unchanged since their original collapse. The proposed scientific goal can be reached only with a high-multiplexing MOS mounted on ELT.

1.4- Publication agreement: yes

2.1- PI: M. Bellazzini

2.2- CoIs: P. Ciliegi, E. Diolaiti, the MAORY team

2.3- Institute: INAF - Oss. Astr. di Bologna

2.4- Country of Employment: IT

2.5- Career Stage: faculty

2.6- E-mail: michele.bellazzini@oabo.inaf.it

3.1- Source of targets: HST, VLT, LBT

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 21, 24, Vegamag, I

3.4- Target size: point source

3.5- Number of targets: 500

3.6- Density of targets: 100

3.7- Target coordinates: RA:22 - 23;Dec:-70 - -60, RA:9 - 10;Dec:+45 - +55

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: diffraction, 1

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4.2- Field-of-view: 1x1arcmin

4.3- Multiplexity and pick-off FoV: 100, fiber

4.4- Plate scale stability: N/A

5.1- Wavelength range: H

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: other, MOS feed by the MCAO module

6.2- Desired special mode: N/A

6.3- Desired AO mode: MCAO

7.1- Integration time per target or field and per setup: 0.5, 1.0, i.e. seeing=0.8

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 4

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
spectral resolution > 5000 and large multiplexing. According to the adopted ELT-ETC, AO is very useful but not critical.

9.3- Detailed description or other comments:

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The dwarf spheroidal galaxies (dSph) of the Local Group are excellent sites to study the properties of Dark Matter halos. Their mass budget seems largely dominated by Dark Matter, with M/L ratios in the range 10-200 (Gilmore et al. 2007). The low overall mass of their DM halo (~107 M_sun) suggests that they are among the first stuctures to collapse in the Universe and, possibly, the smallest halos that were able to host star formation (Strigari et al. 2008). They have no gas, hence they are pure non-collisional non-dissipative systems, and, if one limits to satellites of the Milky Way, they are sufficiently nearby (D < 150 Kpc) that large samples of medium-high resolution spectra of their members stars can be assembled with 10m-class telescope. Thus the kinematics of their stars are currently used to infer the mass distribution of the DM halos they are embedded into.

LG dSphs are strongly clustered around M31 and the Milky Way. For this reason, it is widely believed that their evolution has been deeply influenced by the interaction with the main galaxy they are orbiting about, by means of tides (Penarrubia et al. 2008 = P08) and ram-pressure stripping (Mayer et al. 2007). The most recent studies (Munoz et al. 2008; P08) have shown that the typical low-mass galaxies may loose up to 99% of their original DM halo by tidal stripping and still leave a bound remnant closely resembling present-day dwarf spheroidals. Hence, the kinematics of individual stars in nearby dSphs provide insight on DM halos that may have been strongly shaped by their co-evolution with a giant halo. Moreover, P08 have demonstrated that, in addition to substantial mass-loss, tidal evolution can also induce a significant lowering of the central density of dSphs. Hence, it is likely that the mass and the structure of the halo of these dSphs does not reflect those of the original halos as they emerged from the cosmological evolution of structures. An insight into the pristine status of DM halos would be very valuable, as it would directly test the predictions of cosmological N-body models on the galactic scale.

The ideal system to look for such a pristine DM halo would be a dSph galaxy as isolated as possible from any other distribution of mass, in the present and in the past. There is a bunch of dwarf galaxies in the LG, at large distances from either the MW or M31, that may fit these requirements (see Gallart, 2008, ASPCS, 390, 278; Kopylov et al. 2008, K08 hereafter). Here we focus our attention on two specific cases that are the most promising ones. The Tucana dSph galaxy (Lavery & Mighell 1992) and the VV124=UGC4879 dSph galaxy (K08) are both located at the extreme boundary of the LG, more than 0.9 Mpc away from M31 and/or the MW and more than 0.5 Mpc away from any other member of the LG. Both systems are dominated by stars several Gyr old, they have no gas and display a fairly regular elliptical shape, suggesting that they are quite simple systems that reached their dynamical equilibrium since several Gyr. They have a very low velocity with respect to the baricenter of the LG. In particular, the low negative velocity of VV124 (V_LG=-12 km/s) suggests that the galaxy has recently inverted its Hubble flow and it is falling toward the LG for the very first time. Hence the original DM halo of these galaxies should be essentially untouched.

The best suited kinematic tracers for these galaxies are Red Giant Branch (RGB) stars, as they are bright, old, and present in large number over the whole extension of the galaxy. However the much larger distance with respect to typical satellites of the MW (~1 Mpc vs 0.1 Mpc) makes the observation of large number of RGB stars in these galaxies rather challenging, as the brightest RGBs have $I>21$. The recent study by Fraternali et al. (2009; F09) illustrates very well the limitations of the best-effort study that can be performed with a 10m class telescopes. F09 used VLT-FORS in multi-object mode to get low resolution (R~600) spectra around the Ca triplet (8450-8700 A) of 30 stars at the tip of the RGB of Tuc ($I<21.5$). They accumulated more than 5 hours of exposure to reach a final S/N ratio in the range ~15-30, and the final uncertainties on the radial velocities are in the range 6-13 km/s, i.e. the same range of the typical central velocity dispersions of dSph.
While this study provide a very valuable first insight into the dynamics of this galaxy, it is clear that much larger samples and more accurate velocities are required to achieve our scientific goal.
A multi-object spectrograph with R~ 5000- 10000, covering the D~2.5 arcmin corrected field provided by the MCAO module MAORY would give the possibility to obtain 1-2 km/s accurate Vr for hundreds of RGB stars down to I~24, a range completely out of reach of 10m class telescopes. The FoV of MAORY matches very well with the characteristic dimensions of the targets: the whole body of both galaxies would be covered with just two pointings.

For example, using the ELT-ETC (MCAO)and considering R~10000 spectra in H band, we estimate that, for a I=24 RGB, S/N~20 will be reached with t_exp=1800 s. Tuc has several hundred stars with $I<24$, VV124 has ~4000 RGBs brighter than this limit. Therefore, a full characterization of the kinematics of these galaxies, and, consequently the best possible insight into to properties of pristine DM halo will be possible only with ELT + MAORY + a MOS spectrograph. Any other ground based facility will lack the spatial resolution and the collecting power to reach the goal, JWST will lack the needed multiplexing and spectral resolution. It is possible that similar results (with larger exposure times) may be obtained with ELT + EAGLE (with a low multiplexing efficency) and also with ELT + OPTIMOS (under excellent seeing conditions and/or GLAO).

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1.1- Project Title: A survey for giant planets in the Large Magellanic Cloud

1.2- Project Category: 3

1.3- Abstract:
We propose to use the high efficiency of the 42-m telescope, together with a high resolution near-IR or optical spectrograph to perform a long term survey for extra-solar planets in a sample of 100 intermediate-mass giant stars from the Large Magellenic Cloud (LMC). This campaign will allow to discover the first extra-galactic planets. Their discovery and properties will give crucial information for the models of planet formation and evolution.

1.4- Publication agreement: yes

2.1- PI: Nuno C. Santos

2.2- CoIs: Claudio Melo, Pedro Figueira

2.3- Institute: Centro de Astrofisica da Universidade do Porto (CAUP)

2.4- Country of Employment: PT

2.5- Career Stage: postdoc

2.6- E-mail: nuno@astro.up.pt

3.1- Source of targets: VLT

3.2- Preparatory work on targets required?: yes, Target selection

3.3- Target brightness: 18, 20, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: RA:5 - 6;Dec:-65 - -75

3.8- Moving target?: no

3.9- Variable target?: yes, 4 per year

3.10- Target type: star

4.1- Spatial resolution: 75, 2

4.2- Field-of-view: fiber

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 370 - 680, 1300 - 2500, V, B, H, K

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: CODEX, SIMPLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.25, 0.25, S/N of 10/20 in optical/NIR

7.2- Longest continuous observation time on a target or field: 0.25

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 500

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: yes, we need to follow the radial-velocity variations, algorith to derive precise radial velocities

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

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8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, target selection

9.2- Critical aspects / limiting factors for the science case:
Faint stars: need for high efficiency

9.3- Detailed description or other comments:
The detection over the last 14 years of more than 350 extra-solar planets (most of them detected using radial-velocity techniques) is providing us with a complete new picture of the planet formation and evolution process. However, and as usual in astrophysics, the discovery of new objects opened a number of still unsolved misteries. The whole process of gian planet formation is being debated. New data is needed if we want to understand the process of planet formation and evolution, as well as the frequency of planets in the Universe.

Why a survey for giant planets in the LMC?

Precise spectroscopic studies of dwarf stars with giant planets have shown that the frequency of giant planets is a strong function of the stellar metallicity (Santos et al. 2004, A&A 415, 1153). This correlation may be reflecting the way giant planets are formed. Indeed, a positive metallicity-giant planet correlation is expected if planets are formed by the core-accretion process (Mordasini et al. 2009, A&A, in press). On the other hand, disk-instability models do not predict that metallicity plays an important role in the formation of giant planets.

Recently, however, it has been proposed that the metallicity-giant planet correlation may not be present for intermediate mass stars hosting giant planets (Pasquini et al. 2007, A&A 473, 979). While this result is being debated, it is clear that giant planets exist orbiting intermediate metal-poor stars (e.g. Santos et al. 2007, A&A 474, 647).

Similarly to the metallicity, stellar mass may have a strong infuence on the formation of giant planets. It is now known that the frequency of giant planets around (low-mass) M dwarfs is considerably smaller than the one found for FGK dwarfs (e.g. Bonfils et al. 2007, A&A 474, 293). A tentative correlation between stellar mass and the frequency of giant planets has been suggested (Lovis & Mayor 2007, A&A 472, 657; Johnson et al. 2007, ApJ 670, 833). This conclusion may be expected from the planetary formation models (Laughlin et al. 2004, ApJ 612, L73), and suggest that the frequency of giant planets orbiting intermediate-mass stars may be twice as high as the one found for solar-type dwarfs.

One of the most efective ways to access the frequency of planets around higher mass stars is to search for planets around field giant stars. Several such programs exist, and a few giant planet candidates have been announced (e.g. Sato et al. 2003, ApJ 597, L157; Hatzes et al. 2003, ApJ, 599, 1383; Setiawan et al. 2003, A&A, 398, L19). However, given the large spread in stellar metallicities existing in field samples, disentangling the effect of stellar mass and metallicity on the frequency of giant planets is not a simple task. A survey for planets orbiting a clear sample of metal-poor

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internediate mass giants may hold the key to solve this problem. A sample of giants in the LMC is perfect for this goal.

Further to this, recently, Hawhood (A&A, in press) suggested that the metallicity correlation found for dwarf stars with giant planets may be related to their galactic formation site: the environment conditions in the inner galactic disk may be more suitable for the formation of planetary systems. Indeed, the metal-rich stellar population in the solar neighborhood may be composed of objects from the inner disk that have been scattered to the solar radius (Wiellen et al. 1996, A&A, 314, 438; Grenon, M. 1999, AAp&SS, 265, 331). This hypothesis that recently saw increasing support following observations of chemical abundances in youg stellar regions (Santos et al. 2008, A&A 48,889). In the context of the suggestion of Haywood, it is crucial to test the formation of planets in other environments. Once again, being the closest extra-galactic population, the LMC is the perfect laboratory to address this problem.

In brief, a survey for giant planets in metal-poor intermediate mass giants in the LMC will not only provide the first extra-galactic planets, but will also give an extremely important input for our understanding of giant planet formation. In particular, it will give us crucial hints about the dependence of extrasolar planet formation on 2 important stellar parameters, mass and metalicity. This knowledge will have important consequences for our understanding of the frequency of planetary systems in the Universe, including those with Earth like habitable planets.

Instrumental requirements:

Intermediate mass giants have typically absolute V magnitude Mv~1. The distance moludus to the LMC is $\sim$18.4, which means that the K giants in the sample will have V~19.4. Using the typical V-K magnitudes of 1.4, this implies that in the K band (near IR) the stars will have K~18. We will consider these values for the rest of the proposal.

Near-IR observations: following the tables presented at the SIMPLE high resolution NIR spectrograph website, a S/N of about ~20 is obtained after a 900 second exposure on a K=18 magnitude star.

Optical observations: following the UVES ETC and extrapolating for a 42-m telescope, we obtain a S/N of about 10 in a 900 second exposure for a V=19.4 magnitude K star. This will be the case of the CODEX spectrograph.

In brief, following our experience with CRIRES (e.g. Figueira et al., in preparation) and HARPS (HARPS GTO team), radial-velocity measurements with a precision of 5-10 m/s should be easily obtained after 900s exposures with
both instruments at a 42-m E-ELT.

We note that the intrinsic noise of K giants (due to pulsations and granulation) is of the order of 10 m/s (e.g. Lovis & Mayor 2007). Higher precision in radial-velocity is thus not needed to proceed with this project.

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Sample:

To our knowledge there are no available catalogs of well characterized intermediate-mass giant stars in the LMC. A sample should thus be constructed, based on existing photometric catalogs and making use of low resolution spectrographs at the VLT (e.g. GIRAFFE). Observations with these instruments will allow for example to exclude for binary stars, non members, and select stars within the metallicity range of interest.

Observations:

The sample, including ~100 giants, should be followed during 5 years to allow the detection of long period planets. This number of targets is important to have a first order statistical result (based on the observational results mentioned above, we expect the frequency of planets around metal-poor intermediate mass giants to be around 2-3%). We propose to obtain 4 measurements/year for each star. Considering a 900 second exposure, this means that we will need 100 hours/year, and 500 hours in total during the 5 years of the survey.

1.1- Project Title: Research for exo-planets in open clusters

1.2- Project Category: 3

1.3- Abstract:
We propose to measure radial velocities (Vrad) with the CODEX pectrograph for stars in open clusters (OCs) and with different evolutionary stages. CODEX will allow us to measure Vrad=~10 cm/s for high-resolution (R=100000) spectra with S/N=1000. This will permit us to detect Earth-mass exo-planets for stars of different masses. The first suitable OC is M67, which is rich, and with solar metallicity and age. Our aims are:
-discovering planets in M67 stars similar to the Sun;
-shedding light on the role of stellar mass in the formation of planetary systems;
-extending in the future our exo-planetary research to other OCs.

1.4- Publication agreement: yes

2.1- PI: Katia Biazzo

2.2- CoIs: Piercarlo Bonifacio, Sofia Randich, Maria Teresa Ruiz

2.3- Institute: Arcetri Astrophysical Observatory

2.4- Country of Employment: IT

2.5- Career Stage: postdoc

2.6- E-mail: kbiazzo@arcetri.astro.it

3.1- Source of targets: VLT, VizieR

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 14, 16, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 10

3.6- Density of targets: N/A

3.7- Target coordinates: RA:8 - 9;Dec:11 - 12

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: seeing, 4

4.2- Field-of-view: fiber

4.3- Multiplexity and pick-off FoV: 1, fiber

4.4- Plate scale stability: N/A

5.1- Wavelength range: 380 - 680

5.2- Spectral Resolution: >100000

6.1- Instrument: CODEX

6.2- Desired special mode: N/A

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6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.02, 2, Seeing=0.8", Airmass=1.5, V band, R=100000

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: 60

7.4- Total time: 48

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: yes, M67 from the South is observable during the winter-spring, but in other periods of the year we could select other appropriate open clusters

8.1- Does the execution of observations require real-time decisions?: yes, We will clean the sample from the binary we will probably find, N/A

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
We need very accurate radial velocity measurements. As a consequence, the wavelength calibration system must be as precise as possible for an instrument as the CODEX spectrograph.

9.3- Detailed description or other comments:
Field stars host the majority of exo-planets discovered so far. They represent objects relatively bright and encompassing a large range of stellar parameters, giving us the possibility of studying the dependence of planetary formation on them. On the other hand, because of the composite nature of the field stars and biases in the samples, up to now they did not allow us to understand for instance why the exo-planets are preferably found around metal-rich main-sequence stars. Is there any dependence of planet formation on stellar metallicity (Santos et al. 2005, A&A, 437, 1127; Pasquini et al. 2007, A&A, 473, 649)? What the role of the stellar mass on planet formation (Kennedy & Kenyon 2008, ApJ, 673, 502)? And, how specific is our Solar System, and the Sun?

The answer to these and other questions will come from exo-planet research in open clusters (OCs), which represent a very powerful tool complementary to the approach made in field stars. The study

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in OCs will allow us to control the sample and limit the space of stellar parameters, searching for exo-planets in stars with similar chemical composition and age, and common birth environments. The possibility of finding planet-hosting stars in different evolutionary phases of an OC with a given metallicity would permit us to establish the dependence on their masses, removing possible biases in the metal enhancement observed in planet-hosting field stars. Finally, analyzing OC stars along its color-magnitude diagram, we can study the planet formation as a function of stellar mass, where the age and initial chemical composition are fixed for all the stars.

The old OC M67 is a perfect target to start our research for exo-planets around OC stars. Recent chemical analysis from our group has shown that M67 has a chemical composition extremely similar to the Sun (Randich et al. 2006, A&A, 450, 557). Then, the age of M67 encompasses that of the Sun (3.5-4.8 Gyr; Yadav et al. 2008, A&A, 484, 609). These characteristics marking M67 are of paramount importance if we think that the age and chemical composition of field stars are always "a-priori" rather uncertain. Finally, M67 is a rich OC, which gives us the opportunity to find many stellar candidates sharing similar characteristics, and a large number of stars with different masses and evolutionary stages (from the low main-sequence up to the red-giant branch through the turn-off). These are essential starting points to
exploit the questions discussed above.

This proposal is the culmination of a work, which involved high-resolution spectroscopy to derive elemental abundance of this cluster (Randich et al. 2006, A&A, 450, 557; Pace et al. 2008, A&A, 489, 403), photometry and astrometry to obtain precise membership (Yadav et al. 2008, A&A, 484, 609), and FLAMES/GIRAFFE high-resolution spectroscopy to clean the sample from binaries, and to identify the best solar analogues (Paquini, Biazzo et al. 2008, 489, 677). Thanks to the latter study, 59 probable single radial velocity members remained. Then, we obtained HARPS@ESO and SOPHIE@OHP spectroscopic observations in January-February 2009 to acquire spectra of the 59 pre-selected GIRAFFE stars,
and to extend our sample to 7 turn-off stars and 17 giants with $9<V<15$ mag. Thanks to these observations, we cleaned our sample from other 6 binaries and we found one binary in the giant sample. Then, we asked for other HARPS and SOPHIE observations, and at present we are waiting for the answers of these Proposals.

The very high-resolution spectrograph CODEX will permit us to extend our study to fainter low-mass stars. Observing a star with V=14.5 mag in 3600 s and a star with V=15.5 mag in 7200 s, CODEX allows to obtain S/N~1000 (which is the right S/N to achieve an accuracy in radial velocity of 10 cm/s). Observing 1-2 stars with V~15.5 mag and 3-4 stars with V~14.5 mag, we can obtain in 6 nights enough data points (6-8) at an accuracy of 10 cm/s necessary to find Earth-mass planets. Since the radial velocity accuracy for a given
spectral type scales linearly with the inverse of the S/N ratio (Bouchy et al. 2001, A&A, 374, 733; Pasquini et al. 2006, IAUS, 232, 193), we can acquire several spectra with a S/N ratio of 100/pixel for each observation obtaining an accuracy of 1 m/s. Then, these spectra can be co-added allowing us to obtain the right radial velocity accuracy to look at Earth-mass planets. On the other hand, the precision of 1 m/s is enough to reach Neptun-mass planets. Hence, in 6 nights we can obtain with

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an accuracy of 1 m/s enough data points (6-8) for many stars (10-15) with 14.5<V<15.5 mag allowing us to reach Neptune-mass planets.

Current statistics indicate that 5% of giant planets with solar metallicity and solar mass stars host planets (Fischer & Valenti 2005, ApJ, 622, 1102; Udry et al. 2009, A&SS Proceedings, p.155). For more massive
stars, Kennedy & Kenyon 2008 (ApJ, 673, 502) models predict a statistics at least two times higher. Observing about 10 stars (taking also into account our HARPS/SOPHIE observations) with a wide mass
range (~0.8-2 M_sun) is a reasonable compromise between the required time, a meaningful statistics and the possibility to observe Earth-mass and Neptune mass exo-planets.

Since for the M67 stars with 9<V<15 we already obtained HARPS and SOPHIE observations, and since we are continuing to ask observing time with these instruments, the high-accuracy CODEX data will be used in conjuction with these data in order to obtain enough data points for as much as stars.

Since from our HARPS/SOPHIE sample we have already obtained for M67 good exo-planet hosting candidates, our immediate scope is to continue our research for exo-planets in M67 with these two spectrographs, and in the following years with ESPRESSO, but our future objective is to extend our M67 sample to CODEX with the possibility to apply this research to other OCs.

If the expected numbers of detections will be confirmed, we will be also able to test if any increase of planet frequency with stellar mass is observed or not in our stellar sample.

1.1- Project Title: Activity and magnetic fields in young low-mass stars and brown dwarfs

1.2- Project Category: 3

1.3- Abstract:

Stars and brown dwarfs form in collapsing molecular clouds, at young ages they can harbor accretion disks where planet formation is likely to take place. Magnetic fields are thought to control the accretion process, the occurence and strength of (sub)stellar activity, and the fields probably also influence the formation of planets at least in an indirect way. This proposal aims to investigate the role of magnetic fields during late stages of star- and brown dwarf formation, which are the early phases of planet formation. We propose to use

high-resolution infrared spectra to measure magnetic fields along with rotation velocities and other stellar parameters.

1.4- Publication agreement: yes

2.1- PI: A. Reiners

2.2- CoIs: J.H.M.M. Schmitt

2.3- Institute: Inst. f. Astrophysics, Göttingen

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: Ansgar.Reiners@phys.uni-goettingen.de

3.1- Source of targets: 2MASS, DENIS

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 12, 17, Vegamag, J

3.4- Target size: point source

3.5- Number of targets: 150

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: seeing, 1

4.2- Field-of-view: longslit

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 980 - 2500

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: SIMPLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: .1, 2, N/A

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: 10

7.4- Total time: 40

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
high spectral resolution, high efficiency at 998nm

9.3- Detailed description or other comments:
Magnetic fields play a crucial role in the formation, evolution, and final fate of stars and substellar objects, and probably also during the formation of planetary systems. At the very beginning, magnetic fields influence the contraction of molecular clouds, they control the accretion of disk material onto a star. Stellar magnetic fields lead to a plethora of phenomena connected to activity, and they control the

rotational evolution of late-type stars through wind braking. At the very last phases, supernovae are strongly influenced by the presence of magnetic fields, and the compact end-products of stars can harbor the strongest known magnetic fields in the universe in radio pulsars and related objects.

The sources, strengths and properties of stellar magnetic fields are currently only poorly understood, the main reason for this being the difficulty of directly measuring the field strength. High spectral resolution (>50,000) and high SNR (~100) are required, which is particularly difficult in faint objects as low-mass stars that are intrinsically faint, or in young stellar objects that are usually quite far away (>100pc). The E-ELT will be the first facility allowing a detailed spectroscopic analysis of such objects.

Rotation is known to be the key parameter ruling the magnetic activity in solar-like and low-mass stars, it is perhaps of less importance in fully convective stars and brown dwarfs. The role of rotation and its connection to magnetic fields and activity is probably strongest at very young ages (<15 Myr)), but not much of it is known in star forming regions and young associations, in particular at the low-mass end. Direct observations of rotation in very low-mass stars and brown dwarfs require high data quality as well.

It is the aim of this proposal to observe a significant number of young low-mass stars and brown dwarfs at near-infrared wavelength (Y-K bands). These cool objects emit the bulk of their energy at in this spectral range, and they exhibit a rich spectrum of spectral lines suitable for the measurement of rotation and magnetic fields. Infrared lines are particularly suited for the measurement of magnetic fields because Zeeman splitting scales with lambda2 while Doppler broadening scales only with lambda. Thus, it is the combination of both, large aperture and high spectral resolution in the infrared that allows successful measurements of magnetic fields in the infrared.

The targets of our proposal are young objects of spectral types K and later. We will select targets down to planetary masses in young associations (TW Hya, beta Pic, Tuc Hor, eps/eta Cha) and star forming regions (Sco Cen complex; Taurus, Up Sco, rho Oph, etc.). With the E-ELT, planetary mass targets at an age of 10 Myr will be observable at the required specifications our to a distance of more than 200pc.

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1.1- Project Title: Spatially resolved properties of the galaxies with the most intense star formation at z=1-4

1.2- Project Category: 2

1.3- Abstract:

We propose to obtain imaging and 1-D and 2-D/AO (resolution lower than 50 mas) optical/NIR spectroscopy for a representative sample of 500-1000 IR-bright galaxies at z=1-4 selected with the Spitzer, Herschel, SCUBA-2, and/or ALMA deepest surveys, all of them being extremely faint at optical (R>25) and NIR (K>22) wavelengths. These galaxies are known to dominate the SFR density of the Universe at z>1, and to be an important phase in the early formation of the most massive galaxies in the downsizing scenario. Our main goal is using the photometric and spectroscopic spatially resolved data to obtain robust estimations of parameters such as the stellar and dynamical masses, kinematics, SFR, metallicity, ages of the stellar populations, etc.. on a galaxy-by-galaxy basis. This project, together with the synergies with JWST and ALMA to also characterize the dust and gas properties, will be a giant step forward in our understanding of the formation of galaxies in a key epoch of galaxy evolution.

1.4- Publication agreement: yes

2.1- PI: P.G. Perez-Gonzalez

2.2- CoIs: A. Alonso-Herrero, G. Barro, F. Buitrago, J. Cepa, C. Conselice, J. Gallego, R. Guzman, I. Perez-Fournon, G. Rieke, N. Scoville, L. Tresse, I. Trujillo

2.3- Institute: Universidad Complutense de Madrid

2.4- Country of Employment: ES

2.5- Career Stage: faculty

2.6- E-mail: pgperez@astrax.fis.ucm.es

3.1- Source of targets: Mainly Spitzer and Herschel, and also SCUBA2, JWST and ALMA. May also be detected at faint photometric levels by VLT, Subaru, HST, and deep E-ELT imaging.

3.2- Preparatory work on targets required?: yes, Observations and cataloging with Spitzer (done), Herschel, JWST, ALMA, and E-ELT.

3.3- Target brightness: 23, 26, ABmag, H

3.4- Target size: extended source, 100, 400

3.5- Number of targets: 1000

3.6- Density of targets: >4

3.7- Target coordinates: RA:03:15 - 03:30;Dec:-27:45 - -28:00, RA:12:30 - 12:50;Dec:62:00 - 62:30, RA:09:30 - 10:30;Dec:02:00 - 02:30, RA:14:00 - 14:30;Dec:52:00 - 53:30, RA:02:00 - 02:30;Dec:-04:30 - -05:30

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy, AGN

4.1- Spatial resolution: 50, 1

4.2- Field-of-view: 10x10arcmin

4.3- Multiplexity and pick-off FoV: 20, 2x2arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: 300 - 2500

5.2- Spectral Resolution: bbimaging, nbimaging, 1000-2000, 2000-3000, 3000-5000

6.1- Instrument: EAGLE, OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: MOAO

7.1- Integration time per target or field and per setup: 10, 20, AO, any sky brightness

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

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7.4- Total time: 600

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, other, Herschel

9.2- Critical aspects / limiting factors for the science case:
The science case demands a large collecting area and sensitivity in the optical/NIR, <=0.05" angular resolution for imaging and MOS/IFU, FOV of 25-100 arcmin2. Multiplexing larger than 20.

9.3- Detailed description or other comments:
The redshift range between z=1 and z=4 is of special relevance in galaxy evolution. Indeed, it is now well established that the Universe had a period of high star formation efficiency 7-8 Gyr ago (at z>1), possibly lasting several Gyr. The cosmic star formation rate (SFR) density peaked at z~1, when it was approximately 10 times larger than at z=0 (Madau et al. 1996; Perez-Gonzalez et al. 2005; Hopkins Beacom 2006). An important fraction (>40%) of the total stellar mass density observed in galaxies today formed at z=1-4 (Dickinson et al. 2003; Perez-Gonzalez et al. 2008), just leaving ~10% of the current stellar mass content of the Universe to be formed at z>4. In addition, the formation of galaxies follows a ""downsizing"" scenario (Cowie et al. 1996): the most massive galaxies formed first at z>2, rapidly (with high SFR efficiencies), and in remarkably compact structures at z>2 (e.g., Trujillo et al. 2007), while the star formation in less massive systems proceeds more steadily to lower redshifts in more extended structures (Heavens et al. 2004; Juneau et al. 2005; Perez-Gonzalez et al. 2005, 2008ab).

Most of the previous results were obtained with samples of galaxies selected in the rest-frame ultraviolet (UV) and optical (see also Steidel et al. 1996; Ferguson et al. 2000), and using SFR estimators strongly affected by dust extinction. Although the general picture seems secure, these two factors could still introduce significant biases. The conclusions from optical studies can be tested with surveys at wavelengths where the effects of dust extinction are negligible: in the infrared (IR) and radio. IRAS and ISO probed the local and intermediate-z Universe (z<0.7). They showed that galaxies with dust-enshrouded star formation (ultra/luminous IR galaxies: U/LIRGs) have undergone strong evolution from z<0.7 to z=0 (Flores et al. 1999; Franceschini et al. 2001; Chary & Elbaz 2001). At higher redshifts (z~2), sub-mm observations also revealed a population of dusty star-forming galaxies that are hardly detected in the UV/optical (Smail et al. 1997; Chapman et al. 2003).

More recently, the Spitzer/MIPS surveys at 24 micron have detected star-forming galaxies and AGN at 0<z<3 (Le Floc""h et al. 2004; Egami et al. 2004; Alonso-Herrero et al. 2004), with a peak of detection efficiency at 0.5<z<2.5. These surveys have shown that the cosmic SFR density is dominated by LIRGs at z>0.5, and (U)LIRGs play a leading role in the formation of galaxies at z~2 (Perez-Gonzalez et al. 2005, 2008a; Le Floc""h et al. 2005; Caputi et al. 2006, Daddi et al. 2007). Surprisingly, the LIRGs at z~1 already present spiral morphologies and do not seem to be directly linked to interactions/mergers compared to galaxies of similar mass or color (Shi et al. 2005, Marcillac et al. 2008; although also see Shi et al. 2009).

Although we understand the importance of star-forming IR-bright galaxies in the process of galaxy formation at z>1 and we have already detected large numbers of them with Spitzer/MIPS and (sub-)mm surveys (roughly 4 sources/arcmin2 are detected by MIPS at 24 microns at z>1), we are still lacking a comprehensive characterization of their properties. The main reason is twofold: (1) a non-negligible fraction of them are very faint in the optical/NIR, beyond the photometric and (specially) spectroscopic observing capabilities of 8-10m class telescopes; and (2) their angular sizes are comparable or even smaller than natural seeing. Indeed, more than one third of the galaxies at z>1 detected by MIPS at 24 micron have R>25 and 75% of these have K>22. Thus, these galaxies are too faint and small for currently available optical/NIR (single- and multi-object) spectrographs. The surface density of IR-bright sources detected at z>1 will be larger when the Herschel, SCUBA2, and ALMA surveys at 100-1000 micron are carried out. These new facilities will also be more effective than MIPS in detecting star-forming galaxies at z>2 (e.g., Franceschini et al. 2006). Remarkably, they will allow us to obtain extinction estimates for galaxies at z=1-4 in the low mass end of the stellar

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mass functions (e.g., Perez-Gonzalez et al. 2008a, Marchesini et al. 2009), i.e., for the building blocks in a hierarchical scenario.

Making further progress in our understanding of the formation of galaxies requires studying in detail the integrated and spatially-resolved properties of the optically faint galaxies detected in the MIR-FIR, known to dominate the SFR density of the Universe at z>1 (contributing at least 50% to rho_SFR, Perez-Gonzalez et al. 2005). It is necessary to obtain robust estimations of the redshift, the stellar and dynamical mass, kinematics, SFR, metallicity, ages of the stellar populations, etc for each galaxy in 2 dimensions (through IFU spectroscopic observations), to account for the extinction effects, and to disentangle the frequency and properties of (un)obscured AGNs.

The properties outlined above could be inferred from imaging (broad-band data at several wavelengths), from optical 1-D spectroscopy (to obtain redshifts of our faint targets), and from 2-D spectroscopic observations in the NIR centered at emission lines such as Halpha or [OII], once combined with ancillary data at UV and MIR/FIR/radio wavelengths (see, e.g, Kennicutt 1998). UV observations alone are subject to uncertain extinction corrections, since the correlation between the UV slope and the attenuation is complex, with a strong dependence on parameters such as the stellar population age or the dust-stars relative geometry (Witt & Gordon 2000; Goldader et al. 2002; Kong et al. 2004; Burgarella et al. 2006). Halpha-Hbeta observations can be used to get more precise estimations of the extinctions. Alternatively, the combination of observed (not extinction corrected) UV and/or Halpha/[OII] SFRs and IR derived SFRs allows a consistent analysis of the star formation and extinction properties on a galaxy-by-galaxy basis, once each estimator is calibrated against the others (Kewley et al. 2003; Wu et al. 2005; Calzetti et al. 2005, 2007; Alonso-Herrero et al. 2006). The combination of several tracers (UV, Halpha or [OII], IR) gives the best SFR estimations, since it accounts for the photons coming from the newly-formed stars which do not interact with anything or are just scattered (detected in the UV), the photons that interact with the gas (reemitted through lines), and the photons that interact with the dust (reemitted in the IR). This method has been discussed for HII regions in M81 (Perez-Gonzalez et al. 2006) and M51 (Kennicutt et al. 2007), for nearby galaxies (Bell 2003; Iglesias-Paramo et al. 2006, 2007; Calzetti et al. 2007) including (U)LIRGs (Alonso-Herrero et al. 2006), and for distant sources (Hopkins & Beacom 2006).

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Concerning stellar masses and ages, the best estimations based on stellar population modeling are subject to important uncertainties due to the effect of dust attenuation and the unknown/poorly constrained star formation history (SFH) of each galaxy, and even due to the use of photometric redshifts (e.g., Kriek et al. 2008). The uncertainties can be reduced by using rest-frame NIR fluxes (probed by Spitzer/IRAC), which are less affected by dust extinction, as they usually trace the stellar population dominating the total stellar mass of galaxies. The emission-line fluxes (especially Halpha) can be used to constrain the SFHs (Charlot & Longhetti 2001; Perez-Gonzalez et al. 2003; Kauffmann et al. 2003), while the IR dust emission can be used to constrain the extinction in the models (e.g., Gordon et al. 2000). Dynamical masses measured with emission-line profiles and maps can be used to test the stellar mass estimates (e.g., Drory et al. 2004, Erb et al. 2005, Bundy et al. 2007) and the velocity field or dispersion (based on emission or absorption lines) for each object.

The feasibility and usefulness of NIR observations centered at Halpha or [OII] wavelengths have been demonstrated for UV-selected galaxies (Erb et al. 2006), Halpha-selected galaxies (Tresse et al. 2002) and a few tens of very bright IR-selected sources up to z~0.7 (Rigopoulou et al. 2000; Franceschini et al. 2003, Cardiel et al. 2003). There are also a few galaxies at z~2 with 2-dimensional Halpha maps obtained with VLT/SINFONI, all of them relatively bright (K<22), biased towards blue galaxies, and not representative of the IR-bright galaxy population (Forster-Schreiber et al. 2009). These galaxies present a great variety of dynamical properties (some are mergers, some are disks, some are extremely compact), all with similar SFR efficiencies (e.g., Perez-Gonzalez et al. 2008b), and they present typical sizes below 2-3 kpc (0.1"-0.4"; e.g., Buitrago et al. 2009). Currently, our detailed observations of z>1 galaxies are so scarce and biased that we still lack a clear picture of how galaxies form in the early Universe.

We propose to extend the detailed spectroscopic analysis of IR-bright sources to higher redshifts (z=1-4) and a wider range of optical/NIR/MIR luminosities with the study of a sample of 500-1000 IR-bright galaxies. These sources will be chosen to host very intense and dusty starbursts and thus will be selected at 24-1000 micron with Spitzer, Herschel, SCUBA-2, and/or ALMA in some of the deepest cosmological fields (e.g., GOODS-N, GOODS-S, EGS, COSMOS, or UKIDSS UDS). The sample will contain representative examples of those objects known to dominate the SFR density of the Universe at z>1 (contributing at least 50% to rho_SFR, Perez-Gonzalez et al. 2005). Finally, the different types of objects will be selected in sufficiently large numbers to provide statistically meaningful results as a function of important parameters such as stellar mass, SFR, activity, size, and gas content.

E-ELT will be a unique facility to obtain optical/NIR imaging and integrated multi-object spectroscopy (with the OPTIMOS instrument) or NIR AO/IFU multi-object spectroscopy (with EAGLE) for faint and small objects such as those in our sample (expected magnitudes: R=25-28, JHK=23-26; sizes below 0.5"). The unique contribution from E-ELT will be the high angular resolution and depth. Exploiting the synergies with other future facilities, and combining the E-ELT maps with integrated and spatially resolved data from JWST and/or ALMA, we will be able to characterize in detail and simultaneously the stellar, dust and gas properties of z=1-4 galaxies with spatial resolution, and advance in our understanding of the galaxy formation mechanisms in a key epoch in galaxy evolution.

1.1- Project Title: Metallicities of M dwarfs: with and without planets

1.2- Project Category: 3

1.3- Abstract:

We propose to study the metallicity distribution of M dwarf planetary host stars in comparison with similar stars without planets, based on high-resolution spectra. We have identified a large spectral region in the J band which is optimal for abundance analysis. We will employ our own model atmospheres and synthetic spectra, with special attention to the effects of molecular blanketing. Our methods have been validated by our exploratory studies using CRIRES at the VLT. With SIMPLE at the E-ELT we can observe a statistically significant number of targets, covering the whole relevant metallicity and temperature range. We can efficiently observe a large wavelength range for each target, and thereby extend the number of chemical elements investigated.

1.4- Publication agreement: yes

2.1- PI: U. Heiter

2.2- CoIs: N/A

2.3- Institute: Uppsala University

2.4- Country of Employment: SE

2.5- Career Stage: postdoc

2.6- E-mail: ulrike.heiter@fysast.uu.se

3.1- Source of targets: VizieR, 2MASS, Gaia

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 9, 14, Vegamag, J

3.4- Target size: point source

3.5- Number of targets: 200

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: fiber

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 1100 - 1300

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: SIMPLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: LTAO

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7.1- Integration time per target or field and per setup: 0.01, 0.25, E-ELT Spectroscopic Mode ETC Version 2.14; Spectral Type (Pickles Model): M5V; Telescope Diameter: 42m; Seeing: 0.8 arcsecs; Airmass: 1.15; Radius of circular S/N ref. area: 7.5 (DLC in J); AO-mode: Laser-Tomography AO; Spectral resolution R=50000; S/N ratio: 200;

7.2- Longest continuous observation time on a target or field: 0.25

7.3- Shortest integration time on a target or field: 10

7.4- Total time: 14

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
High-resolution echelle spectroscopy; LTAO (with GLAO or no AO, the programme would need at least 10 times more time)

9.3- Detailed description or other comments:
N/A

1.1- Project Title: High Time Resolution Astrophysics

1.2- Project Category: 1

1.3- Abstract:

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Extremely large telescopes are an opportunity to fully explore a new frontier in astrophysics - sub (temporal) second astronomy. Observations of short time-scale phenomena ranging from flares in normal stars through magnetospheric phenomena in pulsars to turbulence in AGNs will be possible. New fast detector technology, in conjunction with the proposed instrument payload will enable a complete characterisation of the incoming optical radiation with no additional optics.

1.4- Publication agreement: yes

2.1- PI: Andy Shearer

2.2- CoIs: Opticon HTRA network

2.3- Institute: Centre for Astronomy, NUI, Galway

2.4- Country of Employment: other

2.5- Career Stage: faculty

2.6- E-mail: andy.shearer@nuigalway.ie

3.1- Source of targets: Vista

3.2- Preparatory work on targets required?: no

3.3- Target brightness: <15, >32, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 100+

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +90

3.8- Moving target?: no

3.9- Variable target?: yes, 1000 per sec

3.10- Target type: other, HTRA targets

4.1- Spatial resolution: 10, 1

4.2- Field-of-view: 5x5arcsec

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4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: <1, 1

5.1- Wavelength range: 400 - 2200

5.2- Spectral Resolution: bbimaging, nbimaging, 100-300, 300-500, 500-1000, 1000-2000, 2000-3000, 3000-5000, 5000-10000, 10000-20000, 20000-50000

6.1- Instrument: other, All instruments with HTRA capability

6.2- Desired special mode: precision photometry, precision astrometry, polarimetry, polarimetry needed

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1 hours, say 5 hours, depending upon seeing, airmass, lunar phase, thermal background

7.2- Longest continuous observation time on a target or field: 5

7.3- Shortest integration time on a target or field: 0.001

7.4- Total time: 100+

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 100+

7.6- Are the observations time critical?: yes, Coordinated X-ray and Radio Observations

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, Quick look

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: yes, 10

9.1- Synergy with other programmes: ALMA, JWST, VLT/VLTI, TOO of transients - e.g. gamma ray bursts will be an advantage.

9.2- Critical aspects / limiting factors for the science case:
Detectors with time resolution below 1 second are required and potentially will fully open up a new window into the universe - the sub-second domain. These detectors are coming available now and

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will be a mature technology in the next 5-10 years. These include pnCCDs, APD arrays and superconducting detectors such as TESs.

9.3- Detailed description or other comments:
High-Time Resolution Astrophysics [HTRA] looks at the universe on the shortest time-scales. This proposal (description) is on behalf of the Opticon FP7 network which evolved from the HTRA Opticon network NA3.3 under FP6. The purpose of NA3.3 was to co-ordinate and bring together HTRA astronomers across Europe to examine commonalities and to start joint activities. Under this network held informal discussion meetings and organised two workshops. Our initial workshop, in Galway in June 2006, looked what had been achieved under the HTRA heading to-date. This resulted in the refereed book ASSL volume 351 High Time Resolution Astrophysics published by Springer in November 2007 - please see for instrument and science case descriptions. Following on from this we held a second workshop in Edinburgh in September 2007 the proceedings were published by AIP in 2008 - volume 984. These two volumes accurately describe the current state of the art in HTRA and provides a road-map for future
activity.

The specific astronomical science topics covered by the workshops were varied and included:-
1) Binary systems - including CVs, LMXBs and HMXBs
2) Neutron Stars - Pulsars, Magnetars and Isolated NS
3) Normal Stars - including Asteroseismology and Stellar Pulsations
4) Brown Dwarfs
5) Transients and Occultations
6) AGN

All of these areas will benefit from an HTRA capability within the E-ELT instrument pay load. The generic HTRA requirements are temporal resolution down to 1 millisecond, with spectral resolution varying from broad-band for dimmer targets to high resolution spectroscopy for the brighter targets. In all cases, as the sources are often non-thermal emitters, polarisation is important if not crucial. Associated with this generic proposal will be a number of specific science cases all of whom would benefit from instrument detectors with short time constants. These will be written by individuals and members of the Opticon HTRA network - the common theme will the need for ultra low noise detectors as part of the normal instrument design.

Overview review papers on HTRA and E-ELTs
HTRA - review papers High time resolution astrophysics and ELTs: Which wavelength?, Shearer, Andy, Cunniffe, John, Voisin, Bruno, Neustroev, Vitaly, Browne, Michael, Andersen, Torben, Enmark, Anita, and Linde, Peter, Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, 6986, 2008
HIGH TIME RESOLUTION ASTROPHYSICS: The Universe at Sub-Second Timescales, Phelan, Don, Ryan, Oliver, and Shearer, Andrew, High Time Resolution Astrophysics: The Universe at Sub-Second Timescales, 984, 2008
High Time Resolution Astrophysics and Pulsars, Shearer, Andrew, Astrophysics and Space Science Library, 351, 1 2008

High Time Resolution Astrophysics, Phelan, Don, Ryan, Oliver, and Shearer, Andrew, Astrophysics and Space Science Library, 351, 2008

Implications of ELT observations of pulsars, anomalous X-ray pulsars and supernova remnants, Shearer, Andrew, O""""""""""Connor, Padraig, and O Tuairisg, Seathrun, The Scientific Requirements for Extremely Large Telescopes, 232, 285, 2006
High time resolution astrophysics and extremely large telescopes, Shearer, Andrew, Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, 5382, 754, 2004

1.1- Project Title: Signatures of planets and of their formation in circumstellar disks

1.2- Project Category: 3

1.3- Abstract:
Theoretical investigations show that the planet-disk interaction causes structures in circumstellar disks, which are usually much larger in size than the planet itself and thus more easily detectable. The specific result of the planet-disk interaction depends on the evolutionary stage of the disk. Exemplary signatures of planets embedded in disks are gaps and spiral density waves in the case of young, gas-rich protoplanetary disks and characteristic asymmetric density patterns in debris disks. Observations with EPICS will provide a deep insight into specific phases of the formation and early evolution of planets in circumstellar disks.

1.4- Publication agreement: yes

2.1- PI: Sebastian Wolf

2.2- CoIs: Guiseppe Lodato, Michiel Min

2.3- Institute: University of Kiel, Institute of Theoretical Physics and Astrophysics

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: wolf@astrophysik.uni-kiel.de

3.1- Source of targets: General

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 1, 100, mJy, J

3.4- Target size: extended source, 10, 1000

3.5- Number of targets: 200

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per year

3.10- Target type: star

4.1- Spatial resolution: 5, 1000

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 500 - 2000

5.2- Spectral Resolution: bbimaging, 10000-20000

6.1- Instrument: EPICS

6.2- Desired special mode: precision photometry, precision astrometry, polarimetry, coronography, N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.1, 1, N/A

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 90

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, VLT/VLTI, SKA/SKAPF, N/A

9.2- Critical aspects / limiting factors for the science case:
High dynamic range

9.3- Detailed description or other comments:
Supplementary comments:
- Target size:
  Depends primarily on disk inclination, inner disk radius
- Number of targets:
  Young protoplanetary and debris disks;
  Estimate based on already 113 spatially resolved disks listed at circumstellar disks.org; Oct/2008}
- Target coordinates:
  a) Young disks: Objects primarily associated with specific star forming regions;
  b) Debris disks: Objects distributed all over the sky
- Variability of the targets:
  Variations of the to be observed structures on the timescale of months to years expected
- Field of view:
  The disks might be larger than the range given, but it is the potential planet-forming region (innermost 1" x 1" region for an object at approx. 100pc distance) for which only limited constraints can be derived today (e.g., with 2-beam interferometry or AO polarimetric imaging)
- Multiplexity:
  Single targets, even in the case of binary protostars / binary disks
- Plate scale stability:
  To be constrained by the desired special modes - see below
- Wavelength range:

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The given values are placeholders.
In general, observations in the optical/near-infrared wavelength range with various filters would allow to constrain the spatial disk density structure and dust grain properties.
- Spectral resolution:
a) Broad band imaging: serves the primary goal: Detection of weak structures outlined in the abstract;
b) Pseudo-long slit high spectral resolution (spectral resolution 1500-20000):
Motivation: Line variability in FU Orionis objects found between 4350-8690 Angstroms.
Goal now: Disentangle various models for variability (e.g. planets)}
Feasibility: to be demonstrated based on model simulations (sufficient flux)
- Desired special mode:
a) Coronagraphy: For objects where the central star is visible;
b) Polarimetry:
b1) Differential polarimetry: disk observation close to central star;
b2) Complementary constraints for dust processing and evolution
c) Precision Astrometry: Allowing to detect motion of structures on the timescale of months/years;
d) Photometry: Provides required link a quantitative image analysis based on models
- Integration time per target or field and per setup
Given value is only a placeholder for a broad range of integration times needed to trace both inner and outer structures in disks
- Total time required to complete your programme
90h
Estimate based on simple imaging:
200 objects x 5 filters x 300 s (various integration times);
Not considered in this estimate: Spectroscopic observations, Polarimetric observations
- What fraction of the total time would suffice to obtain scientifically useful results? [%]
Value given based on observations of already best-studies sources of both types of disks
- Does the execution of the observations require real-time decisions?
Assumption here: Real-time decisions based on a quick-and-dirty image analysis on the fly appears only modestly useful.
- Synergy with other facilities:
Multi-wavelength observations will allow to obtain complementary constraints for the disk structure (e.g., inner regions: ALMA)

1.1- Project Title: Pristine C and N abundances in Local Group galaxies

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1.2- Project Category: 2

1.3- Abstract:
Carbon and Nitrogen are among the most abundant elements in the universe. A reliable reconstruction of the star formation history of extra-galactic systems requires accurate spectroscopic measures of the abundance ratios of these species.

We propose OPTIMOS/E-ELT to obtain C and N abundances for conspicuous sample of stars in 9 local group galaxies up to distances of ~90kpc. Target stars are selected at magnitudes fainter than the Red Giant Branch bump. This way, we will obtain for the first time un-mixed C and N abundances in extra-galactic system.

1.4- Publication agreement: no

2.1- PI: Lorenzo Monaco

2.2- CoIs: N/A

2.3- Institute: Departamento de Astronomia, Universidad de Concepcion

2.4- Country of Employment: CL

2.5- Career Stage: postdoc

2.6- E-mail: lmonaco@astro-udec.cl

3.1- Source of targets: SDSS, WFI, VLT

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 19, 21, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: seeing, 19

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: 300, fiber

4.4- Plate scale stability: N/A

5.1- Wavelength range: 400 - 450

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 3, 3, T=5000K, S/N=70 on the faintest selected stars of each target galaxy (V=21) at 410nm, R=10000, 0.80 arcsecs, seeing limited

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 27

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
resolution, wavelength range, multiplexity, sensitivity

9.3- Detailed description or other comments:
Dwarf galaxies are the most abundant type of galaxy in the Universe. Whether they can be considered the cosmological building blocks from which giant galaxies are formed is still an open question. A reliable reconstruction of the star formation history of these small galaxies is, hence, crucial to address this topic. The photospheric chemical abundances of red giants hide the record of the various generation of stars which led to the present day stellar content of these objects. Indeed, a number of surveys are tracing the abundance pattern of various elements in the closest Milky Way satellites. The systematic lack of Carbon and Nitrogen abundances in dSph galaxies is a serious gap in this framework. C and N are among the most abundant element in the Universe and yet obtaining abundances is a relatively challenging task mainly due to the faintness of the target stars. Actually, C abundances have been measured so far for only 7 stars (see Frebel et al. 2009) and no N abundance measures have been recorded so far for stars in dSphs. Additionally, all of the above measures involve stars close to the tip of the Red Giant Branch (RGB). No change in the C and N abundances is theoretically expected from the first dredge-up episode occurring at the base of the RGB (Spite et al. 2006). At variance, C, N abundances are known to be significantly altered by the extra-mixing processes arising at the RGB-bump level. Therefore, all the C abundances measured so far for RGB stars in dSph are likely not reflecting the original chemical composition of the interstellar material from which they were formed.

OPTIMOS/E-ELT will allow to obtain for the first time un-mixed C,N abundances for sizeable sample of stars in 9 dwarf galaxies up to a distances of 90~kpc with a relatively modest time request. This large distance range, will allow to study the CN enrichment history of dwarfs belonging to different classes (dSph, Ultra-faint dwarfs, dwarf Irregulars) and lying in different environment (i.e. isolated and in interaction with the Milky Way).

1.1- Project Title: Lithium abundance in Local Group galaxies

1.2- Project Category: 2

1.3- Abstract:
A discrepancy emerged between the cosmic Li abundance as measured by the WMAP satellite and the constant Li abundance measured in metal poor halo dwarf stars (the so-called {\em Spite plateau}). Several models are being proposed to explain such a discrepancy.

OPTIMOS/E-ELT offers us the unique opportunity to measure for the first time the Li abundance in a conspicuous number of stars in a sample of 4 galaxies at distances up to 50kpc belonging to different classes (dSph, Ultra-faint dwarfs, dwarf Irregulars), having different masses and lying in different environments (i.e. isolated and in interaction with the Milky Way).

1.4- Publication agreement: yes

2.1- PI: Lorenzo Monaco

2.2- CoIs: N/A

2.3- Institute: Departamento de Astronomia, Universidad de Concepcion

2.4- Country of Employment: CL

2.5- Career Stage: postdoc

2.6- E-mail: lmonaco@astro-udec.cl

3.1- Source of targets: SDSS, WFI, VLT

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 21.5, 22, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: N/A

4.1- Spatial resolution: seeing, 19

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: 300, fiber

4.4- Plate scale stability: N/A

5.1- Wavelength range: 630 - 690

5.2- Spectral Resolution: 20000-50000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 10, 10, T=6000K, S/N=70 on the faintest selected stars of each target galaxy (V=22) at 671nm, R=20000, 0.80 arcsecs, seeing limited

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 40

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 25

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

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9.2- Critical aspects / limiting factors for the science case:
resolution, wavelength range, multiplexity, sensitivity

9.3- Detailed description or other comments:
Several among the local group galaxies and Milky Way satellites are known to host populations of metal--poor stars. Like the metal--poor populations in our own galaxy these are the fossil records of the early stages of the formation of these galaxies. In the 1980 Monique and Francois Spite (Spite & Spite 1982) made the topical discovery that the metal--poor turn-off stars in our Galaxy display a constant Li abundance, whichever their metallicity or effective temperature, this constant Li abundance is usually called the Spite plateau. The most straightforward interpretation of this fact was that the Li observed in these stars was in fact "primordial", i.e. produced during the first three minutes of life of the Universe. In fact in the first three minutes the Universe synthesised nuclei of deuterium, the two stable He isotopes (3He and 4He) and 7Li, but none of the heavier nuclei. The abundance of these nuclei depends on the baryon/photon ratio, therefore on the the baryonic density of the Universe. Thus, in principle, the Spite plateau allows us to determine the baryon/photon ratio which cannot be deduced from first principles. However, currently, this interpretation of the Spite plateau is seriously challenged by the measurement of the baryonic density, with unprecedented precision, from the fluctuations of the CMB, by the WMAP satellite Spergel et al. (2007). The results of the first three years of data imply a primordial Li abundance of 2.64, while the observed value is around 2.1 Bonifacio et al. (2007, and references therein). There are a number of possibilities to reconcile the WMAP observations and the Li observed in Halo dwarfs, e.g. using non--Standard Big Bang Nucleosynthesis (BBN) in order to predict the abundances of the light elements. The most appealing such model is the case of a late--decaying massive particle (Jedamzik 2004a,b; Jedamzik et al. 2006) A depletion of Li in the atmospheres of metal-poor stars is another possibility, although it is difficult to produce such a uniform depletion in all stars. Recently, Piau et al. (2006, ApJ, 653, 300) have suggested that part of the discrepancy
might be explained by a first generation of stars that depleted lithium efficiently.

In this situation it becomes of great interest to observe the Li abundances in metal-poor dwarfs of external galaxies. In scenarios which invoke non standard BBN, these stars should show the same Li abundance as the metal-poor stars of the Milky Way (MW). In the scenario proposed by Piau et al. (2006) the amount of Li would be, instead, significantly different. In fact, the amount of material processed through the first generation of stars can be different for two different galaxies. Particularly, giant galaxies like the MW and low-mass dwarf galaxies are likely to experience quite different chemical enrichment histories, including the fraction of gas processed through the first stars. Finding a different level of Li abundances in two different galaxies would greatly support the scenario of Piau et al.

OPTIMOS/E-ELT offers us the possibility of measuring Li abundances in a conspicuous number of stars in a sample of 4 galaxies (Sgr, LMC, Coma Berenices and BootesII) up to distances of about 50~kpc and with a relatively modest time request. Therefore, we will obtain crucial measures for galaxies belonging to different classes (dSph, Ultra-faint dwarfs, dwarf Irregulars), having different masses and lying in different environments (i.e. isolated and in interaction with the Milky Way).

1.1- Project Title: The physics of exo-planets atmospheres

1.2- Project Category: 3

1.3- Abstract:
This programme aims at detecting atmospheric spectral features of extra-solar planets around very low mass stars. This will allow us to constrain the physical and chemical conditions of the planet atmospheres, and, for rocky planets in the habitable zone, even to detect traces of life. The strongest absorption features of planet atmospheres can be detected, in the near-IR, observing the star during a planet transit. Transits should occur every 6 days, and last 30-60 minutes. Depending on the atmosphere scale height, a total exposure time between 2 and 50 hours will be needed, for a Jupiter- and an Earth-like planet, respectively.

1.4- Publication agreement: yes

2.1- PI: Livia Origlia

2.2- CoIs: D. Minniti, M. Zoccali & the SIMPLE Team

2.3- Institute: N/A

2.4- Country of Employment: IT

2.5- Career Stage: faculty

2.6- E-mail: livia.origlia@oabo.inaf.it

3.1- Source of targets: e.g. VLT, VISTA

3.2- Preparatory work on targets required?: yes, Detection of exo-planets around low mass stars, by means of radial velocity and transit surveys at near IR wavelengths, and precise determination of transit ephemerides.

3.3- Target brightness: 10.5, 15.0, Vegamag, J

3.4- Target size: point source

3.5- Number of targets: 500

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per week

3.10- Target type: exoplanet

4.1- Spatial resolution: 50, 2-3

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 840 - 2500

5.2- Spectral Resolution: >100000

6.1- Instrument: SIMPLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: SCAO

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7.1- Integration time per target or field and per setup: 2, 50, LTAO, seeing 0.8, airmass=1.15

7.2- Longest continuous observation time on a target or field: 0.5

7.3- Shortest integration time on a target or field: 900

7.4- Total time: 250

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 25

7.6- Are the observations time critical?: yes, observations must be carried on during transits

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, service observing

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
1. The ephemerides need to be correct.
2. The detection of the atmosphere of Jupiter-like planets is guaranteed.
The detection of ocean- or Earth-like planets is possible only if they are found in a transiting orbit around a
0.1 Msun star within 25 or 16 pc, respectively. There area few hundreds such stars, and the fraction of them having
small transiting planets is hard to predict.
3. For the faintest (J=14-15) planets with Jovian atmospheres LTAO is probably more efficient than SCAO.

9.3- Detailed description or other comments:
The study of extra-solar planets is a new and rapidly developing field of research, with an enormous impact both on the scientific community and on the general public. IR high-resolution spectroscopy with SIMPLE on the E-ELT will provide a formidable tool to observe planet atmospheric spectral features during transits. The strongest absorption features of planets are at IR wavelengths and can be used as diagnostics of the physical and chemical conditions of the atmosphere (e.g. Brown 2001, ApJ 553, 1006). In the case of planets in habitable orbits, the atmosphere spectrum may be used even to detect traces of life (e.g. Des Marais et al. 2002, AsBio 2, 153).

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Atmospheric features can be detected during the transit of the planet in front of its parent star if the cross-section of the planet atmosphere, relatively to the stellar disk, is sufficiently large to produce absorption lines of measurable depth in the observed spectrum. SIMPLE will observe transmission spectra in a variety of exo-planets, resulting in enormous progress. Here we will chose the most challenging case, listing at the end various other interesting possibilities.

Obviously, the smaller the stellar disk (hence the stellar mass), the easier the detection. M-type dwarfs are the most numerous stars in our Galaxy. This proposal aims at observing planets around 0.1 Msun stars. Transits of Earth-like planets in the habitable zone (where water is liquid) around 0.1 Msun stars would last 30-60 minutes, and occur every 6 days. The S/N required to detect their atmosphere depends on the scale height of their atmosphere.

A Jupiter-like planet, with an atmosphere scale height of >100 km, will have a cross section of 0.01 relative to the stellar disk size, thus a S/N of ~300 will be required to detect it. This can be easily reached in just 2 hour exposures, for stars with J<=15. Since the absolute magnitude of 0.1 Msun stars is M_J=10.3 (Baraffe et al. 2003, A&A 402, 701), they can be observed with J~15 out to 90 pc. According to the local space density estimated by Cruz et al. (2007, AJ, 133, 439) there are ~15,000 such systems in the solar vicinity. It is reasonable to expect that at least several hundreds of them will have transiting Jupiter-like planets.

Much more challenging will be to detect the atmosphere of an Ocean planet (60 km atmosphere height; Kuchner 2003, ApJ 596, 105) or even a Earth-like planet (10 km). The atmosphere of an ocean planet would have a cross section of 2x10-4, thus requiring a S/N of 2x104 to be detected. The atmosphere of an Earth-like planet will have a cross section of 3x10-5, thus requiring a S/N of 105.

Given the lengths of the transits (~30min) and their frequency (~6d) there will be ~60 transits every year. A reasonable time to monitor such systems would be ~2-3 years, yielding some ~50 hours exposure, if some of the time is lost for transits occurring during the day, clouds etc. A total integration time of 50 hours would yield a S/N of 5000 at resolution R=100,000, for stars of apparent J=12.5 (i.e., 0.1 Msun stars within 25 pc). This is not quite enough for our purposes. However, one can take advantage of the high spectral resolution of SIMPLE to subtract with high precision the telluric features from the spectra, and then rebin the co-added spectrum to a lower resolution, in order to measure the broad absorption feature of the exo-planet atmosphere.

Rebinning by a factor of 20 (R=5000) would allow to reach the required

S/N~2x104, in a 50h exposure, hence to detect the atmosphere of an ocean planet around a J<=12.5 mag star. There are ~330 stars of 0.1 Msun within 25pc, hence with apparent J=12.5 or brighter.
The detection of the atmosphere of an Earth-like planet is at the edge of the possibility of SIMPLE on the E-ELT. The required S/N could be reached by rebinning by a factor of 50 (R=2000) or higher, on a 50h exposure, with limiting magnitude of J=11.5. Stars of 0.1 Msun could then be measured only if they are within 16 pc. The total number of such systems in the solar neighborhood is estimated to be 86. Success is therefore critically dependent on the (unknown) fraction of such systems having transiting planets. It is a tough bet. However, the possible detection of habitable conditions in just one Earth-like planet would be such a huge leap forward for humanity, that it would certainly justify the investment of a 30 minute exposure every week, for 2-3 years.
Even though we focused on the observation of transmission spectra of the atmospheres of extrasolar planets around low-mass stars, we would like to mention other possibilities with SIMPLE:
- search and characterization of extrasolar planets in the nearest globular clusters using RVs.
- the study of Titan´s atmosphere.
- the study of outgassing of Enceladus, Triton, etc.
- the study of Pluto´s atmosphere and other massive KBOs.
- search and study of atmospheres of super-Earths satellites around massive planets.
- the detection and spectroscopic study of secondary eclipses from exo-planets.
- the spin characterization using the Rossiter-McLaughlin effect.

1.1- Project Title: The metallicity evolution at high redshift

1.2- Project Category: 2

1.3- Abstract:
We propose to use SIMPLE to directly investigate the formation of proto-galaxies in the early Universe by observing metal absorption lines associated with galaxies soon after the re-ionization epoch (z>6), i.e. the first epoch of star formation and metal enrichment. The metal absorption lines detected by SIMPLE at the re-ionization epoch will directly test various scenarios of early chemical enrichment in primordial galaxies, and possibly trace the first metal

pollution by the first population of stars (the so-called Population III). By measuring the relative chemical abundances, SIMPLE will also allow us to investigate the dust content in primordial galaxies.

1.4- Publication agreement: yes

2.1- PI: Livia Origlia

2.2- CoIs: R. Maiolino & the SIMPLE Team

2.3- Institute: INAF - Bologna Observatory

2.4- Country of Employment: IT

2.5- Career Stage: faculty

2.6- E-mail: livia.origlia@oabo.inaf.it

3.1- Source of targets: SDSS,VISTA,SWIFT

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 19, 21, Vegamag, J

3.4- Target size: point source

3.5- Number of targets: 25

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: AGN

4.1- Spatial resolution: 50, 2

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

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4.4- Plate scale stability: N/A

5.1- Wavelength range: 900 - 2500

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: SIMPLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: LTAO

7.1- Integration time per target or field and per setup: 1, 10, LTAO, seeing 0.8, airmass=1.15

7.2- Longest continuous observation time on a target or field: 0.5

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: yes, of the GRB part of the project, only

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, service observing

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: yes, 120

9.1- Synergy with other programmes: JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
Note that the Target-of-Opportunity only applies to the GRB part of the project, i.e. ~10%)

9.3- Detailed description or other comments:
Understanding the metallicity evolution of galaxies and tracing galaxy formation through the cosmic ages are very important and challenging issues of observational cosmology and in particular for the epoch close to the dark ages, when the first luminous objects were formed leading to the re- ionization of the Universe. Absorption lines due to systems along the line of sight of high-z quasars or GRBs provide the

most accurate tool to investigate the metal content and relative abundances at high-z. Currently the investigation of metal absorption lines has mostly been limited to intermediate redshifts (z<4), both because at higher redshifts some of the important metal lines in the far and near-UV are progressively shifted into the near IR region, and because at higher redshift the cosmological dimming of both quasars and GRBs makes them very difficult to observe with the high S/N and high spectral resolution required to investigate the absorption features. The main goal of this proposal is to extend the observation of absorption systems to z>6, with focus to z>7, which would allow the investigation of the metal enrichment approaching, or within, the re-ionization epoch. Around this epoch we expect an abrupt change of the metal content and of the relative chemical abundances since we approach the epoch of the first metal injection into the ISM. Some hints of such a downturn in the metals content of high-z absorbers at z~6 have been found thanks to deep and extensive recent campaigns, but still based on a small number of (only) CIV absorbers (and jeopardized by various "tentative" detections). The expectation is that by probing a larger number of absorbers, by sampling several metal lines and, most importantly, by extending the search to even higher redshifts (z~7) well within the re-ionization epoch, we may really trace the first phases of the metal enrichment in primordial galaxies forming at the end of the dark ages. The most ambitious goal is to detect, in z>6 absorption systems, the chemical abundances pattern expected to be produced by the very first generation of stars, i.e. those stars forming out of the pristine (zero metallicity) gas, the so called Population III stars. The detection of the chemical signature of Population III enrichment would be a major breakthrough in Astronomy. This proposal aims at investigating the early metal enrichment in proto-galaxies, and at finding the metal signature of the first generation of stars, by using SIMPLE to observe a sample of quasars and GRBs at z>6, focusing on those at z~7 or higher. SIMPLE will allow us to reveal absorption metal lines of systems intervening along the line of sight (both DLA and Lya Forest). Thanks to the sensitivity and wide, simultaneous spectral coverage of SIMPLE we will be able to detect UV resonant absorption lines, redshifted into the near-IR, associated with various ionization states of several species (e.g. C, Al, Si, Fn, Fe, Zn). These absorption features will provide not only the average metallicity of the proto-galaxy associated with them, but also detailed abundance patterns. The abundance patterns will be compared with detailed models of chemical evolution of galaxies in the early universe. In particular, the abundance patterns will be compared with the expected yields of the first generation of massive stars, i.e. PopIII stars.

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Unlike other Fe-peak elements, zinc is not depleted into dust; therefore, the detection of the ZnII absorption doublet at 203-206 nm will provide a unique tool to investigate the abundance of the Fe-peak elements in high-z proto-galaxies. Iron-peak elements are considered as a "clock" of star formation, due to their delayed enrichment. Therefore the measurement of the ZnII in high-z galaxies will allow us to date the first epoch of star formation in these objects.

Iron is mostly locked into dust grains, hence measuring the depth of the FeII UV absorption feature relative to the ZnII lines, will provide unique information on the amount of dust already formed in these systems. This will be an extremely important result, since dust is expected to play a crucial role in the early phases of star formation (by affecting the IMF and the star formation rate) and it has also crucial implications on the detectability of these objects. Probing the amount of dust in these high-z systems will also shed light on the mechanism responsible for dust production in the early universe, which is a hotly debated issue.

Metal absorption lines will be searched and investigated both in intervening systems along the line of sight of QSO and GRBs, but also within the host galaxies of these systems (associated absorption systems). In the case of the QSO host galaxies, the detection of the associated metal absorption lines with SIMPLE will allow us to investigate the formation of massive galaxies in the early universe.

To statistically constrain the metallicity evolution in the early universe we need to observe a sample of about 20 QSOs at $z>6$, with highest priority for those at $z>7$. Samples of quasars at $6<z<6.4$ are already known from extensive wide field optical surveys (e.g. SDSS). Quasars at $z\sim7$ are expected to be detected within the coming VISTA surveys, as well as in planned space missions (e.g. Euclid). The current quasar samples at $z>6$, as well as the ones expected to be delivered by the VISTA surveys, have J band magnitudes in the range J(Vega)~19-21 mag. To determine the metallicity and abundance patterns from the absorption systems we need to achieve a S/N~30. This implies integration times ranging from 1 hour to 10 hours.

High-z GRB will also offer a unique chance to trace the metal enrichment in high-z proto-galaxies. A number of facilities are planned to be in operation during the ELT era both for the detection and for the identification of high-z GRBs. We expect a few GRB at $z>5$ per year to be observable from one hemisphere with J(Vega)<19, even if observed ~1-2 hours after explosion. We plan to followup with SIMPLE a sample of 5 GRB at $z>6$ for 3 hours after explosion.

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1.1- Project Title: Extragalactic X-ray binaries

1.2- Project Category: 1

1.3- Abstract:
There are far more X-ray binaries in nearby galaxies than there are in the Milky Way. This allows us the opportunity both to study populations on reasonable sample sizes, and to investigate sources of types not existent in the Milky Way (e.g. ultraluminous X-ray sources, which might contain intermediate mass black holes).

1.4- Publication agreement: yes

2.1- PI: Thomas J. Maccarone

2.2- CoIs: , Peter Jonker

2.3- Institute: University of Southampton

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: tjm@phys.soton.ac.uk

3.1- Source of targets: Primarily Chandra and XMM observations

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 20, 28, Vegamag, R

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: N/A

4.1- Spatial resolution: seeing, 3

4.2- Field-of-view: 10x10arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 600 - 700

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: MICADO, OPTIMOS, other, AO instrument working in red optical light

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 2, 4, N/A

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: 1000

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: yes, the first few epochs of spectroscopy may gives hints at the orbital period, which can inform the sampling for future observations., N/A

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

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8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: SKA/SKAPF, SKA should allow radio observations of extragalactic X-ray binaries

9.2- Critical aspects / limiting factors for the science case:
Service mode spectroscopy with a wide range of timescales accessible is absolutely necessary for mass function measurements of extragalactic X-ray binaries. Most of the systems whose optical counterparts will be bright enough for spectroscopy will have long enough orbital periods to make classical scheduling infeasible.

9.3- Detailed description or other comments:
The E-ELT should be able to make advances in understanding the optical properties of extragalactic populations of X-ray binaries. Because the Milky Way''s bright X-ray binary population is small and its star formation history is complicated relative to those of the elliptical galaxies and starburst galaxies which form a significant fraction of the extragalactic sky which has been surveyed carefully in X-rays, it is more difficult to use the Milky Way to unravel the binary evolutionary processes that produce X-ray binaries and, in turn, radio pulsars.

Extragalactic X-ray binaries are far more numerous than Galactic ones. At the peaks of their outbursts, they should be sufficiently, bright, and also variable, to be detected against the background light of their host galaxies. What is needed is sensitivity to variable sources brighter than about V=28 to allow studies of the bulk of the X-ray binary population in Cen A, and the brighter binaries in the Virgo Cluster. Ideally, this could be done in bands bluer than 0.8 microns so the contrast in color between the disk emission and the red giants would be maximized, but it can be done very well in the bluest end of the MICADO band. Well established relations from Galactic binaries show that we can make good estimates of the orbital period of an X-ray binary from its optical/infrared and X-ray fluxes near the peak of an outburst. Therefore, finding these optical counterparts will provide extremely powerful information for understanding the period distribution of X-ray binaries.

Mass estimates for some extragalactic X-ray binaries should be possible with an ELT. In particular, the ultraluminous X-ray sources, X-ray sources brighter than the Eddington limit for 10 solar mass black holes, are of great interest, since some fraction of them may contain intermediate mass black holes. Many of these ULXs have high mass donor stars, and emission line spectroscopy can currently be done for the few brightest of these in order to trace out their orbits. This is inherently unreliable, as the ionization of the stellar winds of massive stars by the X-rays from the accretor means that the winds do not trace the motion of the center of mass of the star. Absorption line spectroscopy will be possible with an ELT, since an order of magnitude greater collection area is just what is needed to get the same signal to noise on absorption lines in the future as we can get from emission lines now. Given the importance of the question, and the disagreement between the mass estimates from all the available indirect techniques, it is essential to make direct mass measurements from radial velocity curves.

NOTE: due to the nature of this project, the exposure times given above are rough estimates. Exposures needed will depend on what the orbital periods turn out to be, and good candidate sources will continue to be found with better X-ray data. In some cases, multiple object spectroscopy will make sense because there will be multiple good candidates in the same galaxy. The main need is to ensure that campaigns with large numbers of medium length spectra can be made.

1.1- Project Title: a METIS study of brown dwarf disks

1.2- Project Category: 3

1.3- Abstract:

We propose a detailed study of disks around young sub-stellar objects with E-ELT/METIS, exploiting its unique capabilities that are complementary to JWST/MIRI. We will determine the structure and evolution of the disks and their dust, and get a comprehensive inventory of gas chemistry over a range of disk radii, including water and organic molecules. We will trace the dynamics of the warm inner disk gas, and may directly detect and characterize accreting proto-planets still embedded in the disk - an opportunity that may be unique to very low-mass objects.

1.4- Publication agreement: yes

2.1- PI: Roy van Boekel

2.2- CoIs: N/A

2.3- Institute: MPIA Heidelberg

2.4- Country of Employment: DE

2.5- Career Stage: postdoc

2.6- E-mail: boekel@mpia.de

3.1- Source of targets: VLT, VISTA, SDSS, Spitzer, JWST, Panstarrs, UKIDSS, ...

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 2, 40, mJy, N

3.4- Target size: point source

3.5- Number of targets: 20

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: other, young, sub-stellar object

4.1- Spatial resolution: diffraction, 3

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: L, M, N

5.2- Spectral Resolution: bbimaging, 100-300, 50000-100000

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6.1- Instrument: METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.5, 5, N/A

7.2- Longest continuous observation time on a target or field: 5

7.3- Shortest integration time on a target or field: 1800

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
Sensitivity (genral), spatial resolution (for spectro-astrometry and detection of embedded planets), spectral resolution (for gas chemistry, dynamics)

9.3- Detailed description or other comments:
Circumstellar disks are known to be ubiquitous around young stars of low and intermediate mass, and evidence is gathering that this continues into the still poorly studied high-mass regime. The disks are thought to play an essential role in the star formation process by funneling material toward the central object an carrying away angular momentum. Moreover, they are thought to be the sites of on-going planet formation. In recent years, evidence for disks around young sub-stellar objects in the form of infrared excess emission was found using the Spitzer Space Telescope.

Due to the observational challenges involved, brown dwarf disks represent still largely unexplored territory. Main science questions include: What is the spatial structure of the disks around brown dwarfs, and how does it evolve? What are the properties of the solid state material ("dust"), how do they evolve, and can we witness the onset of planet formation? What are the disk kinematics, how

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does large scale transport of material through the disk and accretion onto the central object proceed? Do planets form in brown dwarf disks and if so, what kind of planets form, and where in the disk do they form? In any of the above mentioned aspects, (how) do brown dwarf systems differ from young, sun-like stars?

Even the youngest brown dwarfs have very low luminosity compared to stars. This poses particular challenges on METIS science in this field, in particular in comparison to JWST/MIRI. This comparison largely defines the scope of the current science case. METIS" strengths are the high spatial and high spectral resolution, whereas JWST wins on sensitivity and the larger spectral domain probed. Due to the expected small apparent spatial extent of brown dwarf disks, they will likely remain spatially unresolved in the classical sense, but direct spatial information may be obtained using spectro-astrometry, and due to the high spatial resolution of ELT/METIS we may detect accreting proto-planets embedded in the disk. Contrary to JWST/MIRI, METIS will spectrally resolve the detected emission lines, yielding major advantages. It allows to establish whether observed emission lines originate in the disk surface or in a wind or jet, fitting detailed (non-LTE) radiative transfer models w
hich results in dramatically better measurements of abundance ratios as a function of radius, which in turn lead to better constraints for chemical models. However, sensitivity considerations will limit high resolution spectroscopy of brown dwarf disks to a sub-sample of the brightest sources.

In spatially unresolved observations, the disk structure and evolution can be studied indirectly by measuring the SED at near- and mid-infrared wavelengths, and subsequent fitting using radiative transfer disk models. The dust composition and evolution can be studied through IR spectroscopy, in particular in the N-band which contains the 10-micron silicate complex which is sensitive to the mineral composition, grain sizes, and thermal history of the material (crystallization). In both these aspects, JWST will be superior to ELT/METIS due to its higher sensitivity and ability to take spectra from 5 to 28 micron. Important contributions from METIS include the study of disks in close binaries (that are spatially unresolved to JWST), and targeted follow-up of sources studied JWST. In particular, some sources are known to be variable at mid-IR wavelengths, both in the level of IR emission and in the shape and strength of their dust features (Leisenring et al. 2008). JWST will like
ly discover many of these and METIS allows continued study of such top-priority targets.

The gas chemistry in brown dwarf disks is essentially unexplored territory, though first detections of water (ref) and organic molecules (Pascucci et al. 2009) in Spitzer spectra of very low mass objects approaching the brown dwarf regime have been announced. JWST will be able to detect many more spieces in brown dwarf disks, but the limited spectral resolution will leave all individual lines spectrally unresolved and many line complexes blended. In the N-band, the circumstellar emission will dominate in young brown dwarf systems, providing a clear diagnostic of the disk material (in the near infrared, the IR excess is relatively small and the photosphere shows very strong and complex spectral structure, which may complicate isolating the disk signature). With a resolution of R=50000 (6 km/s), all lines can be individually measured and those formed close to the central object can be spectrally resolved. We investigated in particular the observability of water and find that it is readily observable with METIS, displaying a rich emission line spectrum and allowing the determination of abundances, temperatures, isotopic ratios, ortho- to para ratios, and radial abundance structures. Many lines of (organic) molecules are observable, including C2H2, CH3, NH3, HCN, HNCO and CS. The N-band covers the bulk of both the dominant oxygen carbon chemistries.

The gas kinematics of circumstellar disks can be traced down and spatially resolved to a small fraction of the diffraction limit using spectro-astrometry. Extrapolating the measured performance of VLT/CRIRES to ELT/METIS, we may expect reaching a resolution of $\sim$200 micro-arcsec on a 40 mJy source in 30 minutes of integration time, corresponding to $\sim$0.01 AU in the nearest known brown dwarf disks. This brings the CO emitting region within reach of ELT/METIS, allowing direct measurement of the gas dynamics in the inner disk. In more remote or fainter objects, analysis is limited to spatially unresolved but spectrally resolved line profiles, yielding e.g. the inner radius of the CO emitting region, assuming Keplerian rotation. While brown dwarf photospheres have very complex absorption spectra, typical observed rotational velocities 5 to 20 km/s. The hot inner disk gas has velocities that are $\sim$3-10 times higher, making both components spectrally separable.

A particularly exciting possibility offered by brown dwarf disks, is the direct detection of young, accreting proto-planets still embedded in the disk. A young, accreting Jupiter-like planet will have a luminosity of order 10-5 to 10-4 Lsun (e.g. Burrows et al. 1997), during the run-away gas accretion phase possibly reaching even 10-2 Lsun (Fortney et al. 2005). The planet"s luminosity will locally heat up the disk from which it is forming, making the disk appear bright at 10 micron. In more massive objects, the central object is very luminous and irradiates the disk surface, making the entire disk surface bright and making the additional "bright spot" caused by the planet exceedingly difficult to detect by contrast. Here, the intrinsic faintness of brown dwarfs turns to our advantage. A giant planet forming at 5 AU within a brown dwarf disk will be visible as a faint dot, spatially separated by approximately 2*lambda/D at 10 micron (for a distance of 50 pc) from the brig ht, central disk regions with a contrast of order 100:1 (in case of runaway gas accretion, the contrast will be much more favorable and the planet may even dominate the system luminosity). A combination of METIS M- and N-band imaging of such objects will allow direct determination of the (accretion) luminosity of a forming planet. Moreover, low resolution spectroscopy will reveal the dust composition and thermal processing of the disk region near the planet.

1.1- Project Title: Resolving the chemistry of planet formation with E-ELT METIS

1.2- Project Category: 3

1.3- Abstract:
The gaseous molecular content of the inner regions of protoplanetary disks play a pivotal role in the formation of planets. New observations demonstrate that the mid-infrared wavelength region of typical protoplanetary disks is blanketed with molecular emission lines, including H2O and the organics HCN and C2H2. Using E-ELT METIS, we propose to obtain line images of a large sample (~100) of planet-forming regions in hundreds of molecular transitions in the atmospheric N-band window.
The data will reveal how water and other important molecular species evolve and contribute to the formation of planets and their atmospheres.

1.4- Publication agreement: yes

2.1- PI: Klaus Pontoppidan

2.2- CoIs: Cornelis Dullemond, Rowin Meijerink

2.3- Institute: California Institute of Technology

2.4- Country of Employment: other

2.5- Career Stage: postdoc

2.6- E-mail: pontoppi@gps.caltech.edu

3.1- Source of targets: Spitzer, JWST, ALMA, Herschel

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 10, 10000, mJy, N

3.4- Target size: extended source, 10, 100

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: RA:3 - 19;Dec:-77 - +30

3.8- Moving target?: no

3.9- Variable target?: yes, 2 per year

3.10- Target type: other, Protoplanetary disk

4.1- Spatial resolution: diffraction, 2.5

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 7500 - 14000, N

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: GLAO

7.1- Integration time per target or field and per setup: 0.1, 1, per setup, 1" seeing, 1-2 mm PWV

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: yes, Maximal Doppler shifts of ~20-30 km/s are need to shift targeted lines out of telluric line absorption

8.1- Does the execution of observations require real-time decisions?: yes, N-band observations are sensitive to rapid changes in the column of precipitable water vapor, Quicklook extracted spectra and real time PWV measurements.

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

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9.1- Synergy with other programmes: ALMA, JWST, VLT/VLTI, This program will have very strong synergies with JWST, Herschel and ALMA

9.2- Critical aspects / limiting factors for the science case:
A spectral resolving power of 50,000-100,000 in the N-band is essential to resolve the lines, a critical capability not available with JWST-MIRI data.

9.3- Detailed description or other comments:
Inner disk chemistry and the formation of exo-solar planetary systems
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Evidence collected from Solar System material has shown that the Solar Nebula was an environment characterized by a rich chemistry during the process of planet formation. This chemistry played a pivotal role in the formation of giant planets by providing a reservoir of volatile solids to aid in a rapid build-up of planetary cores. It has long been thought that the volatiles that formed in the Solar Nebula, including water, seeded the surfaces and atmospheres of the terrestrial planets. However, while there is evidence of this in ancient Solar System material, very little is known about how volatiles evolve and influence planet formation in current analogs to the Solar Nebula - the so-called protoplanetary disks. A critical difficulty is that the size of the region actively forming planetary systems is likely small (0.1 - 20 AU), compared to the angular resolution of current telescopes (~50 AU). Further, the chemistry of the warm and dense inner disk region is traced by molecu
lar lines in the infrared (3-200 micron), a wavelength region in which current ground-based high resolution spectrometers are not very sensitive.

Given infrared spectroscopy with higher sensitivity and better spatial resolution than is currently possible, questions central to our understanding of the early Solar System and the formation of other planetary systems can be answered: 1) Theory predicts that the dynamic interplay between, in particular, water vapor and the buildup of planetesimals is crucial for planet formation. Water and other volatiles account for half the condensible mass in a protoplanetary disk. Processes such as freeze-out, diffusion and solid body migration can act to concentrate large amounts of ice in the inner disk midplane, facilitating planet growth (e.g., Johansen et al. 2007, Dodson-Robinson et al. 2009, Ciesla 2009). This predicted transport of water should be observable. 2) The planet-forming region represents a chemical environment very different than those studied in the interstellar medium. The very high densities, temperatures, radiation fields and importantly, short dynamical and chemi
cal time scales in such regions generate conditions that may be more easily compared to atmospheric chemistry (e.g., Woitke et al. 2009). In direct comparison, models for planetary atmospheres clearly show that complexities are high and predictabilities low, making the acquisition of empirical data absolutely crucial for understanding inner disk chemistry. We believe that a high-resolution mid-infrared spectrometer on the E-ELT will provide a ground-breaking and unique new window on planet formation.

Spitzer has demonstrated the enormous potential of mid-infrared molecular tracers

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Recent data obtained with the Spitzer Space telescopes has demonstrated that the mid-infrared spectra of protoplanetary disks around T Tauri stars (young stars with masses of 1 solar mass or less) are generally blanketed with strong molecular emission lines (Salyk et al. 2008, Carr & Najita et al. 2008). Species detected so far include CO, H2O, OH, CO2, HCN and C2H2. Given the low resolving power of Spitzer (500 km/s compared to intrinsic line widths of 10-50 km/s), lines from many more species are likely waiting to be discovered with instruments with higher spectral resolution. In some ways, the mid-infrared spectra of protoplanetary disks may be compared to the densely packed millimeter spectra of hot molecular cores surrounding protostars, in which tens of new and complex molecular species have been identified. About half of all T Tauri disks (out of a sample of ~100) show molecular emission at the low Spitzer resolution (Salyk, Pontoppidan et al., in prep, Carr et al., in
prep.). Infrared molecular emission has also been seen from very low mass stars at even lower spectral resolution (Pascucci et al. 2009). The lines trace dense gas at temperatures of 300-1000 K, and ground-based, high resolution (R=100,000) N-band spectra of a few sources have demonstrated that the line profiles are double-peaked and in detail match emission from Keplerian disks (Knez, Najita, in prep.). This demonstrates that the lines are indeed formed in a temperature inversion layer in the atmospheres of protoplanetary disks. The radii traced span from the inner rim of the disk at ~0.1 AU to ~10 AU, making these lines a main tracer of chemistry and gas dynamics in the region of disks actively forming planets. For young, optically thick disks, the lines only trace the disk surface, but as the disk evolves toward the transitional stage, the disks become optically thin at mid-infrared wavelengths. This allows the entire vertical column to be traced by these lines - at a cr
itical stage in the process of planet formation.

The essential contribution of E-ELT METIS

Why has this type of work not already been done in much greater quantity? Currently high resolution spectroscopy in the mid-infrared is highly limited because instrumentation mounted on 8-10 m class telescopes is only able to reach a continuum S/N of ~10-20 on the few brightest targets. As an irony of nature, the brightest disks, generally surrounding intermediate-mass stars (M > 2 Msol) with harsh photo-dissociating radiation fields do not show the same strong molecular emission as the lower-mass stars (Pontoppidan et al., Salyk et al., in prep.). This current limitation means that the mid-infrared windows (the 7.5-13.9\,μm atmospheric N-band, as well as the 17-25\,μm atmospheric Q-band) will be mostly unexplored territory at high spectral and spatial resolution by the time the E-ELT begins operation. JWST-MIRI will have obtained large amounts of sensitive low-resolution data to add to the existing Spitzer data, providing target lists and presumably a long list of un
aswered questions, thus allowing for truly ground-breaking E-ELT science. In conclusion, instead of obtaining spectra of a few select lines from the 2-3 brightest targets, an ELT will be able to obtain resolved spectra for hundreds of lines in hundreds of targets with continuum fluxes of 0.1-10 Jy and typical N-band line-to-continuum ratios of 1:10 - 1:1. The high spatial resolution will allow direct imaging of the radial distribution of the line emission as well as sensitive spectro-astrometry.

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1.1- Project Title: Unravelling the formation of massive galaxies: ELT studies of high-redshift ULIRGs

1.2- Project Category: 2

1.3- Abstract:
Luminous far-infrared starbursts are an important element in galaxy formation at z>1-2. We do not understand why this is: What drives their rapid increase at high redshifts? What do they evolve into? There are hints that AGN-feedback drives the decline at z<2 and that these starbursts are linked to QSOs and the formation of ellipticals. ALMA will trace their far-infrared emission and cold gas, but ELT/EAGLE is essential to yield critical information on the dynamics and metallicity of their stars and warm ISM, the properties of AGN and the ages and masses of their stars, needed to understand their nature.

1.4- Publication agreement: yes

2.1- PI: Ian Smail

2.2- CoIs: Mark Swinbank, Scott Chapman, Rob Ivison

2.3- Institute: Durham University

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: ian.smail@durham.ac.uk

3.1- Source of targets: Herschel, SCUBA2, ALMA

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 18, 24, Vegamag, K

3.4- Target size: extended source, 50, 2000

3.5- Number of targets: 500

3.6- Density of targets: 1

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 10x10arcmin

4.3- Multiplexity and pick-off FoV: 20, 2x2arcsec

4.4- Plate scale stability: 10, 3600

5.1- Wavelength range: 500 - 2400, 350 - 500

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: EAGLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 10, 0.8 seeing, high-and-dry site, 30 deg ZD

7.2- Longest continuous observation time on a target or field: 6

7.3- Shortest integration time on a target or field: 1800

7.4- Total time: 250

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 25

7.6- Are the observations time critical?: no

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8.1- Does the execution of observations require real-time decisions?: yes, of reconfiguration to remove those sources well detected, N/A

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
Multiplex and/or field of view of EAGLE - limits on either of these will reduce the efficiency of the survey and increase the necessary time to complete it.

9.3- Detailed description or other comments:
In the last decade UV/optical surveys have suggested that the star formation activity in the Universe peaked ~8 Gyrs ago at z~1 (Lilly et al. 1996, Madau et al. 1996). However, surveys in the mid- and far-infrared show that up to half of the extra-galactic background light is radiated in the infrared, peaking near 200um. Much of this background appears to be produced by obscured star-formation in dusty, but intrinsically luminous, infrared (IR) galaxies (LIRGs, L_FIR>10^11Lo) which are expected to lie at moderate and high redshifts, z~1-2 (Dole et al. 2004; Papovich et al. 2004). Crucially, surveys at longer wavelengths, particularly in the sub-mm/mm, have suggested that far-IR luminous galaxies may even dominate the star-formation at z>2 (Blain et al. 1999). Due to the dust, these galaxies are typically faint in the restframe UV, and so their importance is understated by UV/optical surveys. Thus, understanding the evolution of the star-formation rate density with reds
hift requires characterisation and interpretation of cosmological surveys conducted at both optical/UV and infrared and sub-mm wavelengths (e.g. Lagache et al. 2005).

The Spitzer Space Telescope has characterised the mid-IR emission from LIRGs out to z~1 at 70-, and most effectively, 24-um (Le Floc'h et al. 2005; Perez-Gonzalez et al. 2005). However, at higher redshift, the strongly variable K-correction at 24um and the large 70um beam limits the usefulness of Spitzer for tracing the obscured populations and we must rely on new submm/mm surveys with SCUBA2, Herschel and ALMA. The activity in the sub-mm galaxy (SMG) population found by such surveys appears to peak at z~2 and may contribute up to half of the star-formation density at this epoch (Chapman et al. 2005), depending upon the IMF. The high star-formation rates (SFR, ~1000Mo/yr) implied by L_FIR in these systems are sufficient to form all the stars in a massive galaxy (M*>10^11Mo) in just ~100 Myr. Taken with recent results suggesting large numbers of massive, passive galaxies at z~1-2 (e.g. Franx et al. 2003; Daddi et al. 2005; van Dokkum et al. 2006; Cimatti et al. 200
8), it has been speculated that SMGs are the progenitors of luminous elliptical galaxies (e.g. Lilly et al. 1999; Genzel et al. 2003; Swinbank et al. 2006; Tacconi et al. 2008).

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One of the surprises in the submm is the rapid evolution of ULIRGs: at z~2 they are 1000x more numerous than at z=0. To understand this evolution we need to understand both the physical processes which trigger these far-IR luminous events and their subsequent termination. One important insight comes from the similarity between the redshift distributions of SMGs and QSOs (e.g. Chapman et al. 2005) suggesting an intimate link between high-z ULIRGs and AGN activity (Coppin et al. 2008). Indeed, theoretical models now invoke feedback from SMBHs to regulate and terminate star-formation in massive galaxies (Croton et al. 2006, Bower et al. 2006; Kaviraj et al. 2007). To test this conjecture we need to answer several questions:

Is AGN feedback process responsible for the rapid decline in the ULIRG population below z~2?

Does this process also suppress SF in the LIRG population at z<1?

Or do other processes (e.g. merger histories) drive the down-sizing behaviour seen in the U/LIRG populations at z>1-5?

Can we directly link high-redshift ULIRGs and QSO populations through dynamical or structural tracers?

The apparently vigorous activity in the high-redshift ULIRGs suggests they may be important laboratories for understanding other aspects of galaxy and structure formation at high redshifts. For example, what impact do these uniquely powerful events have on the gas and galaxies in their immediate surroundings? Do they influence star formation in dwarf galaxies in their surroundings? If these high-redshift ULIRGs are indeed the progenitors of luminous local Ellipticals, then they should also reside in biased environments, the thermal histories of which link directly to the X-ray emission from the intracluster medium in clusters at z~0-1. More fundamentally, there are questions about the similarity of the activity in high redshift and local ULIRGs - does what we know about the physics of star formation and the Inter-Stellar Medium (ISM) in local ULIRGs also apply at high redshifts? Or does the stellar Initial Mass Function differ in these systems (e.g. top-heavy), meaning
they represent much less significant events in the formation of galaxies?

Unfortunately, current studies of U/LIRGs at z>1 are hampered by small and inhomogeneously-selected samples and so their conclusions are limited. Herschel represents a significant advance over previous deep mid-IR (typically 24um) surveys since PACS and SPIRE can undertake wide surveys at 70-500um, wavelengths which better sample the dust emission in galaxies at z>1 and so yields more reliable LF and SFR estimates (Calzetti et al. 2005; Alonso-Herrero et al. 2006; but see Calzetti et al. 2007). At longer wavelengths we expect similar breakthroughs from the new SCUBA2 submillimetre camera on the JCMT and ALMA, providing surveys of 1000""s of very distant ULIRGs. Thus we are about to entire an era where for the first time studies of high-redshift U/LIRGs are limited not by the quality of the sample selection, but by our ability to study representative samples, of what is likely to be a very varied population. The difficulty here being the extreme faintness of typical

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SMGs: K~21 (Smail et al. 2004), with examples as faint as K~24 and beyond (Frayer et al. 2004; Wang et al. 2009).

ALMA""s combination of sensitivity and resolution will enable it to trace gas and dust continuum emission in these luminous galaxies at high redshift. However, it is blind to both warmer gas emission and more critically the stellar emission in these galaxies - whose structure, ages and dynamics are expected to provide unique tracers of the build-up of the spheroids. Thus ALMA will be unable to determine the relative masses of gas-rich SMGs and gas-poor QSOs and luminous red galaxies at high-redshift, necessary to test an evolutionary relationship between these populations. Equally, ALMA will be an ineffective tool to study the interplay of AGN activity and star formation and hence test the physics which links the formation of these two components, which is most effectively traced by ionised gas. Similarly JWST can trace cool material in the ISM, but it will struggle to obtain observations of large samples of these sources due to its limited grasp.

At z~1-3 many of the best calibrated tracers of the ionisation and metallicity of gas and the ages and masses of stars lie in the optical and near-infrared. Thus the immense sensitivity and excellent spatial resolution of ELT will play a prominent role in studies of high-redshift ULIRGs. In particular, EAGLE and OPTIMOS are the instruments of choice for this statistical study of the faint counterparts to high-redshift ULIRGs. Potentially HARMONI may contribute to the detailed investigation of individual sources identified from EAGLE, but its lack of any multiplex means it competes to some extent with JWST.

1.1- Project Title: Peculiar erruptive variable(s)

1.2- Project Category: 3

1.3- Abstract:
Even years after the outburst, we still are puzzled about the nature and future of the mysterious eruption of V838 Mon. Several discussions about relatives are ongoing. The discovery of a blue companion (Munari et al. 2005), a possible cluster around the star (Bond & Afsar, 2006) and the position in the arm +II (Kimeswenger, 2007) and the unusual chemical composition need further investigations. This application deals with this target(s), unusual chemical and dynamical evolution of the ejected material. This requires hires molecular (TiO / AlO) spectroscopy in the optical at extremely high spatial resolution only possible with an ELT.

1.4- Publication agreement: yes

2.1- PI: Stefan Kimeswenger

2.2- CoIs: N/A

2.3- Institute: Astro- and Particle Physics Innsbruck

2.4- Country of Employment: AT

2.5- Career Stage: faculty

2.6- E-mail: Stefan.Kimeswenger@uibk.ac.at

3.1- Source of targets: NTT, VLT

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 14, 25, Vegamag, V

3.4- Target size: extended source, 20, 300

3.5- Number of targets: 3

3.6- Density of targets: N/A

3.7- Target coordinates: RA:7 - 7;Dec:-2 - -2, RA:17 - 17;Dec:-17 - -20

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: N/A, star cluster, ISM

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 450 - 1000, 1000 - 5000

5.2- Spectral Resolution: 10000-20000

6.1- Instrument: other, a combination of HARMONY, SIMPLE & EPICS

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6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.2, 0.5, airmass, lunar phase, expected / estimated features (no template availabe / possible yet)

7.2- Longest continuous observation time on a target or field: 0.5

7.3- Shortest integration time on a target or field: 2

7.4- Total time: 20

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
opical IFU with very small spaxels and good AO in the optical

9.3- Detailed description or other comments:
Scientific Background:
The mysterious eruption and the spectacular light echo of V838 Mon has drawn not only the attention of the press on this object. But the nature of the object still remains, according to several contributions to the LaPalma conference on V838 Mon in May 2006, unclear.
V838 Mon, the twin V4332 Sgr and a possible further mislaid candidate from 1943 – V 1148 Sgr (Kimeswenger, 2007 ASPC, 363, 197) are completely unknown types of objects. The only thing we (seem) to know is, that they eject a massive cool dust and metal rich material to the ISM.
Several scenarios are discussed:
a) A carbon flash of a 65 solar mass star (Munari et al 2005, A&A, 434, 1107) - this requires a "long" distance scale of > 10 kpc.
b) a "born again" very late helium flash central star of a planetary nebula with an episode of accretion of metal poor material from a companion star (Lawlor, 2005, MNRAS, 361, 695) -

although the "post eruption accretion" widened the range of possible distances, this model has a rather strict constraint on a short distance scale (if we understand V4334 Sgr and V605 Aql properly).
c) A collision of main sequence stars (Tylenda & Soker, 2006, A&A, 451, 223) adopting the masses and the collision parameters this model allows any distance. But it is unable to describe the behavior of the progenitor (Kimeswenger & Eyres, 2006, IBVS, 5708)
d) A Nova with a low mass He-WD causing an eruption as calculated in Martini et al. (1999, AJ, 118, 1034) and Yaron et al. (2005, ApJ, 623, 398)- this allows a wide range of distances - fixing the distance would give a strong constraint on these up to now completely untested theoretical models of He-WD Novae (except possibly V445 Pup).
e) Capture of a planet causing the first expansion – hence reaching another massive planet in a wider orbit a month later (Retter et al. 2006, MNRAS, 370, 1573).

All those models are sexy with respect to their (possible) impact to stellar evolution and enrichment of the ISM with evolved material. But the cluster hypothesis of Bond & Asfar for V838 Mon even gives a deep impact on the IMF in the outer metal depleted disk part of the Galaxy.
The next “todos” are a proper investigation of the surroundings and a distance determination. This will require some investigations with NTT and VLT class telescopes. But finally we require spectroscopy of individual clumps of the ejected material. This requires high contrast (the knots will have 25-27th mag a few 10-100 mas from 15th mag stars) and high resolution in radial velocity. Even proper motion imaging of the knots will give an enormous scientific input. All those things will be only feasible with an ELT.

1.1- Project Title: Extended Planetary nebulae

1.2- Project Category: 3

1.3- Abstract:
Since about one decade a controversial discussion in the community is carried out about the nature and the physical state of clumps substructures, multi phase nature, filling factors etc. of PNE and especially of their extended haloes of planetary nebulae (PNe). Up to now used 1D hydrodynamic & radiative transfer simulations give different results than 2D-3D photoionization studies. A detailed investigation of the ionization structure of the individual clumps as partly seen in the ring nebula by HST and the remnants of the AGB wind is applied for to unveil the physical state.

1.4- Publication agreement: yes

2.1- PI: Stefan Kimeswenger

2.2- CoIs: N/A

2.3- Institute: Astro- and Particle Physics Innsbruck

2.4- Country of Employment: AT

2.5- Career Stage: faculty

2.6- E-mail: Stefan.Kimeswenger@uibk.ac.at

3.1- Source of targets: NTT, VLT

3.2- Preparatory work on targets required?: yes, pre-imaging wide survey

3.3- Target brightness: 24, 28, ABmag/arcsec2, V

3.4- Target size: extended source, 10, 100

3.5- Number of targets: 50

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: N/A

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 400 - 1000, 3000 - 12000

5.2- Spectral Resolution: nbimaging, 300-500, 10000-20000

6.1- Instrument: HARMONI, METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: .2, .4, using PNe template in ETC - might be an underestimate in clumps themselfes

7.2- Longest continuous observation time on a target or field: 3

7.3- Shortest integration time on a target or field: 100

7.4- Total time: 250

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, quick look pipelines - especially in the termal IR

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
short wavelength efficiency

9.3- Detailed description or other comments:
Planetary Nebulae (PNe) around the knee of the HRD at maximum temperature in their evolution are known often to show extended haloes (catalogues in Corradi et al. 2003, MNRAS 340, 417; 2004, A\&A 417, 637). HST images show us many fine structures and the comparison of densities obtained with (optical) spectroscopy and radio observation yield to the conclusion that we deal with a clumpy inhomogeneous material with filling factors < 0.1. As these targets are the phase were a dying star ejects most of the evolved inner material and as this phase is the most common one for all stars the understanding is critical for the whole cycle of ISM enrichment.
Static Photo-ionization modeling with CLOUDY (Ferland 2006), MOCASSIN (Ercolano et al. 2005, MNRAS, 362 1038) or SUNRISE (Jonsson 2006, MNRAS, 372, 2) allow a very detailed description of the physics and includes a large number of atomic transitions. It suffers from a

dynamical description of the physical processes and detailed radiative transfer models of the cumpyness.
Hydrodynamic + radiative transfer modeling from the AGB to the PNe phase (Sch\"onberner et al. 2005) include a complete dynamical setup, but they suffer from the coarse description of the radiative processes, from the fact that they are all in 1D only and do not implement clumpy media at all. This discussion "peaked" in Schönberner's talk (2008, ASPC, 391, 139) were the results of photo-ionizing studies were called "fictions.
The clumps and their PDR regions contain most likely a large fraction of mass of the ejecta but are weak emitters. They are "lost" in classical investigations in the bright surrounding thin nebula.
This science case shows, as many diagnostics only can be done at wavelength down to 400 nm (or even below) that high angular resolution at medium spectral resolution with a good contrast due to the bright surroundings is required. It "forces" extensions to the high frequency end - both - of the ctelescope coating as wess asl of the IFUs.

1.1- Project Title: Dark Matter and Dark Energy with Gravitational Lensing and the E-ELT

1.2- Project Category: 2

1.3- Abstract:
This is a proposal to use gravitational lensing in order: 1- to map the distribution of visible and dark matter on the galaxy scale and their evolution from z~0 to z~2, and 2- to measure w, the equation of state parameter of dark energy as well as Ho, well complementary with the CODEX H(t) long-term measurement.
The lensed sources are selected from large surveys (SDSS, LSST, PanStarrs, SkyMapper) to span a broad range of morphological types and masses. We will use mainly three E-ELT instruments: MICADO, EAGLE and METIS on the E-ELT, with AO.

1.4- Publication agreement: yes

2.1- PI: F. Courbin

2.2- CoIs: G. Meylan, P. Jabonka, M. Tewes, C. Faure

2.3- Institute: Ecole Polytechnique Fédérale de Lausanne

2.4- Country of Employment: CH

2.5- Career Stage: faculty

2.6- E-mail: frederic.courbin@epfl.ch

3.1- Source of targets: SDSS, LSST, PanStarrs, SkyMapper, VLT, VISTA, ALMA, SDSS, VizieR, NED, etc.

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 17, 32, Vegamag, R

3.4- Target size: extended source, 5, 200

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: 5, 3

4.2- Field-of-view: 30x30arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 100, 10

5.1- Wavelength range: 400 - 13000

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: EAGLE

6.2- Desired special mode: precision astrometry, also need precision photometry

6.3- Desired AO mode: best

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7.1- Integration time per target or field and per setup: 0.5, 3, (see more details at the end of the science justification)

7.2- Longest continuous observation time on a target or field: 3

7.3- Shortest integration time on a target or field: 10

7.4- Total time: 400

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 25

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: yes, the E-ELT is just too new to go blindly for service mode ! , full IFU pipeline available for the observations

8.2- Would you welcome remote observing capabilities?: yes, all pipelines working well

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, synergy with VLT, JWST, ALMA

9.2- Critical aspects / limiting factors for the science case:
This proposal uses several ELT instruments. We have tried in the technical case to reflect only the most important
technical caracteristics relevant for the program as a whole. Also, our targets contain both point sources and extended source, with a large dynamical range.

9.3- Detailed description or other comments:
Gravitational lensing is an incontrovertible tool for the study of dark and visible matter at all spatial scales as well as for cosmology. As such, it is the main science driver for the space missions of the next decade, both at NASA (beyond Einstein) and ESA (Cosmic Vision).

Gravitational lensing by a compact mass (lens) can produce multiple images of background sources. The way light rays bend, passing the gravitational field of the lens depends on its radial total surface mass density and on the adopted cosmology, hence making of gravitational lensing an efficient tool both for galaxy formation and evolution and for cosmology. Very interestingly, gravitational lensing offers the best mass estimator available so far in astrophysics as it relies only on General Relativity.

The surface density of strongly lensed sources is about 1 per square degree, with present-day detection limits and spatial resolution. About 10000 strongly lenses sources, either quasars or galaxies, therefore exist in the southern hemisphere, of which about 200 are currently known. With the major all-sky surveys undertaken in the next few years (PAN-STARRS, LSST, SkyMapper), we can safely predict that thousands of new lenses will be available by the time the E-ELT enters in operation. When space-based lensing surveys such as EUCLID or JDEM will deliver their first data (2017), this number will reach up to millions over the whole sky.

With large samples of lenses in hand, we identify several key science areas that can be addressed with the E-ELT, most of the time with complementary observations with ALMA and the JWST :

1- Dark and Visible Matter in Galaxies

When a source (e.g., a quasar) lensed by a foreground galaxy experiences photometric variations, these variations are seen at different epochs in each of the lensed images. This "time delay" between the arrival time of photons from each image of quasar is directly related to the radial slope of the total mass of the lensing galaxy, for a fixed cosmology. Measuring time delays therefore allows to infer the mass distribution in the lensing galaxy. Such a measurement, for hundreds of lensed quasars, is well within the reach of the large synoptics surveys under way when the E-ELT becomes available.

Reconstructing the total mass profile of lens galaxies requires excellent astrometry of the lensed images from deep sharp imaging and integral field spectroscopy with medium resolution (5000-10000). The latter will allow to incorporate the velocity and the velocity dispersion profiles of the lensing galaxies in the mass model.
With such E-ELT data, it will be possible to map the total mass profile of individual galaxies, for most morphological types up to z=2, i.e., when most of the processes at work in galaxy formation take place. Comparing this profile with the visible mass (E-ELT near-IR imaging) will allow to trace the evolution of the mass-to-light ratio with redshift as well as its spatial variations across galaxies. Strong gravitational lensing has the potential to provide the best mass/light characterization of individual galaxies, hence constraining cosmological simulations.

2- Dark Energy and the Hubble Constant

Quasar time delays can be used to infer Ho, using the above accurate mass modeling of lensing galaxies. Measuring Ho is important for two reasons. First, lensing offers an independent way of measuring Ho and is complementary to the H(t) measurement with CODEX. Second, and much more importantly, CMB missions such as WMAP are measuring a strong anti-correlation between Ho and w, the equation of state parameter of dark energy.

This anti-correlation can be used to measure w, from an accurate measurement of Ho. In practice, this requires Ho to ~1% accuracy, which is only possible by combining different methods. Gravitational lensing is one of them. It has the advantage of having systematics that are very different from the ones affecting other methods such as supernovae or Cepheids, i.e., it is very effective in constraining the error ellipse in the Ho vs. w plane.

3- Natural Telescope

Strong lensing is accompanied by an apparent light magnification of the lensed sources, by up to 5 magnitudes. This allows ultra-deep and high-resolution spectroscopy not only to measure redshifts, but also star formation rates, stellar masses, and velocity fields. Thanks to the stretching of the sources due to lensing, all these observable can be measured with a spatial resolution that surpasses that of the E-ELT alone. A 5-magnitudes magnification is equivalent to having a 420m E-ELT !

4- Missing Satellites Problem

The flux ratios between the lensed images of a distant source are predicted with a few percent accuracy by lens models, provided matter is smoothly distributed in the lens. However, the situation changes as soon as small substructures, either luminous or dark are present in the lens. Measuring the flux ratios between the lensed images and their deviation to the predictions by smooth lens models, allows to characterize the clumpyness of mass in lensing galaxies and is sensitive to very small masses, down to 108 solar masses. These measurements must be taken in the mid or far-IR (L-band) where the contamination by microlensing in the lensing galaxy is negligible. The source magnitudes are in the range R = 17-21 (point sources).

Instruments used : 1- near-IR imaging (MICADO: 30 min J-K),
2- far-IR imaging (METIS, L~20, point-source S/N=100), 3- EAGLE with IFU.
Typical time spent on-target is 3 hours for spectroscopy, plus 1 hour of imaging, all with AO for a sample of ~100 targets. This is about 400h. Spectroscopy of magnified sources (point 3) will require up to 1 night per object. We do not count this in the 400h mentioned above as depending on the specific targets, the scientific goals and needs in telescope time may be very diverse.

1.1- Project Title: A SIMPLE view of the world of cool stars

1.2- Project Category: 2

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1.3- Abstract:
Cool stars are fundamental tracers of galaxy evolution in many different environments and can be best studied in the IR. Here we present two science cases where SIMPLE-EELT with its combined sensitivity, high spectral and spatial resolution can provide fundamental breakthrough, with major impact in our understanding of galaxy formation and chemical enrichment. i) The detailed characterization of the faint, Main Sequence stellar populations in the inner Galaxy, which is of fundamental importance to constrain the formation of the Galactic bulge. ii) The study of distant AGB stars in the Local Group and beyond, which is critical to characterize sites and modality of stellar nucleosynthesis.

1.4- Publication agreement: yes

2.1- PI: Livia Origlia

2.2- CoIs: B. Gustafsson & the SIMPLE Team

2.3- Institute: INAF - Bologna Observatory

2.4- Country of Employment: IT

2.5- Career Stage: faculty

2.6- E-mail: livia.origlia@oabo.inaf.it

3.1- Source of targets: VLT, VISTA, JWST

3.2- Preparatory work on targets required?: yes, Accurate photometry and color-magnitude diagrams for target selection.

3.3- Target brightness: 17, 19, Vegamag, H

3.4- Target size: point source

3.5- Number of targets: 200

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 50, 2-3

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 840 - 2500

5.2- Spectral Resolution: >100000

6.1- Instrument: SIMPLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: LTAO

7.1- Integration time per target or field and per setup: 1, 2, LTAO, seeing 0.8, airmass=1.15

7.2- Longest continuous observation time on a target or field: 0.5

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 300

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, service observing

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

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9.1- Synergy with other programmes: JWST, Synergy with VLT, VISTA, JWST for target selection and accurate photometric estimates of the
photospheric parameters

9.2- Critical aspects / limiting factors for the science case:
A full spectral coverage in one exposure is mandatory to take full advantage of the chemical information provided by all the key elements, whose lines are spread over the 0.8-2.5 micron wavelength range

9.3- Detailed description or other comments:
The realm of cool stars comprises a large variety of stars in different evolutionary stages and environments. Because of their intrinsic low temperatures, high metallicities and/or dust content, cool stellar populations are best studied in the IR. High resolution near IR spectroscopy represents a formidable tool to properly characterize their physical, chemical and kinematic properties and their interaction with the surrounding environment. Especially for spectral type G or later, the near infrared domain is rich in information about the chemical composition of stars: molecular lines (CO, OH, CN, C2) can effectively trace CNO and their isotopic ratios; atomic lines of Fe, Si, Mg, Ca, Ti, Na, Al, Mn and some s and r process elements are excellent diagnostics for heavier metals abundances. Very high resolution (R>=100000) is essential to measure accurate and reliable isotopic ratios, which are good indicators of the mechanisms producing the elements, hence of their nucleosynthesis sites. To measure all the key metals a full spectral coverage up to 2.5 micron is crucial. The J and H bands contain lots of atomic lines for deducing elemental abundances of interest, and OH, CN and the second overtone 12C16O and 13C16O molecular transitions for deriving accurate 16O, 14N, 12C and 13C abundances. The K band is fundamental to measure fluorine (from HF), the 12C17O and 12C18O first overtone molecular transitions and obtaining accurate 17O and 18O isotopic abundances, whose detailed nucleosynthesis is still poorly understood (e.g. Prantzos, Aubert & Audouze 1996, A&A 309, 760; Tosi 2003, ASP Conf. Ser. 304, 390), despite their importance in the overall understanding of the stellar mixing processes and the chemical enrichment of the interstellar medium. Below we present two important science cases where SIMPLE-EELT with its sensitivity, high resolution, and wide wavelength coverage will have a crucial impact.
THE HIDDEN INNER GALAXY
In order to understand the early evolution and the chemical enrichment of our Galaxy and the role played by the different nucleosynthesis sites (Core Collapse or Thermonuclear Supernovae, and Asymptotic Giant Branch stars) we need to study the oldest stars, that are direct

witnesses of the conditions at the epoch of the major star formation episodes. In our Galaxy, that means deciphering the detailed abundances of halo and bulge stars. For the latter, it also means to use the near IR wavelengths, the only part of the spectrum easily accessible in the inner 3 kpc and in the Galactic center, because of the severe extinction (except for a few "windows", see e.g. Zoccali et al. 2006, A&A 457,1; Gratton et al. 2006, A&A 455, 271; Fulbright, McWilliam & Rich 2007, ApJ 661, 1152). The inner Galaxy is not a simple population, since several sub-structures coexist, the spheroidal bulge, the bar, the inner disk, and the nuclear region. Their formation, evolution and mutual interaction are not yet understood in a coherent and comprehensive way, nor is their chemical enrichment history. For instance, the possibility of mixing of the inner disk stars to the bulge and effectively build up a (pseudo-)bulge secularly may have a strong impact on the disk formation mechanism(s). A systematic, homogeneous study of the inner Galaxy populations, mapping their ages, chemical composition and dynamics, besides contributing to the understanding of our Galaxy, is also very significant in the broader context of understanding extragalactic bulges in general and nuclear stellar populations from their integrated properties. Telescopes of the 4-10m class only allow the study of the brightest, i.e. evolved, red giants and supergiants (e.g. Rich, Origlia, Valenti 2007, ApJ 665, 119; Davies et al. 2009, ApJ 696, 2014). However, in order to safely trace the pristine chemical enrichment history of the inner Galaxy, one need to observe non evolved, main sequence stars as well as subgiants. Indeed, surface abundances of the lightest elements, like Li, C, N and their isotopes change during the first ascent of the red giant branch, while also heavy elements surface abundances can be altered during AGB evolution. Old, main sequence stars in the inner Galaxy towards the dust-obscured Galactic Center have apparent magnitudes of H=17-19, hence an ELT and a spectrograph like SIMPLE are mandatory for a systematic study. Indeed 4-8m class telescopes can i(if any) measure such faint stars only in the rare circumstance of a micro-lensing event (e.g. Cohen et al. 2008, ApJ, 682, 1029).

THE SHINING AGB STARS

AGB stars have a double importance in studies of stellar and galaxy evolution: i) they are unique sites of production of certain metals, ii) they trace the presence of intermediate age stellar populations in distant galaxies. To truly understand the chemical evolution of the galaxies a clear picture of the sites of element production is mandatory. While alpha-elements are primarily synthetized in core collapse SNe and Fe-group elements by thermonuclear SNe, C, N and heavier elements like the s-process nuclei are produced primarily

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during the AGB phase of intermediate mass stars (about 3-8 Msun). At the moment our understanding of AGB stars is unsatisfactory, since the fundamentally important physical mechanisms, like the mixing in the deep layers of these stars and the dredge up of the chemical elements produced are still poorly understood. High resolution near IR spectroscopy is fundamental to see through the dusty envelopes of these stars and admit accurate spectral synthesis High spectral resolution also admits observations of line profiles, e.g. of CO lines formed in different layers, which are of key significance for understanding the structure and the dynamics of the outer atmospheres and the winds. These information IS fundamental, since the yields of AGB stars are critically dependent on the stellar mass-loss mechanisms. Here, systematic studies of the motions and winds in the outer atmospheres from AGB stars of different types have to be made and compared with dynamical simulations. 4-8m class telescopes allow us only to study massive Galactic AGB stars of nearly solar composition in detail (e.g. Lambert et al. 1986, ApJS 62, 373) and less detailed work in the Magellanic Clouds (e.g. de Laverny et al. 2006, A&A 446, 1107; McSaveney et al. 2007, MNRAS 378, 1089), SIMPLE-EELT will open a new, crucial window for a systematic study of AGB stars in stellar populations with different metallicities, ages and masses in the Local Group and beyond. This will give new physical input for all modelling of galactic evolution, of fundamental significance also for the understanding of the history of our own Galaxy.

1.1- Project Title: Unveiling the physical and chemical properties of Extragalactic Star Clusters systems

1.2- Project Category: 2

1.3- Abstract:

Stellar clusters are a powerful tracers of the star formation history and chemical and dynamical evolution of their host galaxies. They can be observed out to very large distances, provided that the instrumental equipment has enough sensitivity, spatial and spectral resolution to distinguish them from the unresolved background. SIMPLE-EELT with its high spectral and spatial resolution will offer a

unique chance to characterize stellar clusters in two key environments not currently reachable with 4-8m telescopes, namely massive ellipticals as Centaurus A and the Virgo cluster, and distant starburst galaxies. HST and JWST will characterize the target luminosity and radius, SIMPLE the chemical abundances and velocity dispersion

1.4- Publication agreement: yes

2.1- PI: Livia Origlia

2.2- CoIs: A. Bragaglia & the SIMPLE Team

2.3- Institute: INAF - Bologna Observatory

2.4- Country of Employment: IT

2.5- Career Stage: faculty

2.6- E-mail: livia.origlia@oabo.inaf.it

3.1- Source of targets: HST, JWST

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 18, 20, Vegamag, H

3.4- Target size: extended source, 50, 200

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star cluster

4.1- Spatial resolution: 10, 2

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 840 - 2500

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: SIMPLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: LTAO

7.1- Integration time per target or field and per setup: 2, 3, LTAO, seeing 0.8, airmass=1.15

7.2- Longest continuous observation time on a target or field: 0.5

7.3- Shortest integration time on a target or field: 600

7.4- Total time: 250

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 60

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, service observing

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, Synergy with HST & JWST for target selection and accurate photometric estimates of the
cluster luminosity and radius

9.2- Critical aspects / limiting factors for the science case:
A full spectral coverage in one exposure is mandatory to take full advantage of the chemical information provided by all the key elements, whose lines are spread over the 0.8-2.5 micron wavelength range

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9.3- Detailed description or other comments:
Star clusters are powerful diagnostics: they are easily observable out to large distances and can be used to constrain the star formation and assembly histories of galaxies, nucleosynthesis and chemical evolution, the epoch and homogeneity of cosmic reionization, the role of dark matter in the formation of structure in the early universe, and its distribution in present-day galaxies (Brodie & Strader 2006, ARA&A 44, 193). Major star-forming episodes in galaxies are typically accompanied by significant cluster formation. The main properties of star clusters, especially the metal content and kinematics of their stellar populations are strictly connected with the properties of their host galaxies, thus making them valuable tools for theoretical and observational astronomy. The near IR integrated luminosity of stellar clusters is dominated by cool stars, either red supergiants at young ages (~10 Myr) forming as soon as massive O-B stars evolve, or low mass red giants at older ages. This dominance represents a major conceptual simplification in modeling the integrated spectra and deriving their detailed chemical composition and kinematics, also in the nuclear region of galaxies, where extinction can be severe. Stellar clusters in our Galaxy and M31 have typical half light radii between 3 and 10 parsec, thus implying angular sizes <1 arcsec outside the Local Group. We present here two scientific cases based on the use of the high resolution near IR spectrograph SIMPLE: i) chemical abundances and velocity dispersions of clusters in Centaurus A and in Virgo; and ii) study of the universality of the Initial Mass Function (IMF) using Super Star Clusters (SSC) out to tens of Mpc.
THE GC POPULATION IN CENTAURUS A AND VIRGO
Recently, ACS-HST observations of the Centaurus A (Harris et al. 2006, ApJ 132, 2187) and Virgo galaxies (Cote et al. 2004, ApJS 153, 223; Strader et al. 2006, ApJ 132, 2333) resolved hundreds of candidate globular clusters. These are unique tracers of the early evolution and chemical enrichment in elliptical galaxies and clusters of galaxies. Such a detailed set of chemical abundances and spectroscopic mass estimates for these remote stellar clusters can be quantitatively compared with the well known globular clusters in the Milky Way and other LG galaxies, thus allowing the investigation of whether their overall chemical and structural properties depend on the star formation history and environmental conditions of the host galaxy. High resolution integrated spectroscopy with 8m-class telescopes allowed the measurement of velocity dispersions only of the most massive clusters in Centaurus A (Martini & Ho 2004, ApJ 610, 233) and of a few dwarf-globular transition objects (Hasegan et al. 2005, ApJ 627, 203) in Virgo. SIMPLE-EELT, with a limiting magnitude of H<20 (for spectra with s/n>20), will represent a unique possibility to

simultaneously provide accurate chemical abundances and velocity dispersions of the bright clusters (MH<-11) in Virgo and of the entire globular cluster system (down to 104 Msun) in Centaurus A.

THE UNIVERSALITY OF THE IMF

The IMF is one of the free parameters in contemporary models of galaxy evolution. Usually, the IMF has been modelled by a power-law, (Salpeter 1955, ApJ 121, 161; Limber 1960, ApJ 131, 168; Miller & Scalo 1979, ApJS 41, 513). More recently, there have suggestions that the IMF cannot be represented by a single power-law over the full range of masses (e.g. Kroupa 2001, MNRAS 322, 231; Larson 2003, ASPC 287; Chabrier 2003, PASP 115, 763), and that a significant flattening occurs at M<1Msun. Fundamental arguments also suggest that the IMF could vary in time and with the environment (density, metallicity, overall star-forming condition etc.). There are indications that the IMF in starburst galaxies can be biased towards larger masses (e.g. in M82: Rieke et al. 1993, ApJ 412, 99; McLeod et al. 1995, ApJ 454, 611), maybe as A consequence of a feedback process: the strong heating of the gas increases the average Jeans mass, thus inhibiting the formation of low mass stars. However, it has also been proposed that the metallicity may be a critical parameter shaping the IMF: low metallicities should favour the formation of more massive stars. This is a very hot issue, given the implications for the primordial population of stars, i.e. Population III (Schneider et al. 2002, ApJ 571, 30). An optimal bench to test these theories are the young and dense clusters, the so-called SSCs, generally hosted in starburst galaxies (Billett et al. 2002, AJ 123, 1454). SSCs are virialized, gravitationally bound systems, produced in a single burst. Therefore, they are optimal tools to characterize star-formation rates and IMF in the case of enhanced activity and to check their dependence on metallicity. The broadening of the absorption stellar features (typically 5-10 km/s, Ho & Filippenko 1996, ApJ 466, L83; ApJ 472, 600; Mengel et al. 2002, A&A 383, 137), along with the size inferred by high angular resolution images, give the dynamical mass of the clusters, thus constraining the IMF at low masses. Most SSCs in starburst galaxies are heavily obscured by dust (e.g. Hunt et al. 2001, A&A, 377, 66; Mengel et al. 2002, A&A 383, 137), hence observations in the near IR are best suited to measure both dynamical masses and chemical composition. High resolution spectroscopy at 4-8m class telescopes allows resolving and measuring the most massive SSCs within a few Mpc, only (Larsen et al. 2006, MNRAS 368, 10; Larsen et al. 2008, MNRAS 383, 263) SIMPLE-EELT, with a s/n=20 limiting magnitudes of H,K~20, will resolve and measure detailed chemical abundances and velocity dispersion of young clusters with masses as low as 104 Msun (e.g. like the Magellanic ones) out to distances of few tens Mpc, i.e. including several of the most vigorous starbursting galaxies. This will provide crucial information on the IMF dependence on metallicity.

1.1- Project Title: Probing the inner region of proto-planetary disks

1.2- Project Category: 3

1.3- Abstract:

We propose to study the gas in the inner regions of proto-planetary disks. Warm and hot gas emission from H2, H2O and CO molecules within 20 AU of the central star allow to probe the physical, chemical and kinematic conditions of the disk in the region where planet formation is thought to occur. These molecules have highly excited lines that fall in the K-band part of the spectrum. SIMPLE at the E-ELT will allow for the first time to effectively kinematically and spatially resolve these lines and probe proto-planetary disks in detail.

1.4- Publication agreement: yes

2.1- PI: Livia Origlia

2.2- CoIs: L. Testi & the SIMPLE Team

2.3- Institute: INAF - Bologna Observatory

2.4- Country of Employment: IT

2.5- Career Stage: faculty

2.6- E-mail: livia.origlia@oabo.inaf.it

3.1- Source of targets: VLT-VLTI, JWST, Herschel, ALMA

3.2- Preparatory work on targets required?: yes, Proper selection of targets with evidence of proto-planetary disks.

3.3- Target brightness: 1e-16, 1e-14, fl, K

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3.4- Target size: extended source, 100, 500

3.5- Number of targets: 40

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: ISM

4.1- Spatial resolution: 10, 2-3

4.2- Field-of-view: 2x2arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 2100 - 2400

5.2- Spectral Resolution: >100000

6.1- Instrument: SIMPLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: 1, 3, LTAO, seeing 0.8, airmass=1.15

7.2- Longest continuous observation time on a target or field: 0.5

7.3- Shortest integration time on a target or field: 600

7.4- Total time: 250

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 75

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, service observing

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, Synergy with mid-far IR and sub-millimeter facilities to study the
outer regions of the disks

9.2- Critical aspects / limiting factors for the science case:
None.

9.3- Detailed description or other comments:
Several proto-planetary disks show evidence for a inner hole in the dust distribution much larger than the dust sublimation radius. Holes with radii from a fraction to tens of AU have been inferred modeling the spectral energy distribution of disks and, in a few cases, by direct observations with near infrared interferometers (e.g. Najita et al. 2007; Isella et al. 2006). The possible explanations for these inner holes in the dust distribution include dynamical clearing by large bodies orbiting the star (planets or companions), photoevaporation, grain growth and viscous evolution of the disk. It is essential to characterize this inner region of the disks as some of these processes may inhibit, or seriously influence, the formation of planets, the subsequent planet-disk interaction and the dynamical evolution of the system. Recent observations show that at least in some of the disks the inner holes could either be explained with a drop in the surface density of material due to viscous evolution (Isella et al. 2009), and more generally that the inner regions of the systems, where little dust is present, are still relatively rich in molecular and atomic gas and possibly contain a population of refractory dust grains (Kraus et al. 2008; Pontoppidan et al. 2008; Benisty et al. 2009).
While most of the initial studies of gas in the inner regions of proto-planetary disks have been done observing hydrogen recombination lines or CO rotovibrational lines in the near and mid-infrared, recently it became possible in a few cases to also measure the infrared lines of H2, water and OH. The detection and analysis of different molecular species is essential to constrain the chemistry of the gas in the planet forming regions of the disks and ultimately the

composition of the material out of which the inner rocky planets in our own Solar System were formed. Due to its volatile nature and importance for life, it is especially important to understand the water content of disks.

However, the gas in the inner disks is difficult to probe. Indeed, hydrogen recombination lines can either arise from the disk itself, or from the inner stellar/disk wind and the material accreted by the central star. All the molecules are difficult to observe, because of their faint emission lines. Detections in a few objects have been possible only using ISO and Spitzer high sensitivity mid-infrared spectra (e.g. Thi et al. 2001; Salik et al. 2008) or infrared spectra with ground-based 8-10m telescopes (Bary et al. 2003; 2005; Carmona et al. 2007; Ramsay Howat & Greaves 2007). The major limitation of these studies is the poor spatial resolution of the infrared satellites, which make the association of the detected emission with the inner disk questionable (Bary et al. 2003). Spatial resolution is still a critical limiting factor for 8-10m class telescopes: only indirect analysis or spectro-astrometric techniques allow to constrain the spatial distribution of the warm gas in the inner disk (Najita et al. 2000; Pontoppidan et al. 2008).

SIMPLE at the E-ELT is a unique instrumental configuration to make significant progress in the study of the inner disks. The 10 mas angular resolution of the E-ELT in the K-band, where most of the molecular line of interest are, will allow to resolve this region out to the distance of the nearby star forming regions. Typical line of sight projection of the Keplerian velocities around Solar-type stars in the inner disk are <=10 km/s, depending on the inclination angle of the disk (Pontoppidan et al. 2008), implying that to properly resolve the disk kinematics a spectral resolution >=100,000 as provided by SIMPLE is mandatory. A high spectral resolution is also essential to dilute the continuum emission and detect the line.

The forthcoming mid-far infrared and (sub)millimeter facilities (JWST, Herschel, ALMA) will not allow to measure these inner disks, either because they will be primarily sensitive to the emission of the outer regions of the disks (Herschel, ALMA) or because of their limited spatial resolution (Herschel, JWST). Nevertheless, these facilities will provide complementary observations of the outer disk and on the integrated intensity of mid-far infrared lines, that, once combined with the E-ELT/SIMPLE observations, will provide a self consistent picture of the structure and evolution of proto-planetary disks.

The best targets for spatially and spectrally resolved studies of the inner disks with SIMPLE will be the nearest young stars with circumstellar disks.

In the nearest young proto-planetary disk system known (TW Hya), the

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radius of the inner gap in the dusty disk is ~5 AU. At 50 pc distance this correspond to 0.1" which is at the limit of the current generation of telescopes. More importantly, the region emitting most of the radiation from the warm gas is probably even smaller (~0.2 AU for CO and 0.2-2 AU for H2O), while the full extent of the molecular emission is ~20 AU (0.4"). The presence of warm gas in the inner gap (CO, Salyk et al. 2007) and vibrationally excited H2 (Weintraub et al. 2000) have been confirmed with previous observations and the measured total flux of the H2 line is ~1E-15 erg/s/cm/cm.
SIMPLE will provide a peak S/N per resolution element of ~50 in ~2hrs on source, adequate to measure the H2O lines near 2.29 micron, the CO overtone beyond 2.3 micron and the detection of the H2 v=1-0 S(0) and v=2-1 S(1) lines at 2.223 and 2.248 micron with a spatial resolution of 0.5 AU.
Other best studied star forming regions close to the Sun with relatively large numbers of young solar mass stars with proto-planetary disks are Taurus, Ophiuchus and Chamaeleon, with distances in the range 120-160 pc, while the closest star forming region in a harsh cluster environment is the Orion Nebula Cluster at 450pc. Given the flux values of the detected sources in H2 and H2O, we expect S/N>=10 detections in ~1hrs in the nearby star forming regions and 3hrs in Orion. A comprehensive programme to probe disk evolution and environmental effects would comprise ~10 sources in different evolutionary stages in each star forming region (30hrs) and 5-10 objects in the ONC (15-30hrs).

1.1- Project Title: Mass decomposition of disk galaxies at z~1

1.2- Project Category: 2

1.3- Abstract:

We propose to derive spatially resolved the rotation velocity and stellar velocity dispersion of disk galaxies at redshifts z~1 with the multi-IFUs of EAGLE. With an intrinsic spatial resolution of ~80pc, these observations will allow to 1. decompose the rotation curves into the contribution by Dark Matter Halo, bulge and disk, 2. determine the Dark Matter Halo profiles, and 3. test a potential evolution of Dark Matter Halo concentration with cosmic time. These observations will offer unprecedented tests of the predictions of cosmological simulations based on Cold Dark Matter.

1.4- Publication agreement: no

2.1- PI: Asmus Böhm

2.2- CoIs: Bodo L. Ziegler, Sabine Schindler

2.3- Institute: Institute for Astro- and Particle Physics Innsbruck

2.4- Country of Employment: AT

2.5- Career Stage: postdoc

2.6- E-mail: Asmus.Boehm@uibk.ac.at

3.1- Source of targets: FORS Deep Field, William Herschel Deep Field

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 20, 23, Vegamag, I

3.4- Target size: extended source, 300, 1000

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 1;Dec:-25 - +0

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: 10, 2

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: 20, 5x5arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: 900 - 1500

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: EAGLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: MOAO

7.1- Integration time per target or field and per setup: 10, 10, seeing 0.8 arcsec FWHM, AM=1.5

7.2- Longest continuous observation time on a target or field: 0.3

7.3- Shortest integration time on a target or field: 1000

7.4- Total time: 50

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
The spatial resolution with MOAO achievable at a wavelength of ~10000Ang should be at least ~0.02-0.03 arcsec

9.3- Detailed description or other comments:
The target disk galaxies will be selected from photometric redshift catalogues like the FORS Deep Field or the William Herschel Deep Field. We will derive the gas (using the Halpha emission line) and stellar kinematics (using e.g. the Mg2 index). The S/N requirements for extracting rotation curves and deriving the stellar velocity dispersion can be met at spatial resolutions of 0.01 and 0.1 arcsec (with MOAO), respectively. Assuming that 20 individual IFUs will be available with EAGLE, 20 galaxies can be observed within 10 hours; a statistically significant sample of 100 galaxies could be observed within 50 hours total (according to the ELT-ETC 2.14.), not including overheads.

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The rotation curves will resolve intrinsic scales of ~80 pc, similar to ground-based kinematical studies of local disk galaxies. This will allow to decompose the rotation curves into the contribution by Dark Matter Halo, bulge and disk, and test various Dark Matter Halo profiles. In comparison to local galaxies, we will also able to see whether the concentration of the Dark Matter Halos evolves with cosmic time.

All these observations will offer unprecedented tests of the predictions of cosmological simulations based on Cold Dark Matter.

1.1- Project Title: Resolving the molecular envelope around evolved stars

1.2- Project Category: 3

1.3- Abstract:
We propose to use the high-resolution L and M-band spectroscopic capabilities of METIS to study the innermost circumstellar envelope of evolved low and intermediate mass stars. The IFU spatially and spectrally resolved observations have several main objectives: We want to explore the dynamics of this region, which is within the dust formation zone to get clues on the process that levitate the gas outward. Furthermore, we want to explore the rich molecular chemistry in this region, where pulsation-induced shocks alter the equilibrium chemistry. The ultimate goal is to get insight into the late stages of stellar evolution of these targets.

1.4- Publication agreement: no

2.1- PI: Leen Decin

2.2- CoIs: Joris Blommaert

2.3- Institute: Instituut voor Sterrenkunde, Leuven

2.4- Country of Employment: BE

2.5- Career Stage: postdoc

2.6- E-mail: Leen.Decin@ster.kuleuven.be

3.1- Source of targets: SIMBAD, Herschel, JCMT, APEX, photometric surveys

3.2- Preparatory work on targets required?: yes, target selection based on sub-millimeter observations and photometric light curves

3.3- Target brightness: 1, 13, Vegamag, V

3.4- Target size: extended source, 10, 3000

3.5- Number of targets: 10

3.6- Density of targets:

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 4 per year

3.10- Target type: star

4.1- Spatial resolution: diffraction,

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: L, M

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1 sec, 14, seeing limited (0.8"), BB=2800K, L-band or M-band, resolution=50000, extended source, 1 to 20 spectra on the detector, 21.0 mas (DLC in L-band), V-band magnitude between 1 and 13 mag, signal-to-noise between 40 and 100

7.2- Longest continuous observation time on a target or field: 14

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7.3- Shortest integration time on a target or field: 1

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: yes, depending on phase in photometric variation (variable targets)

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, N/A

9.2- Critical aspects / limiting factors for the science case:
high-resolution L and M band spectroscopy

9.3- Detailed description or other comments:
Evolved low and intermediate mass stars are well known to release significant amounts of gas and dust in the interstellar medium via mass loss. This mass loss dominates the evolution of the star and ultimately causes the star to evolve off the AGB into the post-AGB phase. The mechanisms responsible for these outflows have been extensively studied and take place in the deeper layers of the circumstellar envelope, hereafter referred as `inner envelope''. They involve the combined actions of: 1) acoustic waves steepening into shocks at the stellar photosphere and 2) the presence of dust grains coupled to the gas and accelerated through radiation pressure (Hofner 1999 A&A 346, L9; Nowotny et al. 2005, 437, 273). However, the processes responsible for the formation of dust are still not well understood, especially in case of oxygen-rich targets.

Recently, observations have been obtained that evidence the existence of mass-loss variations on much shorter than evolutionary timescales; e.g. arcs seen in reflection (e.g. Terzian & Hajian, 2000, ASP Conf 199, 34), detached shells of molecular line emission (e.g. Gonzalez Delgado et al., 2003, A&A 399, 1021). These shells are very confined, to an extent which corresponds to typically only ~100 – 1000 yr, with density contrasts corresponding to mass-loss variations of up to a factor ~100−1000 (Decin et al., 2006, A&A 456, 549). The physical mechanism responsible for mass-loss variations, their rate of occurrence and their importance in terms of the amount of matter involved are presently unknown. Moreover, whereas the wind around Asymptotic Giant Branch (AGB) stars is thought to be symmetric, almost all Planetary Nebulae, being their successors, are found to be axi-symmetric. The question is how and when this symmetry break-up happens.

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Furthermore, oxygen-rich stars suffer from the "acceleration deficit" dilemma, which states that mass-loss rates due to the formation of silicate dust alone are orders of magnitude smaller than observed ones (Woitke 2006, A&A 460, L9). The formation of both carbon and silicate grains proposed by Hofner & Andersen (2007, A&A 465, L39) to solve this dilemma seems unlikely due to the presence of atomic sulphur which destroys carbon dust precursors (Cherchneff, 2006). Alternatively, other compounds -- metal oxides and sulfides, alumina or periclase -- are good candidates to accelerating the wind on top of silicates. Interest in oxygen-rich evolved stars has also been rekindled owing to the observations of a rich and interesting gas-phase chemistry in their envelopes (Ziurys et al. 2007, Nature 447, 1094). Furthermore, the recent detection of AlO in the oxygen-rich supergiant VY Cma (Tenenbaum & Zuirys 2009, ApJ 694, L59) and of circumstellar TiO in the inner wind of an S-type A
GB (with a C/O-ratio slightly lower than 1) indicates that small metal oxides in the gas-phase form and survive the condensation phase of solids, despite their key role as precursors in the nucleation of dust grains. Recent non-equilibrium chemistry models predict complex molecules to be formed close to the star and subsequently being ejected in the outer wind as `parent'' molecules (e.g. Willacy & Cherchneff, 1998, A&A 330, 676).

Systematic studies of winds around evolved stars include molecular (sub-)millimeter-line observations, mapping the infrared (IR) dust continuum, IR spectroscopy of dust emission and molecular lines, and observations of atomic or molecular resonance scattering of photospheric light in the shell. Using this first-mentioned technique of observing rotational emission lines of molecular species, the intermediate and outer wind envelope, beyond ~30 stellar radii, can be studied (e.g. Decin et al. 2007, A&A 475, 233; Decin et al. 2009, A&A, submitted), but the thermophysical structure close to the target is not well constrained. In that sense, the other two techniques mentioned above, i.e. using high-resolution IR spectroscopy and observing scattering resonance lines, optically thin along the line of sight through the envelope, offer interesting possibilities to explore the thermophysical, spatial and chemical structures in the inner envelope. Near-IR spectroscopy permits the observ
ations of these molecules that form in the region that is levitated from the photosphere and whose abundances `freeze out'' during the dramatic density drop at the dust formation locus and/or which are depleted onto dust grains.

The high-resolution L and M-band IFU observations offered by METIS are crucial to understand this complex inner wind zone for several reasons: (1) to get information on the velocity fields in these complex envelopes, in particular by resolving lines, many of which are expected to exhibit P CYg profiles or even inverse P Cyg profiles in their absorption and emission portions. Line confusion may be a serious problem that is best met with high resolution. (2) The L and M bands are rich in various molecules as CO, H2O, C2H2, CH, SH, HCl, SiO, OH, CO2, CS, CH, HF, NH, NO, C3, ... which are ideal thermometers and barometers to trace the density and thermal structure in the envelope. (3) Furthermore, several isotopologues can be studied to derive the interesting 12C/13C, 16O/17O, 24Mg/25Mg, ... isotopic ratios to refine our insight into the nucleosynthesis, the neutron sources driving the s-process in AGB stars and the dredge-up efficiencies enriching the outer atmospheric layers.

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(4) Thanks to the IFU, we will be able to `image" the inner wind structure and hence can measure the line intensities (and abundances) as a function of radius from the photopshere. We hence will provide direct measurements of the depletion and freeze out process, and can study the effect of pulsation-induced shocks, the extent of inhomogeneities, the onset of shaping of the axi-symmetric Planetary Nebula envelope, ...
The ultimate goals are to study the enrichment of the interstellar medium by evolved stars, the impact of evolved stars on the evolution of the galaxy, and to link the results to recent observations of presolar grains.

1.1- Project Title: Unraveling the gas producing agents in galaxies

1.2- Project Category: 2

1.3- Abstract:
We propose to use the high-resolution L and M-band spectroscopic capabilities of METIS to study the interstellar gas enrichment by evoled stars in few nearby galaxies. The high-sensitivity of METIS will for the first time allow us to observe the gas-rich spectra of evolved low, intermediate, and high mass stars in galaxies outside our own Milky way. We hence will be able to pinpoint the main gas providers in the galactic interstellar media and to look for dependencies upon type of galaxy, interstellar activity, metallicity, galactocentric radius etc.

1.4- Publication agreement: no

2.1- PI: Leen Decin

2.2- CoIs: Joris Blommaert, Tijl Verhoelst, Stefan Uttenthaler

2.3- Institute: Instituut voor Sterrenkunde, Leuven

2.4- Country of Employment: BE

2.5- Career Stage: postdoc

2.6- E-mail: Leen.Decin@ster.kuleuven.be

3.1- Source of targets: Spitzer

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 20, 1000, mJy, L

3.4- Target size: point source, ,

3.5- Number of targets: 60

3.6- Density of targets:

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: diffraction,

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: L, M

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 200, 10, point source, signal-to-noise of 20, L-band between 20 and 1000mJy, M-band between 8 and 400mJy, resolution of 50000, 1 spectrum on the detector, BB of 2800K

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 200

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7.4- Total time: 360

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 100

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
high-resolution L and M band spectroscopy

9.3- Detailed description or other comments:
All stars end their life by returning most of their mass back to the interstellar medium of the galaxy. Indeed, mass-loss -– rather than nucleosynthesis in their cores -– is the dominating factor in the postmain sequence evolution of stars. The ejecta are enriched in newly produced elements. The ejected material merges with the interstellar matter of the galaxy and is later incorporated into new generations of stars and planets. This recycling of matter between the interstellar medium (ISM) and stars is one of the key evolutionary drivers of a galaxy's visible matter and its spectral characteristics (see, e.g., Meixner et al. 2006, AJ, 132, 2268).

For low- and intermediate mass stars (initial mass <8Msun), the mass loss takes mainly place on the thermally-pulsing Asymptotic Giant Branch (AGB) in a slow (typically 5–25 km/s) dust driven wind with mass-loss rates between 10^(−8) and 10^(−4)Msun/yr. For the massive evolved red supergiants (RSG) (10<M<40Msun), the same dust-driven mechanism may also be an important contributor or even the the driver of the mass-loss process. For the most massive stars (Wolf Rayet (WR) star and Luminous Blue Variables (LBV)), the mass loss takes place in a fast (up to few thousands km/s) line-driven wind with mass-loss rates in the order of 10^(−6)Msun/yr. The explosive ejections of supernovae (SNe) are hypothesised to be one of the major sources of dust particles in the galactic ISM (e.g. Clayton 1979, ApSS 65, 179; Dwek & Scalo 1980, ApJ 239, 193; Barlow 2009). The dust and gas-rich features are clearly discernible in the infrared spectra of these evolved stars.

Although dust and gas are important ISM components and mass loss is an important process, many basic questions still remain. Few examples are:

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(1) What are the main gas and dust producers in starburst galaxies and ultraluminous infrared galaxies (ULIRGs)?
(2) What is the total gas and dust production per group of evolved stars in each galaxy?
(3) Does the kind of gas and dust formed depend on the metallicity of the galaxy?
(4) Is there a dependency of the gas and dust composition — and mass-loss rate – on galactocentric radius?
(5) What is the correlation between the ISM spectral fingerprint and gas and dustejected by evolved stars.

While the study of the dust species invoked in the questions above, will be in close collaboration with a European MIRI project intended to study the dust producing agents in galaxies, the answer on the gas content need the high-sensitivity and high-resolution spectroscopic mode offered by METIS. The ultimate aim of this program is to study in unprecedented detail the gas producing agents as function of metallicity in low-z galaxies, ranging from solar to below 1/25 solar metallicity. While ISO and Spitzer provided us with a first glance of the gas and dust enrichment of the galactic ISM in our own Milky Way up to Fornax dwarf spheroid galaxy (~140kpc) in the 2–40 micron range, the superb sensitivity of METIS on the E-ELT (and of MIRI on the JWST) will for the first time allow us to spectroscopically study the gas and dust species in a statistically relevant sample of evolved stars in Local Group galaxies with metallicities lower than our Milky Way and the LMC (to below 1/2
5 solar metallicity). This will enable us to study gas and dust mass-loss rates and dust condensation sequences in function of the metallicity for galaxies up to ~750kpc. We hence will be able to pinpoint the main gas and dust providers in the galactic interstellar media and to look for dependencies upon type of galaxy, interstellar activity, metallicity etc.

We estimate that evolved AGB stars in dwarf galaxies in the vicinity of the Milky Way are in the flux range between 20mJy and 1Jy in the L-band and between 8mJy and 400 mJy in the M-band, RSG may be a factor ~10 brighter. Interesting molecular features tracing the ejected gas in the L and M-band are CO, H2O, C2H2, CH, SH, HCl, SiO, OH, CO2, CS, CH, HF, NH, NO, C3, ... A spectral resolution of ~50000 is requested to spectrally resolve the molecular lines. We hence will be able to derive reliable abundance estimates. We propose to observe the Sculptor dwarf spheriod (Z/Zsun~0.04), Fornax dwarf spheriod (Z/Zsun~ 0.1) and M31 (Z/Zsun~1.0). We will select a sample of 20 stars in each galaxy. Requesting signal-to-noise ratios between 20 and 50, the integration time is between few hundreds of seconds and 24 hr per spectrum. Requiring ~3 spectra/source to cover different molecular species, a total integration time of ~360hr is requested to complete this program.

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1.1- Project Title: Infrared magnetic field studies of cool stars and exoplanets

1.2- Project Category: 3

1.3- Abstract:
Magnetic fields play a key role in the formation, evolution and atmospheric physics of cool stars. However, direct observation of these fields is extremely difficult due to weakness of magnetic signatures in stellar spectra. Magnetic measurements in the infrared offer several key advantages compared to the studies of optical spectra. A high-resolution infrared spectrometer, such as SIMPLE@E-ELT, equipped with a polarimetric analyzer will allow a major improvement in our ability to measure and deduce detailed structure of magnetic fields in cool stars, brown dwarfs and exoplanets, thus leading to a breakthrough in the understanding stellar and planetary magnetism.

1.4- Publication agreement: yes

2.1- PI: Oleg Kochukhov

2.2- CoIs: Nikolai Piskunov

2.3- Institute: Uppsala University

2.4- Country of Employment: SE

2.5- Career Stage: postdoc

2.6- E-mail: oleg.kochukhov@fysast.uu.se

3.1- Source of targets: VLT, SDSS, VizieR, 2MASS

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 10, 17, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 1-5 per week

3.10- Target type: exoplanet, star

4.1- Spatial resolution: diffraction, 3-10

4.2- Field-of-view: 30x30arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 800 - 2500

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: SIMPLE

6.2- Desired special mode: polarimetry, polarimetric precision 10^(-4)

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 20, for seeing 0.8

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 60

7.4- Total time: 1000

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:

To achieve the goals of the program it is crucial that the high-resolution infrared spectrometer at E-ELT is equipped with a polarimeter that could measure spectra in Stokes parameters (or at least in circular polarization).

9.3- Detailed description or other comments:
Magnetic fields play a fundamental role in stellar physics along the whole Hertzsprung-Russell diagram (e.g. Mestel & Landstreet 2005, in Cosmic Magnetic Fields, Lecture Notes in Physics, vol. 664, p. 183). Fields govern the emergence of stars from protostellar clouds, control the infall of gas on the surfaces of young stars and aid the formation of planetary systems. Magnetic fields are important through the entire life of a typical star. The 11-year cycle and many activity phenomena seen in our Sun (sunspots, eruptive energy releases, dynamic behaviour of the outer layers) is the result of generation, transformation and eventual decay of magnetic fields. In this context, building a comprehensive picture of the magnetic activity in solar-like stars of different ages is a necessary step towards understanding magnetism of the Sun and assessing its impact on the secular terrestrial climate changes.

Despite the importance of magnetic fields in astrophysics, their direct observation is extremely difficult for stars other than the Sun. Up to now measurements of magnetic fields using spectroscopic and spectropolarimetric techniques were mainly performed for A- and B-type stars with peculiar abundances (Mathys et al. 1997, A&AS, 123, 353; Kochukhov & Bagnulo 2006, A&A, 450, 763). For solar-like and low-mass stars magnetic fields were detected in only a handful of brightest objects, in spite of the evidence for the ubiquity of magnetic fields in the atmospheres of many types of cool stars from observation of their enhanced coronal and chromospheric activity levels. Yet, the strengths, topologies, and the role of these fields to stellar evolution is currently unknown.

Two direct methods of magnetic field detection are commonly employed for cool stars. First, regardless of its orientation, the presence of the field leads to Zeeman broadening and splitting of spectral lines. In the optical spectral region this effect is hard to disentangle from other sources of line broadening (e.g., Saar 1988, ApJ, 324, 441). Nevertheless, it provides an evidence for the exceptionally strong fields in T Tauri stars (Guenther et al. 1999, A&A, 341, 768) and in active M-L dwarfs (Johns-Krull & Valenti, 1996, ApJ, 459, L95; Reiners & Basri 2007, ApJ, 656, 1121).

The second method is based upon the analysis of polarization signal in spectral line profiles, combining techniques of high-resolution spectroscopy and polarimetry. Time series of spectropolarimetric measurements can be used to deduce a map of magnetic field vector distribution over the stellar surface (Piskunov & Kochukhov 2002, A&A, 381, 736). Recent magnetic mapping of nearby solar-type stars has revealed a non-trivial interplay between stellar rotation rate and magnetic topology (Petit et al. 2008, MNRAS, 388, 80). For fully convective low-mass stars remarkable large-scale, strong fields were discovered (Donati et al. 2006, Science, 311, 633; Morin et al. 2008, MNRAS, 390, 567), giving support to theories predicting generation of strong, organized fields by turbulence-driven dynamo mechanism (Dobler et al. 2006, ApJ, 638, 336).

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Magnetic measurements in the infrared offer several key advantages compared to magnetic analysis of optical spectral lines (e.g., Johns-Krull 2006, ASP Conf. Ser., vol. 384, p. 145). Most importantly, the Zeeman splitting is proportional to the square of the wavelength, which translates to a factor of 5-10 improvement in the sensitivity of magnetic diagnostic using line splitting or polarization. Secondly, in cool stars strong magnetic fields are commonly associated with reduced temperature regions. The resulting large intensity contrast between photospheric and spot spectra makes detection of starspot fields impossible in the optical but feasible in the infrared. Finally, the line density in the infrared spectra of cool stars is lower than in the optical, and therefore blends are less of a problem. These advantages notwithstanding, with the current technology it is only possible to detect magnetic splitting in the intensity spectra of a few bright, active, low-mass stars (Jo hns-Krull 2007, ApJ, 664, 975). In practice, limited spectral coverage of the existing high-resolution infrared spectrometers allow analysis of just 1-2 magnetically sensitive lines at a time. There are no instruments capable of measuring polarization in the infrared.

Instruments at the current 4-8m class telescopes can be used to obtain magnetic measurements for solar-type and mid-K stars only within ~100 pc. At the same time, high signal-to-noise observations of low-mass and brown dwarfs are possible only for a few dozen stars at the distances not exceeding ~10-20 pc even with the HIRES spectrometer at the 10-m Keck telescope (Reiners & Basri 2007, ApJ, 656, 1121).

Thanks to the increase in the light-collecting area and advantages of the infrared magnetic analysis, SIMPLE at the E-ELT will allow a major improvement in our ability to measure and deduce detailed structure of stellar magnetic fields. For solar-type stars it will become possible to detect magnetic fields in stars over significant part of the Galaxy, linking magnetic properties to other characteristics of solar-type stars in stellar populations with well-established ages (e.g., globular clusters, Orion region) and properly investigating the dependence of magnetic field strength and geometry on stellar age, mass, and rotation. Availability of diverse magnetically sensitive atomic and molecular lines in the 0.8-2.5 micron spectral region will open possibility of diagnosing fields in the starspot interiors and obtaining detailed information about magnetic structures at different atmospheric levels.

For the low-mass stars SIMPLE will allow, for the first time, extending magnetic observations beyond the immediate solar neighbourhood. It will become possible to explore magnetic properties of late M stars in many star-forming regions within ~300 pc and perform meaningful analysis of the magnetic fields in brown dwarfs and free-floating gas-giant planets. These observations will provide crucial observational constraints for the theoretical models of non-solar turbulent dynamo and will play a central role in developing a unified theory for the magnetism in planets, brown dwarfs and stars (Christensen et al. 2009, Nature, 457, 167).

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1.1- Project Title: High Precision Dark Matter Mapping

1.2- Project Category: 2

1.3- Abstract:
The ELT with adaptive optics will provide excellent imaging resolution for distant galaxies. This allows a major improvement in dark matter map resolution from weak gravitational lensing. One can measure the lensing distortion not only of the overall galaxy, but also of its internal structures. This leads to a greatly reduced error on the gravitational shear, which permits a more accurate projected matter density to be inferred. The ELT will therefore allow very precise maps for small patches of the sky; this will be of interest for both cosmology and delensing of gravitational wave sources.

1.4- Publication agreement: no

2.1- PI: David Bacon

2.2- CoIs: Charles Shapiro, Ben Hoyle, Edd Edmondson

2.3- Institute: ICG Portsmouth

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: david.bacon@port.ac.uk

3.1- Source of targets: DES, HST, LISA

3.2- Preparatory work on targets required?: yes, For one application, a LISA survey detecting SMBH binary mergers

3.3- Target brightness: 18, 21, Vegamag, K

3.4- Target size: extended source, 100, 500

3.5- Number of targets: 1 to 100

3.6- Density of targets: 100 to 1000

3.7- Target coordinates: N/A

3.8- Moving target?: no

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3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: 10, 100 to 3000

4.2- Field-of-view: 30x30arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: K

5.2- Spectral Resolution: bbimaging

6.1- Instrument: MICADO

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: .1, 1, i.e. seeing, airmass, thermal background

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 600

7.4- Total time: approx. 24

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10-30

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, Ability to check data soon after exposure

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

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9.1- Synergy with other programmes: ALMA, SKA/SKAPF, N/A

9.2- Critical aspects / limiting factors for the science case:
Exceptional resolution is required.

9.3- Detailed description or other comments:
There are applications of weak lensing that are currently unrealisable, due to the noisiness of lensing measurements. For instance, it would be highly desirable to create a precision map of the lensing along the line of sight to a gravitational wave siren observed by LISA; in this way, the amount of lensing can be corrected for, affording excellent cosmological parameters to be derived from the siren waveform (Holz & Hughes 2005). However, current lensing measurements of the gravitational shear suffer from a large error because of the intrinsic ellipticity of galaxies; the intrinsic shape swamps the very small gravitational distortion of the shape.

This can be rectified if very high resolution images of the galaxies are available. As shown in Bacon et al 09 (in prep; draft available on request), images with approx 50 to 100 pixels across afford a large reduction in shear measurement error. This is because the images then contain many substructures which are themselves lensed; the combined information from all the substructures gives a shear dispersion a factor of up to 10 smaller than that from the overall ellipticity of the galaxy alone.

There is no opportunity to carry this technique out with most e.g. z=1 galaxies with current telescopes, eg HST or ground-based surveys. This is because the pixel size is such that there are less than approx. 10 pixels across a galaxy, which is too few for the technique to substantially reduce the shear noise.

However, with the ELT with adaptive optics, <20mas resolution may be achieved, achieving the required accuracy for much improved shear estimation. Of course, only small regions can be observed; however, this is sufficient to de-lens a siren, or provide high precision pencil-beam dark matter maps for cosmology.

The project would target the few arcminutes around a siren found by LISA; or alternatively, target random lines of sight through the Universe, together with a few well-known cluster regions. The resulting dark matter maps would have up to 10 times the resolution of current lensing maps, leading to a wealth of information about dark matter structures and baryon-dark matter physics. They would also permit the delensing of a siren, reducing the error on the luminosity distance to the siren by a factor of 2, leading to precise constraints on the geometry of the Universe.

1.1- Project Title: Dusty structures around evolved stars

1.2- Project Category: 3

1.3- Abstract:
We propose the use of a mid-IR imager (and IFU) such as METIS, to study the morphology, composition and time evolution of the dusty circumstellar environment (CSE) around evolved stars. These CSE""""s are the result of mass loss (by wind or explosion) from the star, which plays a crucial role in stellar evolution, and in the chemical evolution of galaxies. Our understanding of the role played by dust is still limited, due to the high spatial complexity of its distribution in these objects. An E-ELT equipped with a mid-IR instrument such as METIS will allow actual imaging of these dusty CSE""""s.

1.4- Publication agreement: yes

2.1- PI: Tijl Verhoelst

2.2- CoIs: Stefan Uttenthaler

2.3- Institute: IvS, KULeuven

2.4- Country of Employment: BE

2.5- Career Stage: postdoc

2.6- E-mail: tijl.verhoelst@ster.kuleuven.be

3.1- Source of targets: Literature, VISIR, VLT-I, NACO

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 100, 100000, mJy, N

3.4- Target size: extended source, 40, 2000

3.5- Number of targets: 500

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per year

3.10- Target type: star

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 1x1arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: L, M, N, Q, Q

5.2- Spectral Resolution: nbimaging

6.1- Instrument: METIS

6.2- Desired special mode: polarimetry, N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.001, 0.01, N/A

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 1

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 5

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, N/A

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9.2- Critical aspects / limiting factors for the science case:
An N band low-resolution IFU would actually be better than the narrow band imaging to really see the dust features. Also, the detector must be able to handle targets brighter than the background in N, without damage or leakage to other pixels! Note also that, in spite of only < 1 hour of integration for the entire programme, it is quite overhead dominated!

9.3- Detailed description or other comments:
Context
=======

After their Main Sequence evolution, all stars will at some point develop a strong mass loss, either through a wind (e.g. dust-driven winds from AGB stars) or by more explosive mechanisms (e.g supernovae). This leads to the creation of a dynamic circumstellar environment (CSE) filled with gas and dust at densities far above those of the interstellar medium. Moreover, this newly ejected material is enriched in heavy elements which were synthesised in the stellar interior. In this way, evolved stars drive the chemical evolution of galaxies, and they provide the building blocks for planet formation in next-generation young stellar objects.

In spite of many decades of dedicated research, our understanding of the processes driving and shaping these CSE""""s is still very limited. This is in part due to the high spatial complexity of many of these structures, which could hitherto only be observed in a few closeby objects (and which requires very computationally expensive modelling efforts). Some progress in the observational direction is now being made with IR interferometry and adaptive optics, but either the u-v sampling is too sparse to allow efficient image reconstruction (current-day interferometers), or the baselines are too short to resolve more than a few objects (AO or aperture masking on a single 10-m class telescope).

Immediate objective
==================

An E-ELT equipped with a mid-IR instrument such as METIS would bring a whole variety of evolved objects within range for direct imaging of their dusty CSE. In that sense, it would supersede the short-to-medium baseline VLT-I, providing much better image quality with higher dynamic range. A prerequisite for this research, however, is that the instrument can deal with the high flux levels of nearby luminous objects (of the order of many Jy""""s). This will require either a

selection of small coronagraphs (order of 10\,mas), or a detector which can handle saturation without damage or leakage to neighbouring pixels.
For all these objects, complementary ALMA observations would allow us to create a combined gas+dust picture of the CSE""""s.

METIS Imager:

The imaging mode offered by METIS would allow a detailed study of the morphology of the ejecta, which is known to be related to stellar pulsation (shells), convection (clumps/plumes), binarity (disks) and rotation (torii or aspherical shells). It would for example extend the current VISIR sample of spatially resolved post-main sequence objects (typically a few per class) by a factor of almost 50, finally allowing proper statistical analysis. This is crucial if we want to understand for example the shaping mechanism of Planetary Nebulae. If a substantial time baseline is available (a few years), it would be possible to directly observe the dynamics (e.g. expansion) of the dust in the CSE, which can then be compared to the dynamics of the gas (cfr DRSP by L. Decin).

METIS IFU (or narrow-band imaging as poor alternative):

Morever, a low-resolution N-band IFU (not what is foreseen now!) would allow us to study the dust composition as a function of location within the CSE. This could provide a direct observation of the dust condensation sequence in dust-driven AGB winds, the most difficult unknown in all of AGB star research. Also, it could be used to determine the location of crystalline dust in those CSE""""s where strong dust processing appears to occur.

METIS POLARIMETER: as stellar light tends to get polarized when scattered by dust grains, a polarimetric signature can be used to study the dust distribution and the effects of magnetic fields (which align the dust particles).

We conclude that the mid-IR imaging instrument METIS on the E-ELT would provide break-through observations on evolved stars.

1.1- Project Title: Star formation history, stellar population content and dynamics of the outer halos of giant elliptical galaxies within 100 Mpc distance

1.2- Project Category: 2

1.3- Abstract:

The old stellar populations in the giant elliptical galaxies in the centers of groups and clusters are the end-products of the violent star formation and merger events that took place in dense regions of the high redshift universe. The best record of these events will be found in the long-lasting substructures preserved in the outer halos of these systems, about which little is yet known observationally. The goal of this project is to study the star formation history and the stellar populations present in the halos of giant ellipticals in the nearby clusters, and correlate the stellar properties with their dynamics in the extended haloes of the brightest elliptical galaxies.

The stellar populations will be constrained from deep absorption line spectroscopy (long-slit/IFU) and from deep spectra of planetary nebuale associated with the parent stellar population. The kinematic mesurements based on descrete sources, either globular clusters (GCs) or planetary nebulae (PN), will trace the fossil record caused by past accretion events. The correlation between stellar population""s properties and the kinematic will identify the progenitors that build up the halos in giant ellipticals

The observational part of this project will aim at measuring the Lick indices of deep absorption line spectra and the spectra of individual PNs, to be modeled using SSP and photoionization codes, plus the line-of-sight velocities for several hundreds of PNe and GCs in each galaxy. The theoretical part of the thesis will use these velocities together with the gravitational potential determined from X-ray data to derive the distribution of the orbits in the extended haloes.

Instruments: OPTIMOS, EAGLE

1.4- Publication agreement: yes

2.1- PI: Magda Arnaboldi

2.2- CoIs: Ortwin Gerhard, Ken Freeman, Emily McNeil, Payel Das, Lodovico Coccato, Lucia Morganti, Giulia Ventimiglia, Williams Harris

2.3- Institute: ESO

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: marnabol@eso.org

3.1- Source of targets: SUBARU, CFHT,VLT

3.2- Preparatory work on targets required?: yes, N/A

3.3- Target brightness: 26.5, 28.0, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 4

3.6- Density of targets: N/A

3.7- Target coordinates: RA:10 - 14;Dec:0 - 12, RA:10 - 12;Dec:-10 - -35, RA:11 - 13;Dec:-25 - -45, RA:01 - 104;Dec:-25 - -45

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy cluster

4.1- Spatial resolution: 250, ?

4.2- Field-of-view: 30x30arcsec

4.3- Multiplexity and pick-off FoV: 1, slitlet

4.4- Plate scale stability: N/A

5.1- Wavelength range: 480 - 530, 330 - 2000

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: GLAO

7.1- Integration time per target or field and per setup: 5, 10, based on scaling of current data obtained from 8 meter telescopes

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: ~ 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
absorption line spectroscopy, either long-slit or IFU, in the optical wavelength with R5000-10000
multi fibers or multi slitlest for multi targets spectroscopy (GCs or PNe) with R5000 - 10000 and 10000-20000

9.3- Detailed description or other comments:
N/A

1.1- Project Title: Cosmology with gravitational arc statistics

1.2- Project Category: 1

1.3- Abstract:
We propose a systematic search for gravitational arcs in the most massive clusters of galaxies to put constraints on the underlying cosmological model. The frequency of strong lensing features is a

sensitive function of several parameters, but it highly depends highly on the assumed cosmological model. Determining all other influences with the help of observations enables a constraining of cosmological parameters.

1.4- Publication agreement: no

2.1- PI: Wolfgang Kausch

2.2- CoIs: Sabine Schindler, Axel Schwope, Thomas Erben

2.3- Institute: Institute of Astro- and Particlephysics, University of Innsbruck

2.4- Country of Employment: AT

2.5- Career Stage: postdoc

2.6- E-mail: wolfgang.kausch@uibk.ac.at

3.1- Source of targets: Rosat Bright Survey (Schwope et a., 2000, AN, 321,1)

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 21, 26, Vegamag, R

3.4- Target size: extended source, 100, 1000

3.5- Number of targets: 25

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy, galaxy cluster

4.1- Spatial resolution: 50, 2

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: N/A

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4.4- Plate scale stability: N/A

5.1- Wavelength range: 370 - 1400

5.2- Spectral Resolution: 500-1000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 1, input assuming worst case that in every cluster one arc with R~26mag (Vega) is detected. extended sources=1

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 3600

7.4- Total time: 25

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 100

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
The sample has to be observed completely.

9.3- Detailed description or other comments:
We have established a sample of 25 galaxy clusters selected by their X-ray luminosity L_X from the ROSAT Bright Survey (Schwope et al. 2000). Due to the tight relation between L_X and the cluster mass (Schindler 1999) and the selected redshift regime ($0.1<z<0.6$) this sample contains the most massivest systems in appropriate distance for creating gravitational arcs.

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Statistically, the frequency of arcs depends on various independent parameters, e.g. the source/lens number counts, the lens properties (total mass, central mass slope/concentration/distribution,…..). Additionally, lensing theory shows that the cosmological model has a high impact on the lensing ability of galaxy clusters. Hence determining these independent parameters by observations offers now the possibility to constrain the cosmological model. However, a complete and homogenous sample of detected arcs is needed.

The detection of these very faint (down to R~25-26mag) and thin objects crucially depends on the image quality. In particular, blurring by atmospheric seeing highly affects the detecability, as a direct comparison between ground and space based observation shows. Hence the use of a large mirrored and AO equipped facility dramatically enhances the ability to detect and spectroscopically prove these faint objects. This is crucial for studies based on number counts of detected arcs as arc statistics.

Although there is not much information about OPTIMOS available it seems to be the best suited instrument for our purpose: Assumed imaging capabilities for detecting arcs and the possibility of Multi-object-spectroscopy in the optical/NIR regime for their spectroscopic prove make this instrument the first choice. Additionally the wide field of view (5’x5’, or 10’x10’, respectively) give the opportunity to apply weak lensing techniques for mass map creations to constrain the parameters for the arc statistics. The exposure times are estimated with the ETC assuming a constant t_exp for all clusters.

1.1- Project Title: Kinematics of ionised gas in the accretion phase of young massive stars

1.2- Project Category: 3

1.3- Abstract:

Crucial details about the accretion of matter onto forming massive stars are still unknown. We devise an E-ELT programme to observe a larger sample of massive YSOs in the [Ne II] line at 12.81 micron. High spectral resolution spectroscopy shall be used to map the gas emission close to the central energy source, to determine the kinematics of the ionised gas, and thus to disentangle the complex 3D motions (infall, outflow, rotation). This is a promising way to investigate how these stars gain in mass while affecting and transforming their own accretion flows.

1.4- Publication agreement: no

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2.1- PI: Hendrik Linz

2.2- CoIs: Henrik Beuther, Thomas Henning, Arjan Bik

2.3- Institute: MPIA Heidelberg

2.4- Country of Employment: DE

2.5- Career Stage: postdoc

2.6- E-mail: linz@mpia.de

3.1- Source of targets: VLT(Visir), VLA, ATCA, RMS survey (e.g., Urquhart et al. 2008), CORNISH survey (e.g., Purcell et al. 2008), both from ASP Conf. Ser. 387

3.2- Preparatory work on targets required?: yes, low-resolution N-band spectra (e.g., with Visir) to ensure presence of the [Ne II] line

3.3- Target brightness: 100, 100000, mJy, N

3.4- Target size: extended source, 50, 500

3.5- Number of targets: 200

3.6- Density of targets: N/A

3.7- Target coordinates: l:0 - 360;b:-2 - +2, l:206 - 209;b:-20 - -15

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 2x2arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 0.01, 60

5.1- Wavelength range: 12790 - 12830, 8970 - 9010, 10490 - 10530

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5.2- Spectral Resolution: 50000-100000

6.1- Instrument: METIS

6.2- Desired special mode: other, integral field spectroscopy

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.02, 2.6, R=50000, seeing=0.8", high"n"dry site, 42-m telescope, LT/MCAO, SNR=10

7.2- Longest continuous observation time on a target or field: 5.2

7.3- Shortest integration time on a target or field: 30

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 33

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, SINFONI-like quick-look pipeline

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, VLT/VLTI, other, eVLA

9.2- Critical aspects / limiting factors for the science case:
Essentially, this science case builds on the availability of a high spectral resolution mode in the N band.
Furthermore, the models predict certain physical sizes of [Ne II]-relevant regions. Switching from a 42-m concept to a 30-m concept for the E-ELT would strongly limit the sample selection, both in terms of spatial resolution and sensitivity, to somewhat brighter objects at 0.4 -2.0 kpc. Note, that the larger surveys (e.g., RMS) have most of their discoveries in the range 2 - 4 kpc.

9.3- Detailed description or other comments:
There is mounting evidence that forming high-mass stars gain in mass through accretion events mediated by rotating circumstellar structures. However, these processes cannot be considered simply as a scaled-up version of low-mass star formation. It is one characteristic that for massive star formation the Kelvin-Helmholtz timescale is shorter than the accretion time scale. Hence, O

stars and early B stars have to accrete matter while already burning hydrogen and thus producing an enormous energy output of ionising radiation potentially affecting the accretion. Furthermore, the absolute timescales involved are rather short in general. All the important accretion processes take place when the forming stars are still deeply embedded in their birth cocoons. Observationally, this calls for measurements at long wavelengths to mitigate the effects of extinction.

During recent years, sophisticated analytical and numerical models have been developed to explain the formation of high-mass stars (McKee & Tan 2002; Bonnell & Bate 2006; Krumholz, Klein & McKee 2007). A particularly intriguing model was developed by Keto (2007, and references therein) to describe the effect of the forming massive star and its ionising radiation on its own accretion flow. In this scenario, the ionisation first forms a small quasi-spherical HII region, gravitationally trapped within the accretion flow, whereby the flow of ionised gas is almost entirely inward. With increasing ionisation, the HII region transitions to a bipolar morphology, where along a narrow angle aligned with this axis, the inflow is replaced by an growing outflow. The outflow angle grows further, and in a third, stage the accretion is confined to a thin region along an equatorial disk. So-called Hypercompact HII regions (HCHIIRs, e.g., Kurtz & Franco 2002) might represent these stages of tr

ansition. They exist before the thermal pressure of the ionised gas completely dominates and more and more erases the memory on the previous circumstellar structures during the subsequent ultracompact HII region (UCHIIR) stage.

While some of these HCHIIRs are still too deeply embedded for mid-infrared spectroscopy (e.g., Source I in Orion KL), many High-Mass Protostellar Objects (HMPOs, Beuther et al. 2007) have formed an HCHIIR and can be tackled with spectroscopic IR observations on ELTs. Previous work on the dynamics of the ionised gas in these early stages has focused on hydrogen recombination line observations in the cm and mm range. Physical parameters like the elevated electron densities in HCHIIRs can be assessed therewith (e.g., Keto, Zhang & Kurtz 2008). However, even if the effects of electron pressure broadening have been removed, the thermal line width of ionised hydrogen gas of T=104 K is still ~21 km/s. Infall velocities, however, can be clearly below that (Keto 2007). Here, mid-infrared spectroscopy will give further insights into the dynamics of the gas.

A prominent mid-infrared fine-structure line is [Ne II] at 12.81 micron. Due to its higher atomic weight, the thermal line width of this line in a 104 K plasma will be <5 km/s. This means that high-resolution spectroscopy of the 12.8 micron line offers the chance to resolve closely spaced velocity components along a given line of sight, to follow small variations in line velocity from one position to another, and to detect the presence of turbulence or bulk motion on small scales, but with overall velocity spreads even below the thermal sound speed (Jaffe et al. 2003), which is on the order of 10 km/s.

We devise here an E-ELT observation project to observe a large sample of HMPOs and massive YSOs associated with HCHIIRs and young UCHIIRs. Spectroscopic mapping in the [Ne II] line shall be performed to disentangle the kinematics of the compact ionised circumstellar gas. Different components like rotation on the surface of a disk as well as outflowing and accreting ionised gas can thus be identified. Since the above-mentioned models suggest a variety of motions within the inner 100 - 500 AU, the diffraction-limited performance of the E-ELT is vital to investigate these targets which have predominantly distances of > 1 kpc. High spectral resolution is mandatory for this project. A spectral resolution of at least 50,000 - 60,000 must be attained to ensure a velocity resolution similar to the thermal line width of the neon line. We mention that MIRI at the JWST will

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neither have the required spatial nor spectral resolution for such a project. The final goal is to have spectral m
aps of the ionised gas emission in order to reconstruct the 3D velocity field and to compare kinematics (and line strengths) to the models by Keto and by Krumholz et al. In addition, further fine-structure lines visible in the N band, like [Ar III] and [S IV], can be mapped as well, if they are strong enough. A comparison with the [Ne II] line emission will make an assessment of the physical conditions in the ionised gas possible (e.g., Okamoto et al. 2003).
This project would be an exemplary application for an integral field spectrograph. We know that the current design of the E-ELT instrument project METIS does not contain a mid-infrared IFU. Considering the strong advantages of an IFU for such an observational project, we strongly suggest to consider the addition of a high spectral resolution IFU device in a second instrumentation stage. Several well-investigated HCHIIRs can be tackled with these observations, for instance G28.20-0.04 (Sewilo et al. 2008), as well as many well-known massive YSOs. Furthermore, the surveys RMS (Hoare et al. 2005, Urquhart et al. 2008) and CORNISH (Purcell et al. 2008) have been devised to reveal more new massive YSOs by coordinated infrared and radio observations in the Galactic plane. A larger subset of the ~2000 new YSO candidates can form the input sample for our proposed observations, especially the > 400 candidates associated with compact centimeter continuum emission.

1.1- Project Title: Testing the universality of the IMF in extragalactic stellar clusters

1.2- Project Category: 3

1.3- Abstract:
The form of the stellar initial mass function (IMF) affects nearly all scales of astronomy. The IMF is tied intrinsically to the physics of star and planet formation and, on larger scales, virtually every observable stellar property of a galaxy (colour, magnitude, chemical enrichment history, etc) is influenced by it. Here we propose near-IR spectroscopy of massive clusters in selected starburst galaxies out to ~65 Mpc to probe the universality of the IMF in extreme starburst environments.

1.4- Publication agreement: yes

2.1- PI: Nate Bastian

2.2- CoIs: Chris Evans, Matt Lehnert, and the EAGLE team

2.3- Institute: Institute of Astronomy, Cambridge, UK

2.4- Country of Employment: UK

2.5- Career Stage: postdoc

2.6- E-mail: bastian@ast.cam.ac.uk

3.1- Source of targets: HST, VLT, JWST

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 18, 21, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: 20

3.6- Density of targets: a few

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star cluster

4.1- Spatial resolution: 100, 2

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: 20, 2x2arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: K

5.2- Spectral Resolution: 10000-20000

6.1- Instrument: EAGLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: MOAO

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7.1- Integration time per target or field and per setup: 5, 10, assuming dark night, airmass=1, seeing=0.8 (@zenith)

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 70

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
N/A

9.3- Detailed description or other comments:
The stellar initial mass function (IMF) is one of the most fundamental parameters in astronomy, with the major recurring question being whether it varies with environment. In the local Universe the evidence seems to point towards an invariant IMF, having a power-law index on the high-mass side (i.e. the Salpeter index of -2.35) and a "turn-over" around 0.5-0.8 M_sun. However, it has often been reported (and also often questioned) that the IMF is "top heavy" in extreme starburst environments, i.e. there are more high mass stars per low mass star than expected from the standard IMF. This is a particularly interesting suggestion because the average star-formation rate density was much greater at high redshifts than it is currently, leading some to conclude that the IMF could vary systematically with redshift; this would have a dramatic impact on our interpretation of observations of high redshift galaxies.

With the advent of high spatial-resolution near-IR spectroscopy and the sensitivity of the E-ELT, we will be in a position to test comprehensively whether the IMF does indeed vary in extreme environments. Nearby starburst galaxies are currently forming star clusters which have masses and densities which exceed globular clusters, making them one of the most extreme environments of star formation through cosmic history. Do these clusters have top-heavy or strange IMFs? With high

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signal-to-noise (>100) K-band spectroscopy it is possible to detect the spectral signatures of relatively low mass, pre-main-sequence (PMS) stars in a cluster containing many thousands of O- and B-type stars. This provides information on the relative population of low-mass stars, directly constraining the IMF in each cluster. However, even with 8-10m class telescopes, we are currently limited by sensitivity and spatial resolution.

We propose to use the E-ELT to investigate the IMF in the most extreme star-forming conditions in the "local" Universe. High priority targets include Arp 220 (~60 Mpc), NGC 6872 (65 Mpc), NGC 3256 (36 Mpc) and the Antennae (NGC4038/39, ~20 Mpc). At these large distances massive clusters are not significantly spatially-extended, but good spatial resolution is necessary to ensure that older regions (which contain evolved red giants) are not included. These observations will be complemented by comparison studies of the IMF in more moderate star-forming environments in spiral galaxies such as those in the Sculptor Group, M83, NGC 2997 and NGC 3621.

With high-quality IFU spectroscopy we will measure the line strengths of spectral features created by low-mass PMS and high-mass OB-type stars in the target clusters, giving us a direct handle on the ratio of high-to-low mass stars (i.e. the IMF) and on possible variations therein. Moreover, it has been demonstrated that at a spectral resolving power of R~10,000, moderate S/N of ~30 is sufficient to obtain velocity dispersions of the brightest (and hence most massive) clusters. Specifically, at this S/N or better, one can resolve velocity dispersions that are a factor of two less than the instrumental resolution. Applying this to EAGLE suggests that, at R = 12,000 (for example), a dispersion of ~5 km/s can be measured accurately. If we take a typical size of young clusters, this suggests that we can measure masses down to 2x105 M_sun, approximately the peak of the mass distribution of globular clusters. Greater S/N will enable velocity dispersions to be measured in lower mas
s systems, potentially sampling the cluster mass-function well below the characteristic mass of globular clusters.

We propose EAGLE spectroscopy of the 30-40 most luminous clusters in each target galaxy, to sample the full spatial extent of each galaxy to probe different regions/conditions. Sensitivity calculations for EAGLE spectroscopy, using simulated MOAO K-band PSFs, yield S/N~100 in 5 hrs for K ~20.5. Thus ~5 hrs/pointing are required in the Antennae/NGC 3256, and ~10 hrs/pointing in Arp 220/NGC 6872, giving a total of ~60 hrs, plus a further 10 hrs for observations in nearby systems. Note that excellent northern hemisphere targets are also available for this programme.

1.1- Project Title: GRBs as a tool to explore the high-z universe

1.2- Project Category: 1

1.3- Abstract:
GRB afterglows have proven to be the ultimate pathfinders into the high-z universe. These are the targets that can be used to search for evidence for the first generation of stars, to explore the reionization history of the universe, to detect signs of the end of the dark ages, and to reveal the chemical evolution of the universe. It is suggested that this topic should play an important role in future E-ELT science.

1.4- Publication agreement: yes

2.1- PI: Sylvio Klose

2.2- CoIs: , , Jochen Greiner et al., MPE Garching

2.3- Institute: Thüringer Landessternwarte Tautenburg

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: klose@tls-tautenburg.de

3.1- Source of targets: relies on Gamma-ray satellites

3.2- Preparatory work on targets required?: yes, the afterglow, i.e. the target, has to be detected by other facilities

3.3- Target brightness: 15, 20, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: GRB

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4.1- Spatial resolution: seeing, 3

4.2- Field-of-view: longslit

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 800 - 2500

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: SIMPLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 1, standard values

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: yes, TOO targets

8.1- Does the execution of observations require real-time decisions?: yes, TOO target; usually rapidly fading, N/A

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: yes, 30

9.1- Synergy with other programmes: other, N/A

9.2- Critical aspects / limiting factors for the science case:
TOOs must be technically feasible at the E-ELT (incl. a potential instrument change); gamma-ray satellites that can detect GRBs must be in operation at that time

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9.3- Detailed description or other comments:
Theoretical models suggest that several percent of the GRB progenitor population could be at redshifts beyond z=6. GRB 080913 (z=6.7) and
recently GRB 090423 (z=8.2) have demonstrated that such events exist and can be observed. A rapid response to such events with the E-ELT, once an afterglow was found by other facilities, would offer a deep insight into the high-z universe not achievable by other means in the next decades.

1.1- Project Title: White dwarfs in globular clusters

1.2- Project Category: 3

1.3- Abstract:
Globular clusters have been a key ingredient in our understanding of stellar and binary evolution for a long time. The population of white dwarfs in globular clusters presents unique opportunities to determine the age of globular clusters (and thereby a maximum age of the Milky Way), to understand single and binary evolution (by determining a initial mass - final mass relation) and to understand the evolution of globular clusters themselves. For the study of globular cluster white dwarfs an E-ELT is required, equiped with a medium resolution O-NIR multi-object spectrograph and a high resolution (nIR) imager.

1.4- Publication agreement: yes

2.1- PI: Paul Groot

2.2- CoIs: Christian Knigge, Gijs Nelemans, Danny Steeghs, Tom Marsh, Tom Maccarone, Boris Gaensicke, Vik Dhillon, John Taylor Southworth, Peter Jonker

2.3- Institute: Radboud University Nijmegen

2.4- Country of Employment: NL

2.5- Career Stage: faculty

2.6- E-mail: p.groot@astro.ru.nl

3.1- Source of targets: SIMBAD, HST-ACS, VLT-NAOS/CONICA

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 22, 30, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 1000

3.6- Density of targets: 10-100

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per min

3.10- Target type: star, star cluster

4.1- Spatial resolution: 100, 2

4.2- Field-of-view: fiber

4.3- Multiplexity and pick-off FoV: 100, fiber

4.4- Plate scale stability: N/A

5.1- Wavelength range: U, B, V, R, I, J, H, 300 - 2500

5.2- Spectral Resolution: bbimaging, 5000-10000, 10000-20000

6.1- Instrument: MICADO, OPTIMOS, other, A high time resolution optical/nIR photometric instrument (Ultracam-like); NB: OPTIMOS is OPTIMOS-EVE

6.2- Desired special mode: high time-resolution, N/A

6.3- Desired AO mode: GLAO

7.1- Integration time per target or field and per setup: 2, 4, GLAO, 0.2" spatial resolution, V=24.5, R=10000, Teff =10000 K

7.2- Longest continuous observation time on a target or field: 4

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7.3- Shortest integration time on a target or field: -

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: other, LISA/Chandra/IXO/XMM

9.2- Critical aspects / limiting factors for the science case:
- Blue sensitivity in the spectrograph/telescope: lambda < 400 nm is required
- Multiplexing capabilities
- Spectral resolution R> 5000

9.3- Detailed description or other comments:
Globular clusters have long been a key ingredient in our understanding of stellar and binary evolution, the structure and age of our Milky Way and the content of the high-energy Universe. They offer a unique environment of a large, isolated population of stars which presumably all formed within a very short span of time. This simplicity of the stellar population of globular clusters has been one of their main attractions. At the same time, due to the high stellar density which leads to collisions and exchange interactions between stars and binaries, globular clusters are also complicated from a dynamic and binary evolutionary point of view. Globular clusters are well known to present an overabundance (compared to the general Galactic field populations) of neutron star binaries such as binary millisecond pulsars and X-ray binaries. Only current generations of computers are beginning to be able to simulate globular clusters with full N-body and stellar evolution codes.

Recent detailed studies of massive globular clusters show that they are often not the simple stellar populations we held them for, but show clear evidence for multiple star formation episodes. This ties in with the suggestion that e.g. Omega Cen is actually the remnant core of a companion galaxy to our Milky Way.

Even though globular clusters are very old, and more than 97% of all stars will leave a white dwarf as a remnant, the white dwarf population in globular clusters has long been underilluminated. This is due to the faintness in both the optical as well as X-ray regimes of white dwarfs (in binaries) and the extreme crowding in globular cluster cores. Observations making use of the superb spatial resolution of the Hubble Space Telescope as well as the Chandra X-ray Observatory have revolutionized the field of white dwarf (binaries) in globular clusters. Although it was long realized that the cooling times of white dwarfs can be used as a cosmic clock, it is only very recently that it has become possible to use the white dwarf population in this way, for instance by the detection of the white dwarf population termination in NGC6379 (Hansen et al., 2007). Very deep Chandra observations have revealed a population of faint X-ray sources in globular clusters that consist of a mixture of quiescent low-mass X-ray binaries and cataclysmic variables. An E-ELT optical spectrograph will allow a detailed comparison between the population characteristics of accreting white dwarfs in globular clusters with those of accreting binaries in the field. A recent overview of white dwarf studies in globular clusters is given in Moehler and Bono (2008) and on compact objects in globular clusters in general by Maccarone & Knigge (2007).

The detection of the population of white dwarfs in Globular clusters has raised new questions and enlarged existing ones. The populations appear to be overabundant in low-mass, He-core white dwarfs (e.g. Strickler et al. 2009). This emphasizes the already open and important question what the binary population (primordial and collision-induced) is in globular clusters. Questions on the presence of thick or thin hydrogen layers on the white dwarfs have direct impact on the ages derived from white dwarf cooling models and therefore the age of the globular cluster and the Milky Way. This raises questions on the importance of binary evolution in these systems or whether enhanced mass-loss in single stars on the red giant branch can occur. The detection of the white dwarf termination and the `hook'' in white dwarf colours that is expected from the formation of collisional-induced absorption by H_2 in hydrogen-rich atmospheres (Hansen 1998, Saumon & Jacobsen, 1999) also opens up the possibility to obtain new insight in the physics of degenerate matter at high densities and low temperatures (see e.g. Winget et al., 2009 on the evidence for crystallization).
Existing questions on the distance and reddening towards globular

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clusters are emphasized by the studies of the white dwarf population since they are vital ingredients to the use of white dwarfs as cosmological probes.

>From a theoretical point of view the importance of white dwarf dynamics has been recently investigated by Heyl and collaborators (e.g. Heyl & Penrice, 2009) after observations evidence for an unexpected radial distribution of white dwarfs (Davis et al. 2008) If white dwarfs are indeed born with a modest kick-velocity (order few km/s; Spruit 1998) they can have a large impact on the globular cluster evolution, by cluster heating and delaying core collapse (Fregeau et al. 2009). Due to their large numbers (up to 105 in a rich cluster) their dynamic impact may be much larger than that of the neutron star population.

The population of white dwarfs in globular clusters starts at V = 22-23 in the nearest clusters, and with a white-dwarf sequence turn-off at V~28 in NGC 6397 (Hansen et al. 2007). This makes that few white dwarf candidates have been studied spectroscopically and that accurate proper motion determinations are highly challenging, even with current AO systems and/or HST. To answer the questions raised above on the population of white dwarfs in globular clusters it will be imperative to determine:
a) the masses and temperatures of cluster white dwarfs as well as their chemical composition
b) the mass of the hydrogen envelope layer
c) the spatial distribution as well as dynamics of the population of white dwarfs, preferentially from both radial velocity studies as well as proper motion studies.

A full study of white dwarfs in globular clusters is therefore the domain of the E-ELT. To obtain masses, temperatures and chemical composition of the white dwarf (atmospheres) will require spectroscopic observations at a resolution of R>=5000. To determine the mass of the hydrogen layer asteroseismological studies will be the most direct route, requiring high speed photometry and/or spectroscopy. To determine the dynamics of the population of white dwarfs will require a combination of a high angular resolution imager (to determine proper motions) as well as a medium-to-high resolution optical spectrograph (with R>15000). To make full use of the concentration of white dwarfs on the sky a multi-object spectrograph would be ideal for the spectroscopic objectives.

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Fregeau, J.M. et al., 2009, ApJ 695, L20
Hansen B., 1998, Nature 394, 860
Hansen B., et al., 2007, ApJ 671, 380
Heyl J and Penrice M., 2009, MNRAS, in print (astro-ph 0901.1872)
Maccarone T. & Knigge C., 2007, Astronomy & Geophysics, astro-ph 0709.3732
Moehler S. & Bono G., 2008, astro-ph 0806.4456
Saumon D & Jacobson S.B., 1999, ApJ 511, L107
Spruit H.C., 1998, A&A 333, 603
Strickler R.R., et al., 2009, ApJ 699, 40
Winget D. et al., 2009, ApJ 693, L6

1.1- Project Title: Imaging exozodiacal dust around nearby stars with E-ELT/MIDIR.

1.2- Project Category: 3

1.3- Abstract:

One of the key objectives in the field of planet formations is to detect and characterize habitable planets. A first step toward this aim is to study the exozodiacal light in the habitable zone. This is interesting by itself in order to complement observations of the outer debris disk regions by ALMA and JWST and as a pathfinder to find the good targets (with low enough zodiacal light) for future missions such as Darwin, which will detect habitable planets and characterize their atmosphere. The E-ELT/METIS is THE machine/instrument to perform these objectives. Indeed it will be the first machine to combine both the required angular resolution (1AU at 10 pc at 10 microns) and the required sensitivity (a few mJy at 10 mJy).

1.4- Publication agreement: yes

2.1- PI: Pierre-Olivier Lagage

2.2- CoIs: C. Cavarroc, E. Pantin

2.3- Institute: CEA-Saclay

2.4- Country of Employment: FR

2.5- Career Stage: faculty

2.6- E-mail: pierre-olivier.lagage@cea.fr

3.1- Source of targets: VizieR

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 2, 12, Vegamag, V

3.4- Target size: extended source, 100, 200

3.5- Number of targets: 150

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: diffraction, 3

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 1, 3600

5.1- Wavelength range: N

5.2- Spectral Resolution: nbimaging

6.1- Instrument: METIS

6.2- Desired special mode: coronography, N/A

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: 0.5, 1, N/A

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7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 1800

7.4- Total time: 150

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
high angular resolution and high contrast

9.3- Detailed description or other comments:
The grail of planet searches is to detect and characterize habitable extrasolar planets, analyze the composition of their atmosphere and eventually their capability to sustain life. Space missions such as Darwin (e.g. Fridlund 2004).or TPF (e.g. Beichman et al. 1999) are under study to realize these objectives.

If planets orbit around a star, it is quite plausible that asteroids and comets are also present and then exozodiacal dust produced by asteroid collisions and out-gassing of comets. Dust has a larger surface area per unit mass compared with a large body; it can be spread over a larger solid angle, intercepting more starlight and emitting much more light via reprocessing.

An exozodiacal dust emission at the level of 10 to 20 times that of our own zodiacal cloud can impede Earth-like planet searches due to increased photon shot noise (Beichmann at al. 2006 ApJ 652).

It is very difficult to predict the level of brightness of exozodiacal lights; observational studies of the emission of inner (1 AU) dust disks in the mid-IR are therefore a crucial pre-requisite to the selection of suitable targets for direct Earth-like planet imaging detection. The observational search for exozodiacal lights is a very active field. Ongoing interferometric observations in the near Infrared are suggesting that hot exozodiacal discs may be more common than anticipated (Absil et

al. 2006b; Di Folco et al. 2007). The Sptizer mission has led to very interesting results, such as the discovery of a few “old” stars featuring high excess at 24 microns in the Spectral Energy Distribution, interpreted as “recent” collisions between asteroids. But the search has been limited to exozodiacal lights about 1000 times brighter than the zodiacal light; the limitation factor is not the sensitivity, but the photometric precision (2%), as well as the star photosphere mod
elling precision (Beichman et al 2006 ApJ 639). The JWST might improve a bit the photometric precision and photosphere modelling precision could impove.
But to really overpass these limitations, the star emission and dust emission have to be spatially disentangled. The typical required angular resolution is 100 mas, (1 AU for a star at 10 pc). This requirement immediately set the need for a telescope diameter greater than 25 meters, when observing at 10 microns (a blackbody dust at 1 AU heated by a solar type star will reach an equilibrium temperature of 300 K and a peak emission at 10 microns).

Thanks to its increased sensitivity due to its large collecting surface, combined with its high angular resolution, the E-ELT is THE machine to study exozodiacal lights in the 1AU region around nearby stars (<10 pc). The zodiacal dust light at 10 microns is about 10000 times lower than that of the Sun. The flux of a Solar type star at 10 pc is of 2 Jy; so that we aim at detecting a exozodiacal light at a level of a few mJy. Simulations of observations with METIS have shown that the required sensitivity can be reached (see figure).

The number of counts on the detector from a 2Jy source will be of the same order as the number of counts from the background (sky and telescope), so that a coronagraph is needed.

1.1- Project Title: A CO imaging survey of protoplanetary disks: Resolving the planet-forming region with the E-ELT

1.2- Project Category: 3

1.3- Abstract:

E-ELT METIS offers unprecedented spatial resolution (~20 mas; 1-3 AU) for line
imaging in the atmospheric L and M bands. We propose a survey of 12CO, 13CO, C18O and C17O 4.7 micron ro-vibrational emission lines in protoplanetary disks to directly
image the distribution and dynamics of molecular gas in the planet forming region around T Tauri and
Herbig Ae stars. The survey will produce line images with a few up to 50 or more spatial resolution elements, enough to directly image gas gaps and axial asymmetries due to planet-disk interactions. Dust settling efficiencies can be measured as a function of radius.

In optically thin transition disks, the METIS images will directly measure the radial surface density profile of molecular gas. Finally, monitoring the CO lines with a time cadence of 6 months will produce the first ``movies'''' of inner disk dynamics.

1.4- Publication agreement: yes

2.1- PI: Klaus Pontoppidan

2.2- CoIs: Cornelis Dullemond

2.3- Institute: California Institute of Technology

2.4- Country of Employment: other

2.5- Career Stage: postdoc

2.6- E-mail: pontoppi@gps.caltech.edu

3.1- Source of targets: VLT, Spitzer, SMA, ALMA, Keck

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 10, 10000, mJy, M

3.4- Target size: extended source, 10, 100

3.5- Number of targets: 50

3.6- Density of targets: N/A

3.7- Target coordinates: RA:3 - 19;Dec:-77 - +30

3.8- Moving target?: no

3.9- Variable target?: yes, 2-4 per year

3.10- Target type: other, protoplanetary disk

4.1- Spatial resolution: diffraction, 2.5

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 4500 - 5100, M

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.1, 1.0, median Paranal-type conditions

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: yes, Observing should be timed such that the Doppler shift relative to telluric lines is maximized. Generally, it is enough to schedule observations within a window of ~1 month.

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, E-ELT METIS molecular line imaging and ALMA dust continuum imaging trace the same angular scales, opening possibilities for very exciting synergies.

9.2- Critical aspects / limiting factors for the science case:
This program critically depends on a METIS ~1"x1" IFU in the M-band with a spectral resolving power in excess of 50,000.

9.3- Detailed description or other comments:

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Theory predicts that the process of planet formation depends on a complex interplay of the gas and solid components of protoplanetary disks at radii of 0.1 - 20 AU, the so-called ``planet-forming region''. In order for the disk solids to grow to planetesimals and planet cores, they must decouple from the gas phase, first through dust growth and settling to the mid-plane, and subsequently by radial migration and concentration of cm to m-sized solid bodies. The settling of dust is traced by the depletion of solids from the disk surface and a related drop in dust opacity (e.g., Dullemond & Dominik, 2005). The radial migration of solids depends on the radial gas density profile of the disk (e.g., Weidenschilling 1977; Ciesla 2009, and references therein), and spatially resolved observations of the gas distibution in the inner disk is needed to constrain models. Further, once giant planets form, they dynamically interact with the gaseous component, creating gaps and inner holes in the disk, as well as axial asymmetries such as spiral waves (e.g., Lubow et al. 1999, Kley et al. 2001). Because several processes, not related to the presence of giant planets, can also produce apparent gaps in the dust distribution in the disk, images of the gas distribution as well are essential for constraining planet formation models. Therefore, a dependable tracer of the gas component in the planet-forming region is crucial for constraining models of planet formation.

We propose to use E-ELT METIS to image ro-vibrational lines of 12CO, 13CO, C18O and C17O around 4.7 micron to trace the molecular gas component in a sample of protoplanetary disks surrounding T Tauri stars (young stars with masses 0.1-2.0 Msol). See Pontoppidan et al. 2008 for a demonstration of a detection of all CO isotopologues from a protoplanetary disk. Such E-ELT line images will have a diffraction-limited spatial resolution of 1-3 AU (~20 mas FWHM of the diffraction-limited PSF core, or 1.22 lambda/D ~ 29 mas) for the nearest protoplanetary disks, producing the clearest images of molecular gas in the planet-forming region at the time the E-ELT becomes operational. The proposed observations will be highly complementary to ALMA observations; ALMA line imaging is expected to reach its best performance for for a spatial resolution of 20-50 AU (a few 100 mas) for protoplanetary disks (see the ALMA DRSP), radii where the CO ro-vibrational lines are no longer excited. The proposed E-ELT line observations will be be directly comparable to ALMA dust continuum imaging.

Feasibility

Surveys of the atmospheric M-band have demonstrated that strong ro-vibrational emission lines from CO is a ubiquitous feature of protoplanetary disks around both T Tauri stars (Najita et al., 2003, Salyk et al. 2009) and Herbig Ae stars (Blake & Boogert 2004, Brittain et al. 2007). The CO gas emission vanishes only as the disk progresses toward the debris disk phase, but persists throughout the transition disk phase (Pontoppidan et al. 2008, Salyk et al. 2009).

The spatial extent of the CO emission ranges from 0.1 AU to more than 10 AU (Goto et al. 2005, Pontoppidan et al. 2008, van der Plas et al. 2009). Consequently a significant number of disks (>10) have ro-vibrational CO emission lines that have been marginally spatially resolved with 8m class telescopes equipped with AO correction. With the improvement of a factor 5 in spatial resolution with a 42m telescope and the addition of an integral field unit spectrometer, such as that imagined for METIS, these disks could be imaged with up to 50 resolved elements across the emitting region. The size of the CO line image may increase further as the increased sensitivity of the E-ELT allows the detection of much lower surface brightness line emission farther out in the disk. Based on a spectro-astrometric survey of protoplanetary disks with CRIRES (Pontoppidan et al. 2008, 2009, in prep.), we estimate that at least 50-100 sources will have CO emission lines that can be directly imaged with E-ELT METIS. This survey also shows that typical line widths range from 6 - 50 km/s, demonstrating the essential need for a resolving power of R=100,000. Significantly lower resolving powers would not spectrally resolve line emission from the 3-10 AU region. Simulations of METIS CO imaging are presented in Pontoppidan et al. (2009, ApJ, submitted). We finally note that at 4.7 micron, it is relatively easy to approach diffraction limited performance with low-order adaptive optics correction. The proposed project is therefore well-suited to be carried out early in the E-ELT project.

Science questions to be addressed with a METIS CO survey

- Spatially resolved images of all the CO isotopologues (12CO, 13CO, C18O, C17O) allows the determination of the molecular column density to the surface at unit dust optical depth as a function of radius, testing dust settling models. Is dust settling more effective at smaller radii?

- What is the gas distribution inside dust gaps? Dynamical clearing by planets predict specific surface gas density profiles inside the dust gap.

- The so-called transition disks are protoplanetary disks that are optically thin in the vertical direction, by definition. For these objects, ro-vibrational CO lines become a unique tracer of the entire gas column. METIS will provide a direct measurement of the surface density profile for transition disks, constraining disk evolution models. Specifically, by combining METIS line imaging and ALMA continuum images, it will be possible to search for a predicted concentration of solids at pressure maxima in the disk (Weidenschilling et al. 1977, Johansen et al. 2007).

- Dynamical interactions of planets with the parent protoplanetary disk are

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expected to produce axial asymmetries of the surface density. Spatially unresolved line spectroscopy
is not able to clearly detect such asymmetries. METIS CO images will reveal
3D structures in the gas distribution in the planet-forming region, including spiral waves,
and, given the relatively short dynamical time scales, will be able to monitor such structures.
We predict the production of ``movies'''' of disk dynamics on 3 AU scales in disks within the first few years of
METIS operation.

- The proposed survey can also be used to search for line emission from circumplanetary disks (see separate Pontoppidan et al. E-ELT DRSP proposal).

1.1- Project Title: An E-ELT METIS search for Keplerian disks around proto-planets using IR molecular emission lines

1.2- Project Category: 3

1.3- Abstract:

Given the existence of a large number of exoplanets, forming protoplanets, still embedded
in their parent protoplanetary disks, must exist. A signpost of a compact object in
a gas-rich disk will be a circumplanetary accretion disk, expected to form around
young giant planets of ~1 MJup or more. We propose a deep E-ELT METIS line imaging survey
of transitional protoplanetary disks to search for protoplanets via molecular emission lines formed
in their circumplanetary disks. The unambiguous detection of protoplanets will
revolutionize the study of planet formation and evolution. Further, the detection of circumplanetary disks may be the first step in the study of exo-solar moon systems, an important reservoir for potentially life-bearing worlds.

1.4- Publication agreement: yes

2.1- PI: Klaus Pontoppidan

2.2- CoIs: Geoffrey Blake

2.3- Institute: California Institute of Technology

2.4- Country of Employment: other

2.5- Career Stage: postdoc

2.6- E-mail: pontoppi@gps.caltech.edu

3.1- Source of targets: VLT, Spitzer, SMA, ALMA, Keck

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 0.1, 5, mJy, M

3.4- Target size: point source

3.5- Number of targets: 10

3.6- Density of targets: N/A

3.7- Target coordinates: RA:3 - 16;Dec:-77 - +30

3.8- Moving target?: no

3.9- Variable target?: yes, 2 per year

3.10- Target type: exoplanet

4.1- Spatial resolution: diffraction, 2.5

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 4600 - 4800, M

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 3, 5, Median Paranal-type conditions

7.2- Longest continuous observation time on a target or field: 5

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 75

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: yes, The observations have to be timed to optimize the Doppler shift relative to telluric lines.

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, Detections of protoplanet candidates with ALMA should be followed up with E-ELT line imaging to confirm the presence of a dynamical, compact body.

9.2- Critical aspects / limiting factors for the science case:
An IFU for METIS is critical, as is high spectral resolution (R~50,000) to be able to kinematically resolve the lines from the targeted protoplanets. Diffraction limited imaging at 4.7 micron is needed to optimize contrast.

9.3- Detailed description or other comments:
Circumplanetary disks as signposts of protoplanets

While a zoo of exo-solar planets have been identified, no planet still in the process of forming within a protoplanetary disk has been found. An important goal for the future will clearly be to search for such protoplanets in order to understand the assembly and evolution of (exo) planetary systems.
Forming giant planets of 1 MJup or more are expected to be surrounded by flattened disks as gas and dust accretes from their parent gas-rich protoplanetary disk to the surface of the young planet (Machida et al. 2008, Ayliffe et al. 2009).
The Jovian moon system is clearly an example of the product of a circumplanetary disk that must have had a size

of at least 0.2-0.3 AU2. Circumplanetary disks are important targets for several reasons. First, they may act as signposts for the the presence of a forming giant planet. Second, their existence predicates the formation of moon systems such as that orbiting Jupiter. In the Solar System three out of four worlds believed to have liquid water are moons; Europa, Ganymede and Enceladus, the fourth being Earth. Hence moon systems surrounding giant planets may be at least as fertile for the development of life as terrestrial planets. Young giant planets are warm and luminous, relative to older planets (up to 10-3 Lsol, Chabrier et al. 2007). The circumplanetary disk will be heated both by accretion as well as by passive irradition from the protoplanet and central star. In analogy with the protoplanetary disk in which the circumplanetary disk is embedded, molecular line emission will be an important cooling process. It is therefore expected that circumplanetary disks should be characterized by molecular emission lines. The high spatial and spectral resolution of METIS, combined with its exceptional sensitivity may:
1) allow the detection of molecular line emission from circumplanetary disks at the 0.1-5 mJy level,
2) identify the line emission as coming from a disk surrounding a low mass compact object via the dynamical signature present in spectrally resolved line emission, and
3) begin to reveal the nature and chemistry of forming moon systems around exo-planets.

We propose a deep search for he infrared molecular line emission (primarily, the CO ro-vibrational fundamental at 4.7 micron) from circumplanetary disks in 10 known transition disks with METIS. Transition disks are protoplanetary disks with cleared-out optically thin inner disks, suggesting that they may already have formed one or more giant planets. If the cleared-out inner regions are indeed formed by dynamical clearing by a planet, their sizes are related to the semimajor axes of the putative protoplanets, allowing a strict selection of targets most likely to yield direct imaging detections of protoplanets.

Feasibility

Preliminary radiative transfer models of passively irradiated disks indicate that the ratio of infrared line flux from CO and H2O relative to stellar luminosity is roughly constant down to the regime of young brown dwarfs and protoplanets (see also van Boekel, E-ELT METIS DRSP and Pontoppidan et al. 2009, ApJ, submitted).
Hence one would expect a peak CO 4.7 micron ro-vibrational line flux from 0.1 up to a few mJy for disk surrounding an L=10-3 Lsol protoplanet (similar values are obtained for rotational H2O lines in the N-band, see Pontoppidan et al., E-ELT METIS DRSP). This prediction could be considered a lower limit

if accretion heating from infall onto the central protoplanet is included. Given the expected 5 sigma sensitivity of E-ELT METIS of 0.8 mJy in 1 hour, a deep exposure of 5 hours yields a S/N of 13 per spectral resolution
element at R=100,000. Rebinning down to R=20,000, which should still allow circumplanetary disk lines to be spectrally resolved,
enables peak line fluxes of 0.1 mJy to be detected at the 4 sigma level. Finally, the CO ro-vibrational band consists of
a large number of closely spaced, nearly identical lines, a property that has been used in the past to significantly improve the S/N of spectro-astrometric observations with VLT-CRIRES (Pontoppidan et al. 2008).
The planned instantaneous spectral coverage of METIS will permit the simultaneous observation of 4-8 12CO lines.
By stacking all observed lines, a further improvement in sensitivity of 2-3 can be expected.

Why a line imaging search for circumplanetary disks rather than a more sensitive search using the continuum emission from the protoplanet itself?
Even at the high spatial resolution of the ELT, it may be difficult to clearly separate a continuum point source from the rest of the disk emission. An example of this difficulty can be seen in Greaves et al. 2008. A spectrally resolved emission line from a point source offset from the central star has several favorable properties:

1) It will allow efficient, high-contrast subtraction of continuum emission speckles by simply subtracting the simultaneous continuum image obtained next to the line with a typical IFU. The required contrast
levels are a modest, ~1:103.

2) Detected, spectrally resolved, lines can unambiguously be associated with a compact object via its
kinematic (Keplerian) signature. Further, the average velocity shift of a circumplanetary disk line should vary with the orbital phase of the protoplanet.

3) Protoplanet candidates detected through other means should still be targeted with METIS line imaging to confirm their status and to search for the signatures of forming moon systems and to constrain planet-disk interaction models.

We therefore propose a survey of ~10 disks with large inner dust gaps, corresponding to large protoplanet semimajor axes.
Targets will include sources with dust gaps of sizes 10-40 AU, likely corresponding to planet semimajor axes of
6-20 AU, or 2-7 x 1.22lambda/D at 100 pc. The target list could include TW Hya, SR21, HD135344, LkHa330, T Cha, LkCa 15, UX Tau, GM Aur and HD 141569A. (e.g., Brown et al. 2007, Pontoppidan et al. 2008, Eisner et al. 2009).

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1.1- Project Title: Resolving Solar System Minor Bodies with AO Imaging

1.2- Project Category: 3

1.3- Abstract:
We propose diffraction limited imaging of Solar System minor bodies, which will give us information on their formation and evolution. The E-ELT can resolve the shapes of small near Earth asteroids that have undergone significant evolution and map the surfaces of a significant number of asteroids in the main belt and large Kuiper Belt objects. It will also be able to detect satellites around all of these objects, giving access to a wealth of physical information.

1.4- Publication agreement: yes

2.1- PI: Colin Snodgrass

2.2- CoIs: Benoit Carry, Alan Fitzsimmons, Christophe Dumas

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: postdoc

2.6- E-mail: csnodgra@eso.org

3.1- Source of targets: New moving object surveys, Pan-STARRS, LSST etc.

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 12, 21, Vegamag, V

3.4- Target size: extended source, 10, 1000

3.5- Number of targets: 50

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: yes, 180

3.9- Variable target?: yes, 4 per hour

3.10- Target type: solar system body

4.1- Spatial resolution: diffraction, 5

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: J, H, K

5.2- Spectral Resolution: bbimaging

6.1- Instrument: MICADO, EPICS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.01, 8, brightness critically depends on angular size of object (resolved vs point with satellite), physical size and distance. Conditions not as important as quality of AO in determining the brightness. Mostly very short exposures, but objects need to be followed over a few hours timescale for either mapping as they rotate or satellite orbit determination. Need not be continuous.

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 260

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 5

7.6- Are the observations time critical?: yes, Best results at closest approach of objects

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8.1- Does the execution of observations require real-time decisions?: yes, objects are moving. for binaries, strategy changes depending on detection of companion or not in first images., N/A

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: other, NTT. Physical studies of these bodies that do not require the spatial resolution of the E-ELT (light-curves, colours, spectra) require 4m class telescopes.

9.2- Critical aspects / limiting factors for the science case:
Full AO while tracking moving (Solar System) objects.

9.3- Detailed description or other comments:
The minor bodies of the Solar System (asteroids, comets, distant icy bodies) are remnants of the formation of our planetary system, and thus provide essential clues to the 3rd Astronet science question - what is the origin of planetary systems?. We propose to measure four properties that provide particularly strong constraints on the formation and evolution of these bodies: Their sizes, shapes, surface features and the fraction that have satellites. Additionally, studies of those found to be binary objects provide detailed physical information namely the mass of the system from orbits and density from combination of this with the precise size measurement. All of this information can be directly measured from resolved imaging without any assumptions.

The most detailed imaging is best done by visiting objects with spacecraft, however the cost is similar to the whole E-ELT project to study a single object. With the current 8-10m class telescopes and AO a resolution of about 50km is possible in the main asteroid belt; enough to produce maps of large scale albedo variations on the few very largest asteroids. The E-ELT will have around 10km resolution in the main belt, meaning that 60,000 asteroids will be resolved, approximately 20,000 can be mapped with 50-100 resolution elements across their surfaces and around 50 will be mappable with the same (~3000 elements) resolution as Ceres is now (Carry et al 2008, A&A 478, 325); it will be possible to see what large scale features are unique to certain bodies (eg the very large craters on Vesta and Mathilde) and how much variation is typical for asteroids. For smaller objects the overall shape of bodies even marginal resolution (diameter > PSF) has great value: it gives a direct g
eometrical measure of the size of the objects without having to either assume albedo or measure the thermal flux and apply models. The resulting assumption free size distribution of minor bodies strongly constrains models of Solar System formation. In the other major populations the E-ELT can resolve sub-km Near Earth Objects (at 0.1 AU in H-band ELT can resolve 0.7km) and at Kuiper Belt distances it will be able to map the largest bodies (eg Haumea, which is thought to have a very elongated shape and a dark red spot, both of which could be directly observed).

Resolved imaging is also the quickest way to find asteroid satellites in the main belt and has successfully detected binaries in the Kuiper Belt. Again, the E-ELT will enable us to push to fainter bodies in these populations, accessing smaller primaries and satellites. With good AO correction it is possible to find companions down to a few tenths of the mass of the primary. Given exceptionally favourable circumstances (very close pass) this has also been possible for one near Earth object with current 8-10m telescopes. Binaries are a particularly interesting prospect in near Earth space as it has been found that ~15% of NEOs are binaries (Margot et al., Science 296, 1445-1448, 2002, Pravec et al., Icarus 181, 63-69, 2006), much larger than the fraction in the main-belt (Merline et al., In Asteroids III, 289, 2002). It is now believed that this is directly due to the spinning up of asteroids by sunlight - the YORP effect (Lowry et al., Science 316, 272-274, 2007). Evidence su pporting this is the short timescale required to significantly spin-up NEOs and that many NEO binaries contain a total angular momentum equivalent to a single original body rotating near the strengthless centrifugal limit (Pravec & Harris, Icarus 190, 250-259, 2007). Modelling predicts that this will lead to significant shape change and splitting (Walsh et al. Nature 454, 188-191, 2008), although this may also happen during planetary close approaches (Bottke & Melosh, Nature 381, 51-53, 1996). While currently radar observations lead the way in discovering NEO binaries they are limited to close passes (< 0.05 AU) and depend on the continuing operation of facilities like Arecibo, and only rarely allow extended observations to measure orbits. E-ELT will be able to detect even close binaries within a much larger area of near Earth space, allowing significant numbers to be studied to investigate the evolution of asteroids under the influence of YORP and planetary encounters.

The implications for the design of the E-ELT to enable this science are clear: the E-ELT must be able to track the fastest moving Solar System bodies (Near Earth Asteroids, with rates up to 0.05"/sec) while still providing full AO capabilities.

The total time includes time to achieve observations of N objects from each of the following classes, all of which could be separate programmes and could be shorter (individual interesting objects instead of statistics), and could also be large programmes in their own right:

-Shapes and binarity of small Near Earth Objects (N~20).
-Surface maps of medium to large asteroids (N~20) .
-Shapes/maps of largest Kuiper Belt objects (N~10).

1.1- Project Title: Seeking the Progenitors of Type Ia SNe

1.2- Project Category: 1

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1.3- Abstract:
Due to their enormous luminosities and their homogeneity, Type Ia Type Ia SNe have been used in cosmology as standard candles, with the ambitious aim of tracing the evolution of the universe. Despite the progress made in this field, the nature of the progenitor stars and the physics which governs these powerful explosions are still uncertain. To address this long standing problem, we propose to obtain E-ELT multi-epoch, high-resolution, optical spectroscopy of relatively nearby Type Ia SN/e (v(r)<10,000 km/s). Through the study of time evolution of narrow absorption features originating in the circumstellar environment of the exploding star, we will be able to put stringent constraints on the progenitor""""s nature and to probe the existence of multiple channels to Type Ia explosion.

1.4- Publication agreement: yes

2.1- PI: Nando Patat

2.2- CoIs: S. Benetti, E. Cappellaro, N. Cox, A. Renzini, C. Wolf, P. Podsiadlowski, L. Pasquini, M. Turatto, P. Chandra, R. Chevalier, A. Pastorello, N. Elias-Rosa, W. Hillebrandt, S. Justham

2.3- Institute: E.S.O.

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: fpatat@eso.org

3.1- Source of targets: External SN searches

3.2- Preparatory work on targets required?: yes, SN discovery by external SN searches

3.3- Target brightness: 14.5, 20.0, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 20

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per week

3.10- Target type: SN

4.1- Spatial resolution: seeing, 4

4.2- Field-of-view: fiber

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 380 - 680

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: CODEX

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.2, 4, seeing 0.8, airmass 1.5

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 600

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: yes, OBs need to be triggered in ToO mode. Late epochs could be done in scheduled time.

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: yes, 240

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:

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Optical (>390nm) high-resolution spectroscopy must be available

9.3- Detailed description or other comments:
Pilot observations, run with 8m-class telescopes, have shown not only that what we propose is feasible, but
that indeed dramatic changes take place during the first month of the SN evolution, following the variation of the UV photo-ionizing flux produced by the SN itself. This has led to the first direct detections of CSM in Type Ia SNe, giving unprecedented information about the progenitor system, whose nature is still under debate. However, 8m-class telescope pose two strong limitations: A) on average there is only one feasible target per semester (V<14); B) the spectroscopic follow-up is limited to the first two months (a Ia fades by 3 mags during the first 2 months). The much larger E-ELT area will allow us to significantly increase the sample in a reasonable amount fo time, and to follow the closer events for at least 4 months. This will enable a more detailed and extended analysis of the CS environment.
Moreover, it will be possible to observe very early discovered Ia at phases close to the explosion time, something which is now impossible due to the limited collecting area. This is fundamental, because observations done during those very early epochs will reveal the immediate surroundings of the progenitors.

1.1- Project Title: Probing the Properties of the First Galaxies In the Universe with ELT

1.2- Project Category: 2

1.3- Abstract:
Probing the properties of the first galaxies that formed in the Universe is one of the key extra-galactic science drivers for ELT. In this proposal, we set out some of the main objectives for detailed follow-up spectroscopy of the first galaxies with ELT/EAGLE.

1.4- Publication agreement: yes

2.1- PI: Mark Swinbank

2.2- CoIs: Jean-Gabriel Cuby, Niraj Welikala, Simon Morris

2.3- Institute: Durham University

2.4- Country of Employment: UK

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2.5- Career Stage: postdoc

2.6- E-mail: a.m.swinbank@dur.ac.uk

3.1- Source of targets: e.g. JWST, VLT, VISTA

3.2- Preparatory work on targets required?: yes, optical/near-IR wide, deep surveys

3.3- Target brightness: 25, 30, ABmag, J

3.4- Target size: extended source, 10, 500

3.5- Number of targets: 500

3.6- Density of targets: 1

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: N/A

4.1- Spatial resolution: 75, 37.5

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: 25, 5x5arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: 800 - 2500

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: EAGLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: MOAO

7.1- Integration time per target or field and per setup: 20, 50, seeing<0.6", GLAO

7.2- Longest continuous observation time on a target or field: 4

7.3- Shortest integration time on a target or field: 3600

7.4- Total time: 1000

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
AO assisted, multi-deployable IFU with field of view ~5x5arcmins

9.3- Detailed description or other comments:
Background:

In the standard cosmological framework, bound halos of dark matter form from the gravitational collapse of the primordial perturbations in the initial dark matter density distribution. Cooling is very efficient on galaxy scales and gas quickly loses pressure support and collapses to the center where it cools further to form the first stars and galaxies. Gaining an inventory of the basic properties of the first galaxies between z~20 to the end of reionisation, z~7, is one of the most important challenges in modern astronomy. Indeed, a complete inventory of the formation of the first stars, assembly of the first galaxies and the growth of super-massive black holes through gas accretion is key to building a complete census of the star-formation and quasar activity responsible for reionisation. This requires analysis of the number density, mass (dynamical/stellar), clustering, star-formation rates, and their effect on their environment and will tell us when reionisation happened and what sort of galaxies were responsible (i.e. rare, but UV intense QSOs or less massive, ubiquitous star-forming galaxies).

Observational constraints on the properties of galaxies at z~7 are scarce, with only a handful of spectroscopically confirmed galaxies. Indeed, due to the faintness of these galaxies most of the studies are severely photon starved and so focus concentrates on confirming redshifts through identification of a single emission line (eg. Ly-alpha) and as such very little is known about their basic properties such as stellar and dynamical masses or stellar populations.

The only measurable quantity available today on 8-10 m telescopes at z~6 is Ly-alpha. The first order quantities that can be measured today, and will be in the forthcoming future, are the the Ly-alpha and UV LFs, with their respective evolutions with redshift allowing to draw constraints on the opacity of the IGM to Ly-alpha and therefore on the amount of ionised IGM vs. redshift (this is/will be in synergy with GRB, CMB, QSO, HI science, SWIFT, LOFAR, etc.). One can expect that the next decade will see continued efforts in unveiling the high-z Lyalpha LF, possibly up to z~8-9 (this is already happening). Deep imaging surveys with ground based telescopes (Micado, VLT, VISTA, Micado), and in particular, JWST - which is largely built for this science case - will provide large samples (presumably in the 1000"s) of galaxies at z>7. EAGLE will go ~1.5-2.0 mag fainter than JWST/NIRSpec. The anticipated strategy is that JWST will find the sources efficiently in imaging, and will do initial spectroscopy of candidates in a few fields selected for the availability of multi-wavelength data. EAGLE will follow-up these fields, after careful selection of the candidates from their photo and / or spectroscopy.

Detailed investigation into the intrinsic properties of the first light galaxies is likely to be gleaned from the continuum emission at wavelengths between lambda(rest)=1200-2000A. With the increased collecting area of a 42m telescope absorption lines such as SiIV, CIV will be mapped in detail (mapping the equivalent widths, line profiles and searching for damping). Moreover, emission lines such as HeII1640 might provide diagnostics of population III stars, with the line widths providing constraints on the mass of the underlying system.

ELT IFU spectroscopy of the first galaxies:

At z>7, near-infrared spectroscopy will cover the rest-frame UV and include the spectral features of Ly-alpha, NV1240, HeII1640, CIV1549,

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SiII1393,1402, SiII1260, OI1303, CIII1908 with Ly-alpha accessible to z=20 at 2.4um. Although low resolution spectroscopy can be used to derive redshifts, detailed physics of the galaxies will be derived from the line strengths and profiles of ISM lines such as SiIV, OI and CIV, necessitating high spectral resolution (R~5000). The identification of significant velocity offsets between UV ISM lines, Ly-alpha and photospheric lines in galaxies at z~3 lead to the discovery that a large fraction of star-forming galaxies at z~3 are surrounded by superwinds -- feedback processes which are thought to be the dominant mechanism which expel baryons from galaxies at these early times. The likely shallower potential wells of galaxies at z>7 means that outflows from high redshift galaxies could have both cleared material from the galaxy and surroundings allowing ionizing photons to escape as well as enriching the inter galactic medium (IGM). Through this mechanism problems of how the IGM was re-ionized and enriched in metals even at the highest redshifts (the so-called pre-enrichment problem) could be solved. Resolved spectroscopy of the first galaxies affords the opportunity to probe the geometry and sizes of the outflows and infer the mass-outflow rates. Moreover, the equivalent widths of the absorption lines between 1100 and 2000A (rest-frame) can also be used to investigate the enrichment of the ISM from supernovae, (the metal abundances from O, Mg, Si, P and S). Together with the heavier metal abundance absorption lines, such as N, Fe, Mn and Ni, these can be used to test the star-formation history of the galaxy and probe the stellar populations.

However, it is also worth noting that for galaxies at these very early times, the spectral differences may be very different than those in galaxies at z=3-5. For low metallicity the temperature of the ISM may be much higher due to the lack of coolants and so the high ionisation species (NIV, CIV and HeII) may be much stronger. Importantly, in the era of ALMA and JWST these galaxies can also be observed in the mid-infrared and sub-mm, searching for the underlying cold (and dense) molecular gas and the star-forming regions.

Using spectroscopy around the rest-frame UV continuum with EAGLE, example questions that will be addressed are:

1. What is the ubiquity of the first galaxies and when did the first galaxies "switch on"?

2. What were the stellar populations and stellar masses of the first galaxies and what was their role in reionisation?

3. What is the relative contribution of Population II and Population III (i.e. primordial stars) at early times?

4. What is the interaction between star-formation and gas dynamics within the first galaxies?

5. What are the velocity structures and geometries of the outflows and ionised "bubbles" around the first galaxies?

6. Are the outflows sufficiently metal rich to account for the ``pre-enrichment problem''"?

7. How rapidly did reionisation occur?

8. What physical processes governed the luminosity and mass evolution of the first galaxies, and how did these evolve into more massive systems already charted at lower redshifts?

9. What was the initial mass function within the first galaxies?

10. What structures did the first galaxies form in?

Ubiquity and detectability of the first galaxies:

Galaxies at these early times are faint: there is a strong evolution in the surface density of galaxies as a function of redshift (eg. for a fixed magnitude of m(AB)=28 the surface density of UV-selected lyman-break galaxies at z=6 is a factor 5-10x lower than z=3), suggesting that the surface density of galaxies above z=7 is likely even lower. As such, long integrations will be necessary and there is therefore a need for wide field, multiple deployable integral field spectroscopy in order to efficiently follow-up candidates selected from deep imaging surveys.

In the field, the space density of UV bright galaxies at z=7--10 with m(AB)=28 is estimated to be of the order 1 per square arcminute - significantly lower than the space density of similarly luminous star-forming galaxies at z=5-6 (5-10 per sq. arcmin for z(AB)=28). This indicates a decline in the star formation activity of luminous Lyman-break galaxies out to z~7-10. This scenario has also found supported by estimates of the faint end slope of the star-forming luminosity function at z~6. Even based on pessimistic space densities of 0.2 galaxies per sq arc minute, ultra-deep imaging with JWST or ELT should identify z~10 candidates over large areas and to very faint magnitudes (m(AB)=30 in 1 band).

To estimate the expected space density of galaxies above z=7, we make use of theoretical predictions from Le Delliou et al. (2005, 2006). Although modeling emission and absorption lines from the first galaxies is difficult, models which fit the luminosity functions from z~5 to z~0 can be used to place crude constraints on those at higher redshift as a function of magnitude.

We use the ESO/ELT IC (v.2.7WG) to estimate the limiting magnitudes of sources for which continuum detections can be made. The faintness of these very high redshift galaxies will make continuum spectroscopy with EAGLE difficult without long exposures. As a baseline we have therefore assumed that a large program will use a 30-hour integration per setup in some of the best studied fields (eg with the deepest imaging and/or supporting data, such as the ECDFS or HDFN) to map the properties of the first galaxies. To build a sample of 200-1000 galaxies, overall, we would expect 30 sets of observations (each of ~30hrs in total), totaling (upto) 1000-hours.

For each setup, assuming a 30-hour exposure the ESO ITC suggests that a S/N=5--10 in continuum can be reached for a source with m(AB)=27 at moderate resolution (R=5000) [S/N=5 for an extended object with r_h=0.2"", J(AB)=27, pixel scale=50mas; R=5000, D=42m, GLAO, DIT=1800).

Le Delliou et al. (2005,2006) suggest that the expected space density of the galaxies which will be detected at 5-sigma between z=7.5-9.5 (500Mpc/h) is 0.5+/-0.2 per square arcminute (depending on cosmic variance). With the EAGLE field of view (25-100arcmin2), this will provide ~25 targets, which, after accounting for the atmospheric windows and OH lines leaves ~15 objects at well selected redshifts for efficient follow-up -- ideally matched to EAGLE"s proposed multiplex capability. On these scales sufficient area and volume will allow studies of large scale structure, clustering and cosmic variance on comoving scales of ~5-10Mpc/h at z~8. With angular resolution ~0.1"", 10-20 angular resolution elements across each of the targets will probe the spatially resolved populations within the galaxy, interaction with close neighbours and mergers (many of the LBGs detected at z=5-6 show multiple components or companions of 1-2"" scales in projection). Constraining stellar populations between multiple components/merging systems provides a route to constraining the dynamical masses and stellar mass-to-light ratios of these

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galaxies. Clearly, brightest and most extended spectroscopically confirmed systems will be key targets for further diffraction limited integral field spectroscopy.

1.1- Project Title: Constraining the progenitor models of long-duration gamma-ray bursts

1.2- Project Category: 3

1.3- Abstract:
We propose to probe Wolf-Rayet wind geometries at very low metallicity (1/5 Zsun) to constrain progenitor models of long-duration gamma-ray bursts (GRBs). The favoured progenitors of these GRBs are rapidly rotating Wolf Rayet stars, but stellar winds are expected to remove the angular momentum required for jet formation in the collapsar model. According to our recent VLT linear spectropolarimetry survey, most Wolf-Rayet stars in the 1/2 Zsun environment of the Large Magellanic Cloud (LMC) are rotating equally slowly as those in the Galaxy, which poses a challenge to progenitor models at metallicities larger than 1/2 Zsun. Observations of GRBs however suggest a metallicity threshold that is below that of the LMC. Here we propose to perform a unique study of the very low metallicity environment of the Small Magellanic Cloud (SMC with Z of 1/5 Zsun), with the aim of constraining GRB progenitor models in the critical metallicity range between 1/5 and 1/2 Zsun, with crucial impl
ications for understanding the production of GRBs at low metallicity at high redshift.

1.4- Publication agreement: yes

2.1- PI: Jorick S Vink

2.2- CoIs: Chris Evans, Norbert Langer, Tim Harries, Alex de Koter, Ian Howarth, Jacco van Loon, Hugues Sana, Artemio Herrero, and the VLT/Flames consortium of Massive Stars

2.3- Institute: Armagh Observatory

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: jsv@arm.ac.uk

3.1- Source of targets: CTIO (Massey & Duffy 2001, Massey et al. 2003)

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 11, 16, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 12

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: longslit

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 400 - 700

5.2- Spectral Resolution: 10000-20000

6.1- Instrument: other, any, for WRs B/V range is best, but it could also be done at longer (e.g. NIR) wavelengths

6.2- Desired special mode: polarimetry, N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.1, 1, N/A

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 10

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7.4- Total time: 8

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 90

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: yes, the emission lines should not saturate, N/A

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
the critical aspect is the availability of a spectropolarimeter

9.3- Detailed description or other comments:
Evidence has been accumulating that long-duration gamma-ray bursts (GRBs) are associated with the death of massive stars at low metallicity (see Woosley & Bloom 2006). The next step of the puzzle is to constrain the progenitors of these intriguing events. This is important for our understanding of massive star evolution, mechanical and chemical feedback in star-forming galaxies, including
those at very high redshifts that contain the first generations of massive stars.

The currently most popular model is the so-called ``collapsar model"""" of Woosley (1993), where a rapidly rotating star collapses to a black hole. This progenitor star is likely a hydrogen-free Wolf-Rayet (WR) star (e.g. Mirabal et al. 2003), but it is currently unclear whether such an object is the result of single star (Yoon & Langer 2005, Woosley & Heger 2006) or binary evolution (Wolf & Podsiadlowski 2007, Cantiello et al. 2007).

In both scenarios, the crucial aspect of low metallicity is the reduced amount of angular momentum loss due to weaker stellar winds at low metal content. A recent breakthrough in the metallicity dependence of stellar winds from massive stars has been the finding that WR winds are expected to scale with the metal content (Z) of the host galaxy (Vink & de Koter 2005), and *not* on self-enrichment of metals, as was previously often assumed (e.g. Maeder & Meynet 2003).

The time is ripe to test the physical criteria of the progenitor of the collapsar model empirically. If the WR mass-loss metallicity dependence and the subsequent inhibition of angular momentum removal are indeed the *key* to explain the predominant occurrence of GRBs at low Z, WR stars at low Z should be rotating more rapidly than in the Galaxy. The classical method of v sin(i) measurements from absorption lines does not work for WR stars, because of their broad emission lines. However, there is an alternative: ``linear spectropolarimetry''''''.

Linear spectropolarimetry is a powerful tool to measure wind asymmetry and it works in the following manner: the continuum light is polarised by Thomson scattering off free electrons. In the case of a spherical wind polarised photons from all parts of the wind cancel, and there is no net polarisation signal. In the case where the wind departs from spherical symmetry, a net continuum polarisation will be observed. By contrast, line photons are formed over a larger volume and scatter and polarise less than the continuum photons. As a result, the line becomes *depolarised* with respect to the continuum -- if the wind is asymmetric.
This is called the ``line effect'''''' (see Vink 2007 for example WR stars).

The method has been used extensively for rapidly rotating Be stars. Poeckert & Marlborough (1978) found ``line effects'''''' in
60% of Be stars, which is due to the random orientation of rotational axes -- the sin i effect -- consistent with *all* Be stars having
disk-like outflows induced by rapid rotation. In a similar vein, Harries et al. (1998) performed a linear spectropolarimetry survey on a sample of Galactic WR stars and they found ``line effects'''''' in just 15% of them. This implied that not all Galactic WR stars have significant asymmetric outflow, but only a small fraction of them. The best-fitting results (using both Kolmogorov-Smirnov tests and Monte Carlo simulations) of the Harries et al. sample were obtained if the majority of Galactic objects were spherically symmetric slow rotators, whilst the 15-20% minority represent the more rapid rotators with large intrinsic polarizations (with values exceeding 0.3%). Harries et al. concluded that the inferred axi-symmetries are only present for the most rapidly rotating WR stars in the Galaxy.

We performed a VLT linear spectropolarimetry survey of WR stars in the low Z environment of the Large Magellanic Cloud (LMC) and found that only 15% of LMC WR stars show the sign of rapid rotation, as only 2 out of 13 of them show a significant amount of linear polarisation - an incidence rate equal to that of the Galactic WR survey by Harries et al. (1998). The current datasets suggest that the metal content of the Galaxy (Zsun) and the LMC (1/2 Zsun) is high enough for winds to remove the angular momentum and progenitor models may be constrained to an upper metallicity of that of the LMC (1/2 Zsun).

To further constrain GRB progenitor models, we propose to perform a *complete* survey of Small Magellanic Cloud (SMC) WR stars at Z 1/5 Zsun. Our proposed observations will allow us *for the very first time* to constrain GRB progenitor models in the critical metallicity range 1/2 -- 1/5 Zsun. Because the SMC objects are significantly fainter than those in the LMC, we require the larger collecting area of an ELT.

We wish to establish the differences in wind asymmetries between the Galaxy, the LMC, and the SMC. The HeII line at 4686 A is present in both nitrogen-rich and carbon-rich targets, whilst several other strong emission lines are also observed. We will measure the fraction of line effects in comparison to the Galactic and LMC samples, and for individual objects, we measure the density contrast between the pole and the equator from the inferred level of polarisation (Brown & McLean 1977).

Future ELT work will involve a complete census of all evolved massive supernova progenitors (incl. B[e] Supergiants, Luminous Blue Variables) in both the LMC and SMC to map the links between mass loss and rotation in the most massive stars.

If the spectral resolution of the ELT spectropolarimeter is high enough (comparable to CFHT/ ESpandons), we perform complementary circular spectropolarimetry to measure magnetic fields in low Z massive stars to study the intricate interplay between mass loss, rotation, and magnetic fields, as to constrain massive star models as a function of Z, with unique constraints on models of GRBs and Pair-Instability SNe in the early Universe (see Langer et al. 2007).

1.1- Project Title: Accretion processes in the Galactic Center at the parsec scale

1.2- Project Category: 1

1.3- Abstract:
The Centre of mass of the Galaxy is marked by a supermassive black-hole, Sgr A*. It is surrounded by a parsec-scale cluster of late type stars containing a significant number of massive, young stars. This cluster is surrounded by a ring of molecular clouds, the Circumnuclear Disk, and immersed in a complex of ionised gas, Sgr A West. It is not clear how gas accretion proceeds from large scales to sub-parsec scales. We want to use imaging and spectro-imaging to study the dynamics of the Circumnuclear disk and Sgr A West and their interaction to better constrain those processes.

1.4- Publication agreement: yes

2.1- PI: Thibaut Paumard

2.2- CoIs: Yann Clénet, Guy Perrin, Matt Lehnert, Chris Evans, The EAGLE team

2.3- Institute: LESIA/CNRS – Observatoire de Paris

2.4- Country of Employment: FR

2.5- Career Stage: faculty

2.6- E-mail: thibaut.paumard@obspm.fr

3.1- Source of targets: VLA

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 10, 18, Vegamag, K

3.4- Target size: extended source, 120000, 120000

3.5- Number of targets: 1

3.6- Density of targets: N/A

3.7- Target coordinates: RA:17 - 18;Dec:-30 - -28

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per year

3.10- Target type: ISM

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 2x2arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 1, 1200

5.1- Wavelength range: 2165 - 2175, 2117 - 2127, K, N

5.2- Spectral Resolution: bbimaging, nbimaging, 10000-20000

6.1- Instrument: EAGLE, MICADO, METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.1, 2, scaling from existing SINFONI, NACO and VISIR data

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 1

7.4- Total time: 40

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, 50000

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
Concerning the spectro-imaging (EAGLE) data, the spectral resolution must be sufficient (R>10000) to disentangle the various gas clouds on the line of sight. Spatial resolution in the spectro-imaging (EAGLE) data is important, in particular to remove stellar features. It does not need to be diffraction-limited though: a spatial resolution of 100mas is sufficient. The total field of view is quite extended but does not need to be completely filled since the object is of annular shape.

On the other hand, spatial resolution of the imaging data must be the best achievable (i.e. diffraction-limited). This is necessary to measure proper motion of gas filaments with a high precision.

9.3- Detailed description or other comments:
The Circumnuclear Disk (CND) is a torus-like structure with inner radius 2 pc and outer radius 7 pc. It is fairly clumpy with a significant but low inclination to the Galactic plane (roughly 10°). It surrounds a central cavity which contains both the Sgr A West HII region and the central star cluster.

Sgr A West is also known as the Minispiral because it has (in projection) the aspect of a three-armed spiral. It is not, however, a true spiral in three dimensions: it is composed of several non-coplanar gas flows which orbit the central black hole Sgr A*. It is possible that those flows – or at least the main stream, called Northern Arm – originate in the CND.

The star cluster consists essentially of late-type star, but is famous for holding one of the largest concentration of massive, short-lived stars in the Galaxy. Those early type stars are located in one (or two) geometrical disks and were formed in a burst a few million years ago. Several concurrent, reasonable scenarios exist to explain the formation of these stars. One of those, currently favoured,

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speculates the existence of a massive gas disk in the central parsec a few million years ago. This disk was able to reach self-gravity, fragment into proto-stars and form star. In this scenario, it appears very clearly that star formation in the vicinity of a supermassive black-hole is inherently linked with accretion onto the black-hole itself.

To investigate this scenario, we need to understand how galactic molecular gas can lose angular momentum in order to accumulate in the central cavity. For this reason, we want to understand the dynamics of the CND and of the Minispiral. An important question is whether the Northern Arm is a former clump of the CND which would have fallen into the central cavity. Could the CND at some point in the future shrink into a massive, self-gravitating accretion disk?

High (spectral) resolution spectro-imaging in the K band is of particular interest for this purpose. The BEAR instrument on CFHT has been used already with great success to understand the structure and kinematics of the Minispiral at seeing-limited spatial resolution. There is however currently no instrument able to further this study, or even to reproduce it. EAGLE on the E-ELT on the other hand is very promising in this respect.

A high-enough spectral resolution ($R \geq 10000$) is an absolute necessity for this science program. Indeed, the various individual gas clouds which form the Minispiral and CND differ by only a few 10 km/s in velocity and are often superimposed on the line-of-sight.

A fairly large band (which BEAR did not have) is also required, in order to be able to observe ionised lines, as found in the Minispiral, and molecular lines, emitted in the CND, simultaneously. The K band happens to contain lines emitted by each of the two objects.

In addition, the total field of view is quite large (about 2’x2’). Ideally, one would like to sample this entire field at the best possible spatial resolution. This is not a requirement however for our science case. Indeed, only much smaller regions are at first mandatory to study the link between CND and Northern Arm. The interesting field follows the shape of the inner edge of the ring, and of the spiral. The void regions are a priori less interesting for this project. The gas features being extended, good radial velocities can be derived also with degraded spatial resolution, even though higher resolution would naturally entail more details.

In this respect, a multi-object instrument such as EAGLE can be used in a very effective manner: it is possible to organise the IFUs to follow the shape of the field of view of interest, without “losing” pixels on void regions. Indeed, to cover the entire 2’x2’ field using 20 IFUs of 2”x2” each, one would need 180 non-redundant pointings, whereas the interface between the CND and the Minispiral can be mapped with only 20 individual pointings. Therefore, although we might want to cover the entire field over the years, scientific results can be obtained with the first 10% of data.

The fairly low-spatial-resolution spectro-imaging data need to be complemented with wide-field, high-resolution MICADO images. Those images, taken through narrow-band filters corresponding to both ionised and molecular lines, will help register the spectro-imaging cubes. In addition, repeated imaging observations will provide tangential velocities to complement the radial

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information obtained with EAGLE. Deriving accurate tangential velocities require high spatial resolution.

However, the field at K-band is crowded with stars. This is not the case at mid-infrared, where the dust emission from the Minispiral is clearly visible. In addition to narrow-band imaging at K, we therefore foresee wide-band imaging at N. The mid-infrared data will help determine tangential velocities, but cannot replace the near-infrared images, taken in the same lines as the spectro-imaging data.

1.1- Project Title: Characterizing ULIRGs, and their influence and relationship to the inter-galactic medium

1.2- Project Category: 2

1.3- Abstract:
We describe how the use of the ELT (OPTIMOS and EAGLE) can facilitate a 3D mapping of the IGM in the vicinity of the extreme, starbursting ULIRGs at high redshifts, and at the same time provide detailed characterization of the ULIRGs themselves which is not possible with any other facility. These studies will address how ULIRGs influence and are fueled by their surroundings. Studying these extreme environments will help to better understand the role of luminous starbursts on galaxy evolution and characterize star formation at high redshift in general.

1.4- Publication agreement: yes

2.1- PI: Dr. Scott C. Chapman

2.2- CoIs: Dr. Ian Smail, Dr. Rob Ivison, Dr. Mark Swinbank

2.3- Institute: Institute of Astronomy, University of Cambridge

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: schapman@ast.cam.ac.uk

3.1- Source of targets: SCUBA(2), APEX-Laboca, UKIRT-UDS

3.2- Preparatory work on targets required?: yes, e.g. quasar/AGN radial velocity survey

3.3- Target brightness: 19, 23, Vegamag, R

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: 1

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: AGN

4.1- Spatial resolution: 100, 2

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 50, 60

5.1- Wavelength range: R, K, H, J, U, B, V

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: EAGLE, OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 5, 10, seeing, airmass, lunar phase

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 600

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7.4- Total time: 40

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
spectral resolution, spatial resolution (for quasar tomography)

9.3- Detailed description or other comments:
Simulations of the distribution of baryons in the Universe predict that much material is spread out in a ``cosmic web'''''' between the galaxies, groups and larger structures visible in conventional surveys. To probe this material and investigate its 3-dimensional distribution we must exploit QSOs as bright background sources to trace the web through their absorption. The main components of the web are the Lyα forest, which traces highly ionized hydrogen of low column density and low chemical enrichment distributed through the lower density regions, and metal absorption lines which trace massive galaxy halos (and hence higher density regions) via their metal-enriched gas.

Galaxies and AGN are responsible for maintaining the high ionization state of the IGM at redshifts 2--3, and for enriching the IGM with metals via strong supernova or AGN-driven outflows or "superwinds". Conversely, the physical conditions in the IGM are uniquely sensitive to the physics of the SNe and AGN feedback which is now believed to regulate the evolution of galaxies, particularly during the cosmic epoch when star formation and black hole accretion were at their highest. If the IGM were undisturbed by the galaxy formation process, and it were simply gas sitting in relatively low-contrast over-densities photoionized by a uniform UV background, then it would represent a very precise (and unique) measure of the matter density power spectrum on small scales (e.g., Croft et al. 2002) because such small overdensities

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are still very close to linear at high redshifts. However, the assumption of an undisturbed medium may be a poor approximation to reality, and is certainly not appropriate close to the sites where galaxy formation is proceeding at its most violent (e.g., near the enormous supernova-driven winds from star forming galaxies and supermassive black hole accretion).

Spectroscopic redshift surveys of galaxies have allowed studies of the relationship between the diffuse intergalactic medium (IGM) and UV-selected star forming galaxies (LBGs and BXs) in the same volume (Adelberger et al. 2003,2005). One possible conclusion from these observations is that starburst-driven outflows are transporting significant enriched material to very large galactocentric distances, with much of it likely escaping the galaxies and polluting the IGM. Adelberger et al. (2005) have established a very strong link of moderate-to-high column density CIV systems to galaxies within ~100-200 kpc (proper) in a nearly one-to-one correspondence. Effects on the IGM beyond these radii are ambiguous because of galaxy spectroscopic incompleteness and the need for extremely sensitive QSO spectra.

Of course the presence of CIV does not by itself prove that outflows from the identified galaxies put the metals at large radii - in principle this could have happened from previous generations of powerful galaxies that inhabited the same volumes of space in the past: short-lived ultra-luminous infrared galaxies (ULIRGs) represent one obvious possibility.

ULIRGs could have particularly strong feedback effects on their more proximate neighbours. A well studied population of z~2.5 ULIRGs are the submm galaxies (SMGs -- Smail et al. 1997; Hughes et al. 1998; Chapman et al. 2005; Greve et al. 2005; Baugh et al. 2005, Pope et al. 2006), but high-z ULIRGs selected at other wavelengths are likely similar in many respects (e.g., Chapman et al. 2004, Desai et al. 2008, Dey et al. 2008, Casey et al. 2009). The superwinds from SMGs have been characterized with median velocities ~-600 km/s (Greve et al. 2005, Chapman et al. 2009), stronger than found in UV-selected galaxies, and consistent with their larger starbursts (>1000 Msun/yr). The lifetime of the luminous phase of SMGs is likely to be of order 100 Myr (Tacconi et al. 2006), but could be as short as 10 Myr in specific cases (Smail et al. 2003), corresponding to a light distance of 3 Mpc. Winds of 1000 km/s from long-dead SMGs could thus be common within a dense high-redshift environment, traveling over 1Mpc in 1Gyr. For every SMG there could be of order 10-100 expanding bubbles of enriched gas, sweeping up the IGM. This is an extreme picture, and one which conflicts with the interpretations of Adelberger et al. 2005, but one that should be tested via the detailed ULIRG-to-IGM relationship. Confirming a strong correlation with the IGM for ULIRGs would virtually eliminate the idea that winds from long-dead ULIRGs have any major effect on the IGM.

Measuring the precise relationship of ULIRGs and QSOs with the IGM will help to model their complex role in galaxy evolution. The ``sphere of influence"""" of superwinds from currently active ULIRGs can be studied by examining the physics of the nearby IGM -- its neutral hydrogen content, metallicity, and ionization state, and velocity, together with the same parameters for the ULIRGs themselves. Theoretical models of galaxy formation cannot treat the feedback process in enough detail to understand how it affects the properties of both the galaxies and the IGM; the energetics and extent of radiative and mechanical energy output by galaxies and AGN must be measured observationally.

Specific Proposal:

Addressing the detailed relations between ULIRGs and their surrounding IGM can simultaneously bridge pressing questions about the specific role of ULIRGs in galaxy formation, and broader issues of galaxy formation in general applicable to a wide range of luminosity classes.

. What are the primary drivers of galaxy-scale star formation during the epoch of galaxy formation (z~2-3) and what shuts it off?

. Is the mode of star formation (IMF, efficiency) similar to that found in the local Universe, or is it inherently different?

. How do feedback processes (star formation, AGN, supernovae) influence galaxy formation and the subsequent evolution of galaxies and the IGM?

. Does feedback from AGN play a leading or secondary role in regulating the galaxy formation process.

However, this is a study that necessarily requires the capabilities of an ELT-class facility. The ULIRG-IGM connection is a fundamentally 3D problem, requiring many lines of sight through the IGM in the vicinity of ULIRGs, which themselves are a relatively rare galaxy population even at z~2. QSOs bright enough for echelle observations on 8m-class telescopes (m<19) are very rare even near their peak at z~2.5. The ELT brings into reach a network of background beacons close enough to ULIRGs

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in projection that the winds and metallicity can be directly studied ULIRG by ULIRG.

At the same time, new longer wavelengths facilities will provide breakthroughs in identifying and characterizing ULIRGs at high-z, a necessary requirement (for their precise SFRs, gas, and dynamical masses) for understanding their interaction with the IGM. These include the SCUBA2 submillimetre camera on the JCMT, Herschel, and ALMA, providing surveys of 1000""s of very distant ULIRGs.

However even ALMA is blind to both warmer gas emission and the stellar emission in these galaxies whose structure, ages and dynamics are expected to provide unique tracers of the build-up of the spheroids. This opens up a second critical use of the ELT in characterizing the high-z ULIRGs in terms of the ionisation and metallicity of gas and the ages and masses of stars lie in the optical and near-infrared.

ELT""s order of magnitude improvement in sensitivity and superb spatial resolution will be pivotal in our understanding of ULIRGs and their connection with the IGM. OPTIMOS and EAGLE will deliver the combinations of wavelength, sensitivity, resolution, and multiplexing to accomplish all of these tasks.

1.1- Project Title: Transmission spectroscopy of transiting exoplanets

1.2- Project Category: 3

1.3- Abstract:

The balance between heating and cooling in hot Jupiters is governed by their atmospheres, so understanding the structure and evolution of these exoplanets requires good models for their atmospheres. The atmospheres of transiting hot Jupiters can be studied in some detail using transmission spectroscopy and other methods. Transmission spectroscopy has been applied to only a few systems to-date because it requires very high signal-to-noise. E-ELT will enable us to extend the technique to the large number of moderately bright transiting hot Jupiters being discovered by surveys such as WASP.

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1.4- Publication agreement: yes

2.1- PI: Pierre Maxted

2.2- CoIs: France Allard, Derek Homeier, Patricia Wood

2.3- Institute: Keele University

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: pflm@astro.keele.ac.uk

3.1- Source of targets: WASP, HATNet, TrES

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 8, 12, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 20

3.6- Density of targets: N/A

3.7- Target coordinates: l:0 - 360;b:+10 - +90, l:0 - 360;b:-10 - -90

3.8- Moving target?: no

3.9- Variable target?: yes, 4 per hour

3.10- Target type: exoplanet

4.1- Spatial resolution: seeing, 1

4.2- Field-of-view: fiber

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 380 - 700

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5.2- Spectral Resolution: 20000-50000

6.1- Instrument: CODEX

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 2, 4, continuous observation through a single transit

7.2- Longest continuous observation time on a target or field: 4

7.3- Shortest integration time on a target or field: 3600

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: yes, observations required through transit.

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, near real-time data quality information.

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
Stability of the instrument.

9.3- Detailed description or other comments:
Transiting hot Jupiters provide us with the opportunity to study the atmospheres of extra-solar planets in great detail. Transmission spectroscopy is a particularly effective technique that exploits the change in the apparent radius of the planet as a function of wavelength. At wavelengths where there is a strong opacity source in the atmosphere, the planet will appear larger by approximately one atmospheric scale-height. For a typical hot Jupiter this will result in an increase of about 0.01% in the depth of the transit at wavelengths where the hot Jupiter atmosphere is opaque. The small size of the

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effect has limited the exploitation of this technique to the two brightest known transiting hot Jupiters to-date - HD209458 and HD189733. We have recently obtained data with VLT for a third hot Jupiter system, WASP-17, which has a very low density and is moderately bright (V~11). The low density of this exoplanet results in a large atmospheric scale height, making it feasible to observe the excess absorption due to neutral sodium in its atmosphere. The sodium doublet is a particularly useful diagnostic because the range of opacity in the line puts constraints on the temperature-pressure profile in the atmosphere, e.g., the stratosphere in HD209458 can be seen directly in the shape of the sodium line profile seen in the HST transmission spectroscopy.

E-ELT will give us the opportunity to extend transmission spectroscopy to the large number of hot Jupiters in the magnitude range V=9-11 that are now being discovered by surveys such as WASP. This will enable us to explore how the structure of these planets"" atmospheres varies as a function of planet mass, host star type, orbital separation, etc. Direct measurements such as the detection of stratospheres in these planets"" atmospheres are essential if we are to understand why some hot Jupiters are much larger than predicted by models, and how the interactions between the planets"" atmospheres and tidal evolution of their orbits affect the lifetimes of these planets.

E-ELT will also enable us to explore the atmospheres of planets like HD209458, HD189733 and WASP-17 in much greater detail, e.g., to look for signatures of the (as yet) unknown opacity source at optical wavelengths that produces a stratosphere in HD209458.

1.1- Project Title: Cosmology with Distant Type Ia Supernovae

1.2- Project Category: 1

1.3- Abstract:

Type Ia Supernovae (SNeIa) provide the most direct evidence to date for the accelerating expansion of the Universe and hence for the existence of the mysterious Dark Energy driving this acceleration. Recent major investments in telescope time from both ground and space have increased the number of distant SNeIa useable for cosmology to several hundred. Whereas current SNeIa surveys are limited to z~1, ELT spectroscopy in combination with JWST imaging

could be used to construct a sample of spectroscopically-confirmed Type Ia SNe out to z~4. This increase in the time baseline over which the expansion history of the Universe is mapped would provide major improvements in the determination of the Dark Energy equation-of-state parameter and its rate of change with cosmic time, and would test for unexpected behaviour in the expansion history at early epochs.

1.4- Publication agreement: yes

2.1- PI: Isobel Hook

2.2- CoIs: Filippo Mannucci, William Taylor

2.3- Institute: University fof Oxford

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: imh@astro.ox.ac.uk

3.1- Source of targets: JWST (or ELT itself)

3.2- Preparatory work on targets required?: yes, simultaneous JWST (or possibly ELT) imaging survey

3.3- Target brightness: 23, 25, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: 50

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per millennium

3.10- Target type: SN

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 2x2arcsec

4.3- Multiplexity and pick-off FoV: 1, 2x2arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: 500 - 2400

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: HARMONI

6.2- Desired special mode: N/A

6.3- Desired AO mode: LTAO

7.1- Integration time per target or field and per setup: 0.25, 8, paranal-like site, seeing =0.8

7.2- Longest continuous observation time on a target or field: 8

7.3- Shortest integration time on a target or field: 120

7.4- Total time: 400

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: yes, SNe fade after about 1 week of maximum light

8.1- Does the execution of observations require real-time decisions?: yes, SNe are variable - magnitude not easy to predict so decision needs to be made about whether sufficient S/N has been reached in the spectrum, quick-look spectral exctraction capable of determinig the S/N of the supernova spectrum - bearing in mind it may be on top of a host galaxy

8.2- Would you welcome remote observing capabilities?: yes, quick look at the data to assess S/N Ability to help with or check acquisition (finding the SN on top of the host galaxy is sometimes difficult).

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: yes, 3000

9.1- Synergy with other programmes: JWST, N/A

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9.2- Critical aspects / limiting factors for the science case:
High-spatial-resolution spectroscopy (ideally diffraction-limited)
IFU is ideal to observe the SN and host galaxy simultaneously.

9.3- Detailed description or other comments:

- brighter (lower-z) targets would be observed in J and H bands (the form only allows one band to be specified so K was selected, which would be used for the highest-z targets.)

- sources are variable but only one spectrum is required, hence sampling rate of 1 per millennium

- Spectral resolution needed for the science is R~1000. R=3000-5000 was selected above for better removal of sky lines. If this could be done another way (e.g. OH suppression fibres) then R=1000 would be fine.

- EAGLE could also be used for this case but longer exposure times would be required.

Detailed science case

Introduction

Following the unexpected discovery that the expansion of the Universe is accelerating (Perlmutter et al 1999, ApJ 517, 565, Riess et al 1998, AJ, 116, 1009), major investments in telescope time have increased the number of distant SNeIa useable for cosmology to several hundred (e.g. the Supernova Legacy Survey, Astier et al 2006, A&A, 447, 31, and the ESSENCE survey, Wood-Vasey et al., 2007, ApJ, 666, 694). To date the constraints derived from SN surveys, CMB and Baryon Acoustic Oscillations are consistent with w=-1 at the level of ~6% statistical uncertainty (Sullivan et al 2009, in prep), which implies that the Dark Energy is consistent with Einstein's cosmological constant (equivalent to the vacuum energy density, constant in time and space). However there are at least two important questions that this explanation leaves unanswered. Firstly, why is the measured value of the cosmological constant so much smaller (by 120 orders of magnitude!) than the natural zero-point energy expected from quantum field theory? Secondly, why is the vacuum energy density measured now so similar to energy density in matter? These "fine tuning" issues have led theorists to devise a large range of alternative explanations including modified theories of gravity and models where the equation-of-state varies with time. Essentially the nature of Dark Energy remains a mystery and our lack of understanding of its nature is one of the major problems of modern physics.

Discovery of deviations from w=-1 would rule out the cosmological constant explanation and would provide a fundamental change in our understanding of Dark Energy. The E-ELT has the potential to study supernovae at very large redshifts, to z~4 compared to the current observational limit of z~1. The increase in cosmic time baseline will allow a major improvement in measurements of cosmological parameters and opens up the possibility of observing unexpected behaviour in the expansion history at early epochs. Other major surveys planned for supernovae (such as the proposed SNAP satellite) will reach a maximum redshift of z~1.7. To reach beyond z~2 will require the sensitivity of ELT and JWST. Since supernovae are point sources these observations take full advantage of the AO correction provided by the E-ELT.

As shown below, the E-ELT, in combination with JWST, could be used to construct sample of SNeIa out to z~4 for cosmology. In this example, JWST would be used in imaging mode to find the SNe and to measure their light-curves by repeat imaging of a few fields. HARMONI on the E-ELT would provide the redshift (required in order to use the SN for cosmology) and confirmation of the SN Type.

In addition to the improvement in cosmological measurements gained by going to higher redshift, the spectra themselves contain additional information that can be used to improve constraints yet further. Firstly, since the details of SN spectra are sensitive to the details of the explosion, quantitative comparison of spectra as a function of redshift can provide constraints on the evolution of the SN population (an important test if SNe are to be used as “standard candles” for cosmology). Secondly, it has recently been shown that the strength of certain spectroscopic features, measurable at high-z, correlate with the SN luminosity (Bronder et al. 2008, A&A, 477, 717). This implies that spectral information could be used as an alternative to, or possibly in addition to, light curve width and colour as a calibrator to further improve the accuracy of cosmological measurements.

2) A survey for very high-z SNeIa

Using the JWST NIRCam exposure time calculator we estimate that in

10,000s one could reach a K-band 10-sigma limit of 27mag (Vega), equivalent to a SNIa at z~4 two magnitudes fainter than maximum light. This would allow a reasonable determination of the peak magnitude and the width of the lightcurve (used to calibrate the SNe). Extrapolating SNeIa rates derived from SNLS, we find that monitoring 10 NIRCam fields for 5 years gives 50 SNe in the z range $1<z<5$. Although we have assumed JWST will find the SNe, it is possible that E-ELT itself with an MCAO-fed imager could be used, depending on the FOV of the diffraction-limited imaging camera.

Type Ia SNe are identified by the presence of Silicon in the spectrum. For high-z SNe this is most conveniently observed as the SiII feature at ~4000A in the rest frame. The redshift is usually measured simultaneously from narrow features in the underlying host galaxy spectrum. At z~2 the SiII feature is shifted into the J band, at z~3 in the H band and at z~4 in the K band. The baseline wavelength coverage of HARMONI (0.85-2.4μm) would cover the 4000A SiII feature for a broad range of redshifts from approximately z~1 to z~5.

To determine the sensitivity of the E-ELT with HARMONI for high-z SNeIa spectroscopy, we used the E-ELT ETC (v2.8). Figure 1 (supplied on request) shows an example simulation for the case of a z=4.4 SNIa observed in the K-band. The SiII feature is clearly detected even at this high a redshift.

To observe the full sample of 50 objects would require about 50 x 8 hours = 400 hours, spread over 5 years.

3) Resulting Cosmological constraints

In order to estimate the improvement in estimation of cosmological parameters from SNe with the addition of the JWST/E-ELT sample, we have carried out simulations using the SNOC software (Goobar et al 2002, A&A, 392, 757). The cosmology assumed was a Dark-Energy dominated, flat cosmology with non-varying w ($\Omega M=0.3$, $\Omega\Lambda=0.7$, $w0=-1$, $wa=0$, where $w(z)=w0 + (1-a)wa$ and $a=1/(1+z)$).

Results were compared for a pre-ELT sample of SNe (500 with $0.2 < z < 0.9$ plus 300 low-z SNeIa) and a post-ELT sample (adding 50 SNe with $1<z<5$). It was assumed that Omega_M will be known to an accuracy of 0.03 from other experiments. The JWST/E-ELT sample produced a major reduction in the uncertainty in Omega_M, w0 and wa corresponding to approximately a factor of two in the DETF figure of merit (Fig 2 - supplied on request). Note that as yet no systematic effects have

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been included in the simulations. However the improvement from the use of spectral features to further calibrate the SNe has also not been included.

1.1- Project Title: Tracing the velocity field of intra-cluster stars in the most X-ray-luminous galaxy cluster RX J1347.5-1145 with EAGLE

1.2- Project Category: 2

1.3- Abstract:

We propose the investigation of the velocity dispersion of the intra-cluster stellar population (ICSP) in the most X-ray luminous galaxy cluster RXJ1347.5-1145. By comparing the velocity dispersion of the ICSP with the velocity dispersion of the galaxies in the cluster will be able to study the dynamical state of the cluster in two independent ways. Furthermore, we will study if the dynamics of the galaxies and the ICSP is coupled or not. This will give us insight into the origin of the ICSP. As the ICSP ideally traces the large scale mass distribution in galaxy clusters we will be able to perform a mass decomposition of the galaxy cluster and we will compare the derived masses with X-ray-based mass estimates for this particular galaxy cluster.

1.4- Publication agreement: no

2.1- PI: Wolfgang Kapferer

2.2- CoIs: Asmus Böhm, Sabine Schindler

2.3- Institute: Astro- und Teilchenphysik, University Innsbruck, Austria

2.4- Country of Employment: AT

2.5- Career Stage: postdoc

2.6- E-mail: wolfgang.e.kapferer@uibk.ac.at

3.1- Source of targets: Rosat All Sky Survey

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 26, 28, Vegamag, I

3.4- Target size: extended source, 1000, 5000

3.5- Number of targets: 20

3.6- Density of targets: N/A

3.7- Target coordinates: RA:14 - 14;Dec:-12 - -12

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy cluster

4.1- Spatial resolution: seeing, 1

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: 20, 5x5arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: 800 - 1500

5.2- Spectral Resolution: 2000-3000

6.1- Instrument: EAGLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 100, 100, seeing 0.8"""" airmass 1.5

7.2- Longest continuous observation time on a target or field: 0,3

7.3- Shortest integration time on a target or field: 1000

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 100

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
None

9.3- Detailed description or other comments:
Since the first measurements of the intra-cluster light in the Coma cluster (Bernstein et al. 2005) it is obvious that the intra-cluster stellar population (ICSP) contributes significantly to the total amount of stars in a galaxy cluster. As the ICSP is mainly unbound to galaxies within the cluster it acts like a perfect tracer for the large scale mass distribution in galaxy clusters.

By obtaining line of sight velocities of the diffuse stellar component in the most X-ray luminous galaxy cluster RXJ1347.5-1145 (Gittie et al. 2007, Gitti & Schindler 2004) we will be able to investigate if the velocity dispersion of the ICSP is coupled or decoupled to the velocity dispersion of the galaxies in this particular cluster.RX J1347.5-1145 is massive galaxy cluster at a redhsift of z=0.45. As the ICSP mass fraction increases with the mass of the galaxy cluster (Murante et al. 2004) this cluster has a high probability to harbour a high fraction of a ICSP.

By comparing the velocity dispersion of the cluster galaxies with that of the ICSP it will be possible to study the origin of these stars in more detail. Furthermore a the dispersions of the ICSP can be used for a mass reconstruction of the galaxy cluster. The results

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will than be compared to the X-ray obtained mass for this particular cluster. As the ICSP peaks in its density towards the central massive galaxies the influence of the cooling flow in this particular cluster on the X-ray mass estimates can be studied in detail.

We will use each EAGLE IFU to trace the velocity dispersion at a different position in the cluster. ALL the light within one IFU will be integrated for this, i.e. this project does not requite AO.
Within 100 hrs of total integration time, a continuum S/N of ~20 can be achieved down to I-band surface brightness magnitudes of mu_I~28 which is sufficient to trace the ICSP out to clustercentric radii of ~1Mpc at the cluster""s redshift.

1.1- Project Title: Characterisation of old planets at white dwarfs with the E-ELT

1.2- Project Category: 3

1.3- Abstract:
The low luminosities of white dwarfs offers the chance to study old, mature gas giant companions with the E-ELT. As well as allowing us to investigate the fate of our Solar System after the Sun"s main sequence phase, such observations allow the study of planet formation at the white dwarf progenitors (1.5-8.0Msun stars), and the investigation of planetary evolution and atmospheres at well constrained ages, for comparison with theoretical models ("benchmark systems"). However, the faintness of nearby white dwarfs (typically 12-15th mag) will pose a challenge to instrument designers. We provide realistic example systems for comparison with expected instrument performance.

1.4- Publication agreement: yes

2.1- PI: Matt Burleigh

2.2- CoIs: Fraser Clarke

2.3- Institute: University of Leicester, UK

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: mbu@star.le.ac.uk

3.1- Source of targets: McCook and Sion white dwarf catalogue; SIMBAD; surveys from Spitzer, JWST, GAIA and VLT

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 20, 29, Vegamag, J

3.4- Target size: point source

3.5- Number of targets: 10

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +90

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: exoplanet

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: ?, ?

5.1- Wavelength range: J, H, L, M

5.2- Spectral Resolution: bbimaging

6.1- Instrument: MICADO, EPICS, HARMONI

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6.2- Desired special mode: coronography, none

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 3, predicted brightness of planet

7.2- Longest continuous observation time on a target or field: 3

7.3- Shortest integration time on a target or field: 3600

7.4- Total time: 20

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 100

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, also GAIA, VLT, Gemini

9.2- Critical aspects / limiting factors for the science case:
the brightness of the white dwarf targets (12<V<15 typically) will be a challenge for AO

9.3- Detailed description or other comments:
Science Case for studying planets at white dwarfs

- Understand the evolution of planetary systems in the post-main sequence phase: investigate the fate of the Earth and the solar system

- Study planetary formation (frequency, mass ditribution, orbital separations) at the progenitors of white dwarfs: 1.5-8.0Msun stars (spectral types B, A, F)

- Study old, mature gas giants (from a few x 108 years to several Giga-years in age, 200K < T < 500K)

- White dwarfs have well constrained ages: planetary companions will be ideal for comparison with atmospheric and evolutionary models, providing theoreticians with "benchmark systems"

Advantages of white dwarfs

- White dwarfs are up to ~104 times fainter than their progenitors: improves the contrast problem

- While any planet within a few AU will be destroyed in the Red Giant and AGB phases, the orbits of wider planetary companions will expand outwards by a factor 2-5, depending on the progenitor mass, again improving the contrast problem

- White dwarfs are common in solar neighbourhood (>120 within 20pc)

Disadvantages:

- White dwarfs are faint, typically $12 < V < 15$ in solar neighbourhood, posing a challenge for AO systems

Current searches for planets at white dwarfs, and likely searches before ELT-era:

- Near-IR direct imaging searches from the ground, and searches for mid-IR photometric excess emission with Spitzer have ruled out planets >10Mjup at ~50 nearby white dwarfs (see Hogan et al. 2009, MNRAS, in press, arXiv:0901.0532; Farihi et al. 2009, ApJ, 694, 805), but have not yet identified any planets

- Anomalies in the arrival times of photons from the pulsating white dwarf GD66 are commensurate with the presence of a 2.3Mjup planet in a 6.8 year orbit (Mullally et al. 2008, ApJ, 676, 573). This is likely the first planet identified at a white dwarf, and long-term monitoring of other pulsating white dwarfs may be similarly successful.

- 90 white dwarfs will be observed for planets in wide orbits during the Spitzer warm mission, and ground-based searches are planned with the next generation of AO instruments, eg HiCiao on Subaru.

- JWST will provide a significant leap in sensitivity necessary to find planets as low in mass as 1-3Mjup at white dwarfs. However, its limited resolution will prevent the direct study of planetary companions in closer orbits.

- GAIA astrometry will also identify giant planets at white dwarfs of all ages within the solar neighbourhood.

Example systems:

Here we give two examples of the kind of planetary system that might be found at nearby white dwarfs. Firstly we take the HR8799 system and evolve it to the white dwarf stage, and then we also investigate the likely near-IR brightness of the planet discovered around the pulsating white dwarf GD66.

* HR8799 at the white dwarf stage -

The HR8799 (A5V, 1.8Msun) system lies 39pc away and contains three planets of 10Mjup, 10Mjup and 7Mjup orbiting at 24AU, 38AU and 68AU respectively (Marois et al. 2008, Science, 322, 1348).

The system is very young (30-160Myr) but in 1.75Gyr it will evolve to a 0.58Msun white dwarf and the planetary orbits will expand by a factor ~3 to ~75AU, ~120AU and ~200AU respectively, or separations of ~2", ~3" and ~5" respectively

If we allow the white dwarf to cool to 10,000K over ~0.5Gyr, giving a total age for the system of 2.25Gyr, then the three planets will have the following parameters:

Planet	Mass	Separation (")	J	H	L	M
HR8799b	10Mjup	2"	23.8	24.0	19.9	17.9
HR8799c	10Mjup	3"	23.8	24.0	19.9	17.9
HR8799c	7Mjup	5"	25.3	25.7	20.7	18.5

The white dwarf itself would be V=15.2 and J=15.1 at 39pc, 2.25Gyr

Note that if a similar system was located at 20pc, the planets and the white dwarf would be ~1.5mags brighter

* GD66b

age = 1.2 Gyr
orbital separation = 3AU (6.8 years period)
planet minimum mass = 2.3Mjup
distance = 51 pc
projected separation = 0.06"
planet: J=29.8, H=29.3

white dwarf: J=15.7, H=15.6
contrast = ~5x105

Note that if this system was located at 20pc, the white dwarf and the planet would be ~2mags brighter

ELT instruments:

For a near-IR survey for planets in wide orbits through common proper motions: MICADO

For an AO-assisted near-IR survey for planets in close orbits: HARMONI, EPICS

For studying planets discoverd at white dwarfs by other survey methods (eg examples given above): HARMONI, EPICS, METIS

1.1- Project Title: Morphology and Surface Profile X-ray Bright Optically Normal Galaxies

1.2- Project Category: 1

1.3- Abstract:

We propose to obtain high spatial resolution imaging (down to the diffraction limit in K band) of X-ray Bright, Optically Normal Galaxies (XBONG). The surface brightness profile of these sources in the optical and near infrared band, show no evidence of a presence of an active nucleus which would be expected to trace the X-ray emitting AGN. With the proposed observations, we will be able to explore the nuclear regions of these optically dully, X-ray-bright exotic galaxies with a resolution and sensitivity never reached before.

1.4- Publication agreement: yes

2.1- PI: PAOLO CILIEGI

2.2- CoIs: M. Bellazzini, E. Diolaiti, Maory Team

2.3- Institute: INAF Bologna Observatory

2.4- Country of Employment: IT

2.5- Career Stage: faculty

2.6- E-mail: paolo.ciliegi@oabo.inaf.it

3.1- Source of targets: X-ray instruments, VLT

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 20, 22, ABmag, K

3.4- Target size: extended source, 50, 500

3.5- Number of targets: 50

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: AGN

4.1- Spatial resolution: diffraction, 4

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: K

5.2- Spectral Resolution: bbimaging

6.1- Instrument: MICADO

6.2- Desired special mode: N/A

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6.3- Desired AO mode: MCAO

7.1- Integration time per target or field and per setup: 0.08, 0.16, seeing = 0.8 arcsec

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 5

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
Sky coverage of AO mode at high galactic latitude

9.3- Detailed description or other comments:
While the bulk of the X-ray background has been resolved into obvious AGNs (many being heavily obscured), recent X-ray surveys
have cleary demonstrated that a sizeable fraction (~5%) of faint X-ray sources show no optical signs of activity down to faint levels,
despite their large X-ray luminosity (Lx>1042 erg/s). These X-ray Bright, Optically Normal Galaxies (XBONG) may be elusive, totally
obscured AGNs, super-starburst, or faint X-ray groups, or may be exotic AGNs with radiatively inefficient accretion flow, extreme Blazars,
or transient.

The surface brightness profile of these sources in the optical and near infrared band, show no evidence of a presence of an active
nucleus which would be expected to trace the X-ray emitting AGN.   However these studies are strongly limited by the modest spatial
resolution reachable with the available instruments. These results are in fact based on our pilot study performed with the ISAAC camera

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on the ESO VLT-UT1 telescope which has a pixel scale of 0.147 arcsec and provides only seeing-limited images.

The study of this class of objects with the NAOS-CONICA instrument on the ESO VLT-UT4 telescope are strongly limited by the requirement
of the presence of an adaptive optics reference star brighter than V=14 within 30 arcsec from the target position.

We propose deep K-band imaging with the MCAO/MICADO ELT instruments of this class of object in order to study their infrared morphologies and surface brightness profile. Making a full use of the following ELT MCAO/MICADO capability :

i) very high spatial resoltion down to diffraction limit of about 11 mas (FWHM) in the K band, well sampled with the 3 mas/pixel scale of MICADO and with the MCAO Strehl Ratio greater than 50 per cent in the K band

ii) larger available sky coverage in comparison of any actually available ground based instrument on 8m class telescope (like NAOS-CONICA
or MAD) due less stringent requirements for the adaptive optics reference stars

iii) a huge light collecting area of about 1300 square metres that will allow us to reach high signal to noise ratio (>100) in only 5 minutes for these class of relatively bright objects (K = 20 - 22 AB mag)

we will able to explore the nuclear region for a reasonable number of these optically dully, X-ray-bright exotic galaxies with a resolution
and sensitivity never reached before.

1.1- Project Title: Galactic Population of SNIa progenitors

1.2- Project Category: 1

1.3- Abstract:

Supernovae Type Ia explosions are among the most important
cosmological probes. Through their standard candle properties the
accelerated expansion of the Universe has been established. However,
the systematic uncertainty on the use of SNIa as standard candles is
dominated by the unknown nature of their progenitors. It is generally

agreed that the progenitor is a white dwarf in a binary setting, but it is unknown what type of setting. Since these progenitor systems are intrinsically faint, dim and rare, the E-ELT, equipped with a medium resolution optical spectrograph will be needed to study individual possible SNIa progenitors in our own Milky Way Galaxy.

1.4- Publication agreement: yes

2.1- PI: Paul Groot

2.2- CoIs: Danny Steeghs, Gijs Nelemans, Tom Marsh, Boris Gaensicke, Christian Knigge, Tom Maccarone, Peter Jonker

2.3- Institute: Radboud University Nijmegen

2.4- Country of Employment: NL

2.5- Career Stage: faculty

2.6- E-mail: p.groot@astro.ru.nl

3.1- Source of targets: VST, VISTA, SDSS, EGAPS, Gaia, LSST, Pan-Starrs, PTF

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 19, 26, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 50

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 250, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 320 - 2500

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: OPTIMOS, other, X-Shooter-like instrument would be ideal

6.2- Desired special mode: high time-resolution, N/A

6.3- Desired AO mode: GLAO

7.1- Integration time per target or field and per setup: 2, 6, N/A

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: 180

7.4- Total time: 400

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, other, LISA, IXO, Chandra/XMM, JDEM

9.2- Critical aspects / limiting factors for the science case:
-blue sensitivity
- Spectral resolution (R>~ 5000)

9.3- Detailed description or other comments:
Supernovae Type Ia (SNIa) are one of the most important cosmological probes, thanks to their standard candle properties. It has been

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through the use of Supernovae Type Ia that the first measurement of the accelerated expansion of the Universe, and the discovery of dark energy, was possible (Riess et al., 1998; Perlmutter et al., 1999). Over the next ten years an enormous effort will be made to increase the rate, redshift range and the precision of SNIa measurements. Dedicated space telescopes and/or 8-m class telescopes are being considered which will increase the rate of detection, high quality light curves as well as spectra of SNIa to >~ 1000/yr.

Although the cosmological use of SNIa and the importance of understanding the nature of dark energy is not in doubt, the field of SNIa observations is plagued by an enduring uncertainty that will need to be taken away for the undebated use of SNIa as cosmological probes: what are their progenitors? A cosmic evolution of the peak luminosity of SNIa explosions (e.g. due to a changing chemical composition of the progenitor), or a variable contribution from two source populations (e.g. a `fast'' and a `slow'' channel), will dominate the systematic error on their use as cosmological probes and may, in the worst case, invalidate their use altogether. The currently discovered diversity with under- and overluminous SNIa explosions (see e.g Howell et al., 2006), only further illustrates the need to pinpoint the progenitor population(s).

The ability to determine the nature of the progenitor from the characteristics of the SNIa explosions themselves turns out to be limited by their vary nature: the explosion destroys the object and wipes away most of the indicators of the previous setting. It is generally agreed that SNIa explosions occur when carbon is ignited under degenerate conditions in a C/O core white dwarf that approaches the Chandrasekhar mass (Nomoto et al., 1984; Woosley and Weaver 1986, Leibundgut 2000, 2001, Hillebrandt and Niemeyer, 2000). However, how the white dwarf accretes up to the Chandrasekhar mass is far from clear. Does this occur through stable mass-accretion in a binary system (at rates <10-5 M_sun/yr; e.g. Whelan and Iben, 1973)? Does it occur in a merger of e.g. two white dwarfs, which takes place on a timescale of days to years (Iben and Tutukov 1984)? Does it occur in a system transferring hydrogen (which is not seen in the explosions) or does it occur in a helium or even carbon/oxygen transferring system? The combination of these unknowns leads to a large variety of possible binary settings, ranging from symbiotic stars to supersoft sources to double white dwarfs and helium star - white dwarf binaries (see e.g. Yungelson and Livio, 1998; Parthasarathy et al., 2007). No single population clearly stands out as the progenitor population and only very few current candidate binaries are known to have a combined mass that exceeds the Chandrasekhar mass (see e.g. Napiwotzki et al., 2004; Maxted et al., 2000).

The identification of the progenitors of SNIa is not only limited by the lack of conclusive information from the explosions themselves, but also by the lack of understanding on the space density, abundance and evolutionary history of the possible progenitor systems. A further hindrance is the fact that explosions `out there" need to be linked to parent populations `down here". The rate of SNIa explosions in a single galaxy is so low that we most likely will see none happening within the Local Group in our lifetime.

Answering the question on the progenitor population will require a combination of detailed spectroscopic observations of SNIa explosions themselves and a far more detailed knowledge on the physics, evolution and absolute and relative numbers of possible progenitor populations. On the progenitor populations side current and future Galactic surveys such as the Sloan Digital Sky Survey, the European Galactic Plane surveys, OmegaWhite, Pan-Starrs, LSST, PTF and Gaia will give the required population statistics. However, the required spectroscopic follow-up needed to understand the physics will require an optical medium resolution spectrograph on the E-ELT. Currently with X-Shooter on the VLT we will be able to scrape the top of the population (down to V~21-22), but e.g. the Galactic population of AM CVn stars is expected to peak at V~28 (Nelemans et al., 2004).

References:

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1.1- Project Title: Mapping the ionised gas at large scales: galactic haloes and IGM

1.2- Project Category: 2

1.3- Abstract:

Although cosmological simulations predict well the assembly of massive haloes today, little is known about how their baryonic content was transformed since the early Universe. We are just discovering the large variety of halo compositions in nearby galaxies such as, e.g., the Milky Way or M31. Faint surface brightness structures in their haloes are now recognised to be the relics of former accretion events. To understand how galaxies are built up the necessary next step is to examine the progenitor structures, i.e. observe the properties of the galactic building blocks at their various stages of evolution directly at large redshift.

1.4- Publication agreement: yes

2.1- PI: F. Hammer

2.2- CoIs: H. Flores, M. Puech, S. Peirani, Y. Yang, R. Ibata, A. Fernandez-Soto, D. Schaerer, and the EVE Science team

2.3- Institute: GEPI - Observatoire de Paris

2.4- Country of Employment: FR

2.5- Career Stage: faculty

2.6- E-mail: francois.hammer@obspm.fr

3.1- Source of targets: HST/ACS, JWST/NIRCAM, & VLT/HAWK-I

3.2- Preparatory work on targets required?: yes, spectroscopic redshifts are needed

3.3- Target brightness: >10-19, 10-19, fl, J

3.4- Target size: extended source, 12000, 15000

3.5- Number of targets: 100

3.6- Density of targets: 10

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: seeing, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 2, 3600

5.1- Wavelength range: J, H, I, R

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: GLAO

7.1- Integration time per target or field and per setup: 5, 15, assuming dark sky & GLAO

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 500

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, quick-look reduction tools

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8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, SKA/SKAPF, N/A

9.2- Critical aspects / limiting factors for the science case:
This program requires a low surface brightness detection limit to detect faint emission gas in haloes. Any capability driving the surface brightness detection is therefore crucial, e.g., transmission. Large spaxels are highly desirable to gain in S/N. This program does not require any particular AO correction and can be done in seeing-limited or GLAO conditions.

9.3- Detailed description or other comments:
How do galaxies grow? This history is driven by gas exchanges between the galaxies, their haloes and the IGM. During these exchanges, including the most extreme ones (major mergers) the halomass also dominates the dynamical properties. Studies of the halo gas content of nearby galaxies are relatively recent. Several gas phases can be studied using different techniques, including the neutral gas (radio, Fraternali & Binney 2006) and the ionised gas in the warm (optical emission lines, Rossa & Dettmar 2003; Kamphuis et al. 2007) or hot medium (X-rays and/or highly ionised metal lines, see Strickland et al. 2004). They reveal inflow motions and a slowly rotating halo, but this is still limited to a small number of examples.
Though pioneering, these observations are challenging because in the local Universe half of the metals are locked in stars (Pagel 2002) and thus, most of the action has occurred at earlier epochs. Indeed, half of the stellar mass density of the Universe has been produced since z=1 and more than two thirds since z=2. This occurred mostly during strong episodes of star formation that many (if not all) massive galaxies have experienced during their formation history, as witnessed by the huge evolution of IR luminous (LIRGs) and ultra-luminous galaxies (30 × more numerous at z=1 than at z=0, (Hammer et al. 2005; Le Floc'h et al. 2005). Integrated star formation density in LIRGs and ULIRGs suffice to explain the stellar mass density evolution. Indeed most distant galaxies are actually starbursts (60% at z=0.6; >80% at z>1), and it is likely that such starbursts are accompanied by large exchanges of gas within the halo and with the IGM.

1.1- Project Title: Gamma-ray bursts as cosmological probes

1.2- Project Category: 1

1.3- Abstract:

Gamma-ray bursts (GRBs) potentially reveal the first massive stars formed in the early Universe. The UV radiation of their massive progenitor stars may have been responsible for the re-ionization of the primordial hydrogen, an epoch that has been estimated to have taken place around redshift z~10. Thanks to the intrinsic brightness of the GRB afterglow, GRBs have been detected up to redshift 8.3 (Tanvir et al. 2009), i.e. GRBs are the best probes of the distant Universe. The aim of this proposal is to detect GRB afterglows at very high redshifts (theoretically detectable up to z~20), obtain their spectra, and study their (very) massive progenitors and host galaxies. With these observations we want to further constrain the re-ionization epoch of the Universe, collect information on population III stars, and probe the early phases of galaxy evolution.

1.4- Publication agreement: yes

2.1- PI: L. Kaper

2.2- CoIs: N/A

2.3- Institute: Astronomical Institute, Univ. of Amsterdam

2.4- Country of Employment: NL

2.5- Career Stage: faculty

2.6- E-mail: L.Kaper@uva.nl

3.1- Source of targets: Space-born gamma-ray observatories (e.g. Fermi, INTEGRAL, ...)

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 0.001, 0.02, mJy, H

3.4- Target size: point source

3.5- Number of targets: 10

3.6- Density of targets: 0.04

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: yes, 2 per hour

3.10- Target type: GRB

4.1- Spatial resolution: seeing, 2

4.2- Field-of-view: 10x10arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 10, 100

5.1- Wavelength range: J, H, K, L, M, N

5.2- Spectral Resolution: bbimaging, 1000-2000, 5000-10000

6.1- Instrument: HARMONI, METIS, OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.1, 6, GRB090423 (z=8.3) from 1h to 17h after burst in H band, R=1000, S/N~10

7.2- Longest continuous observation time on a target or field: 6

7.3- Shortest integration time on a target or field: 600

7.4- Total time: 80

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: yes, transient

8.1- Does the execution of observations require real-time decisions?: yes, transient (or not if rapid-response mode), N/A

8.2- Would you welcome remote observing capabilities?: yes, rapid-response mode

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: yes, 10

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:

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This program would benefit from an as wide as possible spectral coverage in one instrument (800 nm - 10000 nm) at R > 1000

9.3- Detailed description or other comments:
The science case is rather obvious; it sets some important operational constraints to the E-ELT and its instrumentation.

1.1- Project Title: Sizing Up Asteroids

1.2- Project Category: 3

1.3- Abstract:
We propose to make observations of asteroids using natural-guide-star AO to achieve goals of two separate, but highly related science programs. We will make observations of several asteroids with angular sizes large enough to resolve, yielding size, shape, and spin-pole directions. We will also observe several dozen objects for the presence of satellites. In particular, we seek to build on our demonstrated ability to resolve near-Earth binaries with optical techniques, as opposed to radar.

1.4- Publication agreement: yes

2.1- PI: Albert R. Conrad

2.2- CoIs: N/A

2.3- Institute: N/A

2.4- Country of Employment: other

2.5- Career Stage: other

2.6- E-mail: aconrad@keck.hawaii.edu

3.1- Source of targets: JPL Horizons

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 9, 13, Vegamag, V

3.4- Target size: extended source, 15, 300

3.5- Number of targets: 18

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: yes, 10 (MBA) to 2000 (NEA)

3.9- Variable target?: yes, 2 per hour

3.10- Target type: solar system body

4.1- Spatial resolution: diffraction, 3

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 0.9 - 2.5

5.2- Spectral Resolution: bbimaging

6.1- Instrument: MICADO

6.2- Desired special mode: precision astrometry, N/A

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: .05, .2, extinction from clouds OK, good seeing required

7.2- Longest continuous observation time on a target or field: 0.1

7.3- Shortest integration time on a target or field: 1

7.4- Total time: 30

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 25

7.6- Are the observations time critical?: yes, NEA approach is typically one night only

8.1- Does the execution of observations require real-time decisions?: yes, binary detection is subtle, none

8.2- Would you welcome remote observing capabilities?: yes, preferred over queue

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: other, WMKO

9.2- Critical aspects / limiting factors for the science case:
Fast non-sidereal tracking (up to 1 arcsecond per second)

9.3- Detailed description or other comments:
Historically, asteroid light curves, accumulated over decades, can yield their rotational poles and axial ratios but not their true dimensions because the asteroid remains unresolved. Radar observations must assume a pole (they cannot measure one) and infrared observations (IRAS is the main source of asteroid sizes) use modeling and assumptions to determine projected areas for a given epoch. We have developed a method to determine the pole and triaxial dimensions of an asteroid in one or two nights from adaptive optics observations, and have successfully demonstrated this technique.

These results will go a long way towards revealing the nature and history of the largest members of minor planets, the building blocks of the Solar System. For example, based on our results for Davida and spacecraft images of Mathilde, we speculate that giant craters caused by large impacts are still in evidence today. As a group, do asteroids retain any memory of primordial spin? Are their spin axes aligned? Are any of them rubble piles as might be suggested by their shapes and spin periods if they turn out to be in hydrostatic equilibrium? Having accurate sizes is crucial for the determination of asteroid volume, and hence density, in the cases where the mass can be determined, e.g., from the presence of a satellite. Uncertainty in asteroid size is the overwhelming uncertainty in asteroid densities in such cases. This has further implications in understanding the internal structure from porosity determinations. Our method allows accurate errors to be placed on each of the 3
triaxial dimensions and we have shown that we can achieve, in some cases, errors below 1% in each dimension, thus significantly reducing errors in density. In a recent example (Conrad et al. 2007), we revised the uncertainty in the size of asteroid Davida in 2 of the dimensions to below 1% from Keck AO observations in 2002, and by adding another set of observations in 2007, to <3% for the 3rd dimension, thus also reducing the volume uncertainty to <3%. Similarly, we have determined the volume uncertainty of asteroid Europa to about 4% from one full coverage set of observations and two other epoch sets of ""snapshots"", to <3% for Eunomia, and to about 2% for Pallas. These kind of errors would lower the density uncertainty from 30% to 8% for densities of

around 2 g/cm3. Our goal is to know the sizes well enough that the mass uncertainty is the significant factor in density uncertainty, which occurs at around 2% errors on axial dimensions.

1.1- Project Title: Observing the Extremes of the Core-Collapse Supernova Explosion Mechanism

1.2- Project Category: 1

1.3- Abstract:
Polarimetry is a unique tool to directly probe the geometries, and hence the physical processes, of SNe explosions. The E-ELT will provide the opportunity to apply this technique at high-z to observe SNe associated with cosmological GRBs and expand the sample volume of the rarest, faintest CCSNe. In this way the E-ELT can potentially probe the geometries of the full range of explosion dynamics of the CCSN explosion mechanism, which has not been possible with the current generation of telescopes.

1.4- Publication agreement: yes

2.1- PI: Justyn R. Maund

2.2- CoIs: Dietrich Baade, Ferdinando Patat, Peter Höflich, J. Craig Wheeler

2.3- Institute: Dark Cosmology Centre, Niels Bohr Institute

2.4- Country of Employment: DK

2.5- Career Stage: postdoc

2.6- E-mail: justyn@dark-cosmology.dk

3.1- Source of targets: Pan-STARRS, SASIR, LSST

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 15, 24.5, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 40

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per week

3.10- Target type: SN

4.1- Spatial resolution: seeing, 10

4.2- Field-of-view: longslit

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 300 - 1000

5.2- Spectral Resolution: nbimaging, 100-300, 300-500

6.1- Instrument: other

6.2- Desired special mode: polarimetry, precision on polarization 0.1-0.3%

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 4, 8, airmass 1.15, seeing limited, observations at four retarder plate angles, DIT=1800s, assuming mag_spec=mag_pol+1, dark/grey time

7.2- Longest continuous observation time on a target or field: 8

7.3- Shortest integration time on a target or field: 1800

7.4- Total time: 1200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

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8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: yes, 3000

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
Optical spectropolarimetry capacity with low instrumental polarization

9.3- Detailed description or other comments:
A number of explosion mechanisms and key processes have been proposed, as the results of hydrodynamical modelling, to be at the heart of the core-collapse induced SN explosions associated with the ends of the lives of massive stars (Minit > 8Msol). The obviously asymmetric nature of these processes leads to distinct signatures in the geometries of the resulting explosions, which can be directly probed using spectropolarimetry. Recent spectropolarimetric observations, in particular those with the ESO VLT FORS1 (see Wang & Wheeler, 2008, ARAA, 46, 433 for a review), have given evidence for the role of the jet-like flows and mixing processes (among others) in the ejecta of CCSNe. The scale of these observations, however, has been limited to a small number of nearby relatively bright SNe (required to provide the necessary S/N to make accurate measurements (<0.5%) of the polarization). Here we outline a potential scientific program which employs the E-ELT to study the high and
low energy extremes of CCSN explosions, by aiming to conduct spectropolarimetry of high-z (z < 1.1) SNe associated with GRBs and the extremely rare and faint SNe (z < 0.1).

A serious constraint on the breadth of previous spectropolarimetry programs (such as ours with VLT FORS1) has been the limiting magnitude of the telescopes in the polarimetric mode, limiting the target SNe to being both bright and relatively nearby examples. To appreciate the true diversity of the explosion mechanism behind these events requires the ability to observe bright SNe at large distances as well as the extremely faint SNe. With VLT FORS1 the highest redshift achieved for spectropolarimetry of a SN is z=0.033 (Maund et al., 2007, A&A, 475, L1), but this was only achieved with significant rebinning. Recent works (e.g. Maund et al., 2007a, ApJ, 671, 1944; 2007b, MNRAS, 381, 201) have shown the wealth of information contained in the data of nearby SNe, that could be achieved for distant events if only higher S/N could be acquired.

At one end of the extreme are the SNe associated with *cosmological* GRBs, either directly identified as SNe or observed as bumps on afterglow lightcurves (Woosley & Bloom, ARAA, 2006, 44, 507). Assuming such SNe have a maximum brightness of MV~-20, these objects will be observable at the threshold z~0.55 at the same resolution and precision as current spectropolarimetry with VLT FORS1 (15A binning). As such SNe are expected to have extremely broad features >10 000kms-1, significant rebinning of the spectrum can extend observations to z~1.15. Importantly, at such high redshifts, these SNe will be associated with *cosmological*

GRBs allowing the first opportunity to directly probe the true geometry of the SNe associated with such events (which can be considered distinct from low luminosity nearby events such as 2006aj and 1998bw, but would include SN 2003dh). For the standard model of the SN-GRB connection, the axis of symmetry of the SN and GRB should be aligned with the l
ine of sight, yielding zero net polarization. For the case of SN 2006aj (Maund et al., 2007, A&A, 475, L1), significant polarization (at particular spectral lines) demonstrated that this alignment was not observed in that case. To actually relate the explosion dynamics of both the SN and GRB components, spectropolarimetry needs to be conducted in the high-z domain of cosmological GRBs, which will only be accessible with ELTs.

The other extreme of CCSNe are the peculiarly faint events such as the Type IIP SN 1999br, 2005cs and, possibly, including faint Type Ia/c SNe like 2002cx, 2005hk and 2008ha (which have been recently suggested to be CCSNe rather than a subclass of Type Ia SNe; Valenti et al., 2009, Nature, 459, 674; Foley et al., 2009, AJ, 138, 376). The significant limiting factor on polarimetric observations of these SNe is their apparent faintness (Mv~-14, at the realm of novae and LBV outbursts) and, therefore, the small volume in which these SNe can be detected and are accessible for polarimetry with telescopes such as the VLT. Instead, the E-ELT will be able to expand the sample volume to z~0.1, at which level it will be possible to acquire high S/N spectropolarimetry, and hence determine their geometries, in statistically significant numbers. Observations of the individual case of SN 2005hk (Maund et al., 2009, subm.) have shown that unlike most normal CCSNe, that SN had a very low
level of polarization.

Importantly, polarimetric observations of these specific types of SNe, in conjunction with observations of normal SNe observed at intermediate distances, will permit a study of the full dynamical range of the SN explosion mechanism and permit us to understand the inherent relationship behind the diversity observed for CCSNe.

Based on previous spectropolarimetric studies of CCSNe, we estimate the observation of ~40 events (at ~5 epochs each, with approximately weekly sampling) is required to begin to identify patterns (and differences) among the SNe. The rate of detection of appropriate events will be sufficiently low that the required time would be spread over a number of years. This will permit the identification of specific physical processes (mixing, magnetic fields, jet like flows...) and relate them to the observed energetics (and classical observables) of these events.

To estimate exposure times we have assumed a generic dual beam spectropolarimeter, using the spectroscopy ETC and assuming a correction for beam splitting of 0.75 mags and a further 0.25 mags for the transmission efficiency of the polarimetry optics. In effect, therefore, we have adopted exposure times for objects a magnitude fainter than the object we actually wish to observe. In addition we multiply the estimated exposure times by a factor of 4 (for observations at each half-wave retarder plate angle). If a WeDoWo single shot polarimeter were used instead, the magnitude correction would be ~2.25+0.25, but with only one observation. A reasonable polarization accuracy of 0.3% has been assumed, which requires (applying the standard relations of Patat & Romaniello, 2006, PASP, 118, 146) a S/N~167 in each spectrum. The possibility of conducting polarimetry with

AO has not been considered, due to the complicated nature of the instrumental polarization (a matter for the E-ELT design team to consider), for a large number of intervening off-axis mirrors. Our estimates are based, therefore, on only seeing limited observations for relatively bright point sources (cf their faint extended host galaxies).

1.1- Project Title: Disk evolution and planet formation around evolved binary stars

1.2- Project Category: 3

1.3- Abstract:

We propose to study disks around evolved binary stars. Despite a different formation history, their chemical properties and structural appearance is similar to what is observed in protoplanetary disks around young stars. Can a disk around an evolved binary produce/harbor a planetary system as well?

Using the imaging capabilities of METIS, we can spatially resolve the geometrical structure of the nearest targets. Its high sensitivity allows for the study of extragalactic sources. The high spectral resolution provides access to the dynamics of the gaseous component of the disk and its dust content.

1.4- Publication agreement: yes

2.1- PI: Clio Gielen

2.2- CoIs: Bram Acke, Hans Van Winckel, Joris Blommaert

2.3- Institute: Instituut voor Sterrenkunde, KULeuven, Belgium

2.4- Country of Employment: BE

2.5- Career Stage: postdoc

2.6- E-mail: clio.gielen@ster.kuleuven.be

3.1- Source of targets: Torun Catalogue of post-AGB stars, and De Ruyter et al. 2006

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 1, 10000, mJy, N

3.4- Target size: extended source, 0, 50

3.5- Number of targets: 200

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 10, 6

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 2900 - 14000

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: METIS

6.2- Desired special mode: precision astrometry, N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.1, 20, N/A

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 200

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7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, and ALMA

9.2- Critical aspects / limiting factors for the science case:
spatial and spectral resolution

9.3- Detailed description or other comments:
We propose to study the stable Keplerian disks observed around a specific class of evolved stars, namely binary post-AGB stars.

Recent studies using Spitzer-IRS spectra and detailed modeling, show that these disks are dust and gas rich, and nearly all show evidence for a purely oxygen-dominated circumstellar environment. In this environment, dust grain growth and crystallinisation occur. Interferometric measurements obtained with VLTI show that the disks have typical half-light sizes of 50 AU in the N-band.

The exact formation of these circumbinary disks is still unknown, but can possibly be explained as a remnant of non-conservative mass transfer when the primary was at giant dimension. The disk seems to play a lead role in the further evolution of the entire binary system.

Surprisingly, disks around evolved binaries show a strong resemblance to protoplanetary disks around young stars, both in chemical composition and geometric structure. This raises the question whether planet formation is also possible in the first.

The high sensitivity of METIS will allow a large-scale study of faint extragalactic objects in the LMC and SMC, for which the luminosity, and thus evolutionary status, is known. This will help to study the correlation between the observed disk parameters and the

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evolutionary timescales of the central-star system.

METIS will be used to probe the hot gas and dust component of the disks. High-resolution spectroscopic data will determine the different gas and dust species, and their kinematics. Disk evolution predicts the gas component to dissipate, and the dust to coagulate, leaving the disk as a debris disk, or a young planetary system. This investigation will constrain the unknown evolutionary timescales of physical and chemical processes in these disks around evolved stars, similar to the study of protoplanetary disks.

Polarimetry and spectro-astrometry can be used to construct position-velocity diagrams and probe the specific locations of different dust and gas species in the disk system. This will be invaluable to constrain whether some peculiar dust and gas species, such as PAHs and CO2 gas, which are observed in the Spitzer-IRS spectra, reside in the disk, in the inner gap, or a more recent outflow event.

For nearby Galactic sources, direct imaging will be possible. This could trace possible disk clearings created by planet formation.

1.1- Project Title: PROBING THE JOINT FORMATION OF AGNs AND MASSIVE SPHEROIDS

1.2- Project Category: 2

1.3- Abstract:

We propose to perform deep, high spatial resolution K band imaging of Extremely Red Objects with the MCAO/MICADO camera. A spatial resolution near the diffraction limit value in the K band will allow us to sample the galaxy profile with a spatial resolution of 40 - 50 pc at a redshift of 1.5, thus allowing an accurate two-dimensional point source/bulge/disk decomposition. This will allow us to derive accurate
structural parameters of the host galaxies and to obtain a careful estimate of the luminosity of their spheroidal component. Using an MCAO module with a large field of view (a circle up to 2.5 arcmin in diameter) we could be able to observe up to 20 EROs in a single exposure down to K=25 AB mag.

1.4- Publication agreement: yes

2.1- PI: PAOLO CILIEGI

2.2- CoIs: M. Bellazzini, E. Diolaiti, P. Saracco, P. Severgnini, M. Longhetti, R. Della Ceca

2.3- Institute: INAF Bologna Observatory

2.4- Country of Employment: IT

2.5- Career Stage: faculty

2.6- E-mail: paolo.ciliegi@oabo.inaf.it

3.1- Source of targets: deep extragalactic surveys

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 18, 25, ABmag, K

3.4- Target size: extended source, 100, 300

3.5- Number of targets: 200

3.6- Density of targets: 5

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: diffraction, 4

4.2- Field-of-view: 2x2arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: K

5.2- Spectral Resolution: bbimaging

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6.1- Instrument: MICADO

6.2- Desired special mode: N/A

6.3- Desired AO mode: MCAO

7.1- Integration time per target or field and per setup: 0.8, 0.8, seeing = 0.8

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 30

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 60

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
Sky coverage of AO mode

9.3- Detailed description or other comments:
Extremely Red Objects (EROs, R-K>5 Elston et al. 1998), initially detected in near-infrared ground based imagin, have the color expected for high redshift passive elliptical and have been used as tracers of distant (z>1) and old spheroids. Deep VLT spectroscopy (Cimatti et al. 2002, 2003) has shown that EROs are nearly equal populated by old, passively evolving systems and dusty star-forming galaxies over a similar redshift range
(z=0.8-2.0 for both the classes).

We propose to perform deep K-band imaging with ELT MCAO/MICADO camera for a suited sample of EROs with a spatial resolution (FWHM) of

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about 15 mas (i.e. near the diffraction limit value in the K band). Such extreme high resolution, well sampled with the MCAO/MICADO pixel scale (3 mas/pixel) , will allow us to sample the galaxy profile with a spatial resolution of 40 - 50 pc at a redshift of 1.5, thus allowing an accurate two-dimensional point source/bulge/disk decomposition.

The above spatial resolution and sampling will enable us to discriminate between regular profiles (exponential and smooth r^{1/m} curves) or to clearly detect an irregular profile. Moreover, it will allow us to derive accurate structural parameters of the host galaxies and to obtain a careful estimate of the luminosity of their spheroidal component. The well defined correlation between the black hole mass (MBH) and bulge luminosity (Lbul) (Mogorrian et al. 1998, Marconi and Hunt 2003) will allow us to evaluate the masses of the active central engine. Moreover, the near infrared light provides a clear advantage over the optical light originally used to determine the MBH-Lbul correlation : it is a better tracer of stellar mass and less subject to the effects of extinction. If the physical correlation is between the BH mass and the bulge mass,
the NIR correlations MBH-Lbul should be tighter than those in the optical because of the smaller variation of the M/L ratio with mass.

Finally, the fraction of galaxies showing evidence for merging can also be derived. In all cases, we will gather fundamental
information on the nature of these extreme red galaxies populating the Universe between z=0.8 and z=2.0.

We propose to observe a total 200 EROs sources already selected in several extragalactic survey. Using the ELT ETC and assuming an observed half-light radius of 200 mas, we estimated that a faint galaxy with K = 25 (AB mag) can be
observed with a S/N ~ 20 (sufficiently high for a detailed morphological analysis) within the half-light radius in about 50
minutes. Assuming the large field of view (FOV) of the MCAO module MAORY (a circle of diameter 2.5 arcmin) and considering that the surface density of the EROs sources is about 3-5 sources/arcmin2 at K = 25 AB mag (Wold et al. 2003), we will be able to observe up to 5 EROs for a single exposure using the MICADO camera (field of view of 53 x 53 arcsec) and up to about 20 EROs for single exposure if a MCAO wide field imager with a 2x2 armin FOV will become available.

1.1- Project Title: Studying Galaxy Evolution in situ

1.2- Project Category: 2

1.3- Abstract:
Many physical processes are thought to drive galaxy evolution and integrated spectra and photometry cannot easily separate many of these processes. Integral field spectroscopy is crucial for unraveling the impact of the myriad of possible contributors influencing galaxy properties. To this end, we propose an ambitious large program with the E-ELT using a near-infrared deployable IFU spectrometer with an integrated multi-object adaptive optics system to observe a large number of distant galaxies. Our goals are to constraint the morphological nature, the physical characteristics and the dominate underlying physical processes that drove galaxy evolution over the first 10 Gyrs of the age of the Universe.

1.4- Publication agreement: yes

2.1- PI: Matthew Lehnert

2.2- CoIs: N/A

2.3- Institute: GEPI, Observatoire de Paris

2.4- Country of Employment: FR

2.5- Career Stage: faculty

2.6- E-mail: matthew.lehnert@obspm.fr

3.1- Source of targets: VLT, HST, VISTA, ALMA, JWST

3.2- Preparatory work on targets required?: yes, These observations will require high completeness spectroscopic observations of several fields of 20"x20" in size or greater. This currently could be undertaken with VIMOS but we emphasize the need for high completeness as current surveys generally do not have the requisite target densities down to faint magnitudes and low emission equivalent widths. ALMA may play a role in this by surveying fields with broad band receivers in order to obtain redshifts and dynamics of distant galaxies, especially the dusty, optically faint galaxies. Also, the multi-slit mode NIRSPEC on JWST could provide sufficient target density and high completeness necessary for our proposed surveys.

3.3- Target brightness: 20, 26, ABmag, K

3.4- Target size: extended source, 100, 1000

3.5- Number of targets: 200

3.6- Density of targets: few

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +90

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: N/A

4.1- Spatial resolution: 75, 2

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: 20, 2x2arcsec

4.4- Plate scale stability: 1, 1200

5.1- Wavelength range: 800 - 2400

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: EAGLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: MOAO

7.1- Integration time per target or field and per setup: 10, 30, dark/grey time, airmass<2, seeing=0.8 (zenith)

7.2- Longest continuous observation time on a target or field: 6

7.3- Shortest integration time on a target or field: 600

7.4- Total time: 370

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

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8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, VLT/VLTI, SKA/SKAPF, The synergies are that VLT and JWST will obtain redshifts for the most suitable targets and significant completeness and density. ALMA will provide a comparison between the warm ionized gas and the warm/cold molecular gas in distant galaxies.

9.2- Critical aspects / limiting factors for the science case:
Integration times in the K-band will be limited by the thermal emission of the telescope. Overall overheads will likely be dominated by the time to set up the lasers and their overall reliability.

9.3- Detailed description or other comments:
There are a myriad of possible physical processes that might influence the final characteristics of galaxies. The classical division of secular processes, those that may drive evolution internally, and environmental properties, those that may drive evolution externally, is no longer purely applicable -- the dichotomy is a false one. An interesting thought experiment reveals why this may be so. The dynamical time at the solar radius is about 220 Myrs. The age of the disk at the solar circle is of-order 9-10 Gyrs. This means that disk of any large spiral like the MW has gone through 10s of dynamical times of evolution. Secular processes would need to be very efficient to operate over so few dynamical times. In fact, some may well be so efficient through amplification by strong resonances or by forming independence self-gravitating clumps which may strongly interact with the disk and themselves through dynamical friction, viscosity, and tidal interactions. All of these p ossible processes are relatively efficient compared to all of the possible secular processes. But the necessary conditions, like strongly Jean''s instabilities, implies that secular processes may operate effectively only in the inner disk. This emphasizes the need to carefully consider the initial conditions of disk formation as well.
Therefore, for any instrument to be effective in studying in situ galaxy evolution, it must address a number of processes that may be important in galaxies. These could be:
Gas accretion in mergers versus quasi-adiabatic/violent accretion. What are the initial conditions of galaxy formation as a function of mass and morphological type?
Angular momentum problem in disks. Why do disks have such high angular momenta and how does this evolve with time? Is there a relationship between disk and bulge formation? Did the bulge form first, then repeated episodes of disk formation and destruction ensue?
"mixing problem" - How do metal mix in galaxies? Is "instantaneous recycling" appropriate and what are the sources of metal gradients?
AGN: quenching, maintenance, why exponential cutoff in both galaxy and black hole mass. How do AGN and galaxies relate their growth? Is it truly coordinated?
Stochasticity and self-regulation of star-formation in galaxies: How? What form does it take and what are the galaxy-scale physical processes that drive it?

But we must translate these questions into physical processes and what we know about their relavent scale in order to design experiments that can attempt to answer these questions. With apologies to the work being done today, we know very little about this "translation" so we must rely on some of what we know, with a lot of speculation and a reliance on our physical intuition. If anything, this is the fundamental reason for building an E-ELT in the first place -- overcoming our ignorance.

Deciding on the design requirements of the ELT and an instrument when considering what the important physical processes are, can be cast as a trade off between surface brightness and physically resolving structure of the distant galaxies. Resolving in this context means both the spatial resolution and the spectral resolution since both choices will impact the ultimate sensitivity to structures in galaxies. Cast this way, in favor of best resolution are:

nature of "components" of galaxies: bulges, clumps, spiral arms, AGN

Jean"s mass as a function of environment and epoch: the formation of clumpy structures in disks

dynamical development of these structures

gauging the importance of minor mergers

mixing of metals within early galaxies

In favor of emphasizing sensitive surface brightness detection limits are:

overall large scale dynamic

tidal features and outer structures of mergers

testing inside-out formation scenarios

understanding the physics of gas accretion and systematics

Thus to understand these problems, there is a tension between resolution, sampling, and light concentration. Now we provide an idea of what reasonable design requirements might be to address these tensions. Obviously, a multi-object spectrometer is a must and deployable IFUs are the only way to combine spatial resolution with many objects.

Spatial resolution: 30% encircled energy in 75 mas across a field of 5 arcmin field of view. This will be sufficient to differential between disks and mergers and to resolve fine scale structures and disk About 70 mas corresponds to about 0.5 kpc at z~2 which would be sufficient to resolve large clumps in high redshift disk galaxies. Spectral resolution: R=5000 which is sufficient to resolve the widths of lines in HII galaxies in the local Universe which may be comparable to distant galaxies. IFU FOV: 1.5 arcseconds which is sufficient to cover most of the current sample of galaxies observed with IFUs like SINFONI. Wavelength coverage: I through K, observing a single band at a time to cover as many diagnostic lines and redshift ranges as possible. Number of IFUs: ~20 is sufficient to observe sufficient targets in one setting given the large number of night sky lines in any band.

Our program is split into several components. The first is a broad shallow survey of galaxies in diagnostic emission lines from z~1-4 to obtain the dynamics of galaxies. These observations will be about 5-30 hours per field (depending on brightness of the galaxies) and observe almost a 1000 galaxies. This part of the program will take about 100 hours in total. For sources in most favorable redshift ranges of 1.2-1.7, 2-2.6, and 3-3.6, the rest-frame optical emission lines are available in 3 bands (only 2 for the highest redshift range listed). In these ranges, we can observe the important diagnostic lines of [OII], [OIII], [NII], H-alpha, and H-beta as well as other important lines. Such a program will require 10s of hours per field of integration time. For 20 galaxies in each redshift

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range will therefore require 270 hours (30 hours per band) for a total of 60 sources. Such deep integrations will allow us to make spatially resolved metallicity and ionization mechanis m estimates.

1.1- Project Title: LISA binaries and Type Ia Supernovae

1.2- Project Category: 1

1.3- Abstract:
The gravitational wave interferometer LISA is predicted to discover many thousands of compact binaries in our Galaxy, mainly detached and accreting pairs of white dwarfs with orbital periods of around 2000 seconds or less. Such systems have a short lifetime before they merge under the action of gravitational waves: they are a contender to be the progenitor population of Type Ia supernovae. Optical observations of these sources can determine their masses, but with typical magnitudes V > 23, and very short periods, only an ELT-mounted spectrograph will be capable of following these objects electromagnetically.

1.4- Publication agreement: yes

2.1- PI: Tom Marsh

2.2- CoIs: Gijs Nelemans, Danny Steeghs

2.3- Institute: University of Warwick

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: t.r.marsh@warwick.ac.uk

3.1- Source of targets: LISA, followed by wide-field survey instrument

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 21, 25, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 2000

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per min

3.10- Target type: star

4.1- Spatial resolution: seeing, 2

4.2- Field-of-view: longslit

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 400 - 700

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: high time-resolution, spectra must be read out in < 10 sec; may not be compatible with OPTIMOS

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 2, 4, 0.8

7.2- Longest continuous observation time on a target or field: 6

7.3- Shortest integration time on a target or field: 10

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: no

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8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, other, LISA must be flying!

9.2- Critical aspects / limiting factors for the science case:
Must be able to access B-band (down to 4200A at least, preferably 3800A) and overheads must be kept small.

9.3- Detailed description or other comments:
There are strong prospects for the first direct detection of gravitational waves within the next 5 years from ground-based detectors such as LIGO. Limited by seismic noise, such detectors are sensitive only to short-lived events. From space, much lower-frequency and longer-lived objects can be detected. In our Galaxy alone are some 100 million pairs of white dwarfs, many of which will end their existence in dramatic merger events caused by the emission of gravitational waves. There are so many in fact that they will form a background noise floor to observations from space (gravitational wave detectors are sensitive to emission from more-or-less the entire sky), and only at frequencies above 2mHz (corresponding to orbital periods shorter than 1000 seconds or so) can we expect to see isolated signals. These objects, the "main-sequence stars" of gravitational wave astronomy, are potential progenitors of a range of exotic objects: first and foremost Type Ia supernovae, but also
millisecond pulsars and several forms of hydrogen-deficient star. LISA discoveries will tell us much about this largely unseen population, but a great deal more can be learnt if we can follow up optical counterparts. For instance, many of these systems will eclipse, and simple timing observations will test both GR predictions of gravitational wave emission, but also the degree to which white dwarfs tidally interact. Most challenging of all will be measurements of the masses of the component stars, mass being crucial to their potential as Type Ia progenitors, since it must exceed 1.4 Msun. In principle straight-forward (time-resolved B-band spectroscopy), the difficulty is that for the majority of targets, V > 20, (see e.g. Nelemans, 2009, arxiv 0901.1778), while time-resolved (ideally < 1/10th of the orbital period), moderate resolution (R=5000 to 10000) spectra are needed. This requires large apertures and efficient spectrographs, efficient data taking (overheads < 10 secon
ds), and at the fainter end of the target distribution, low-!
noise detectors.

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1.1- Project Title: Masses and stellar velocity dispersions of submillimetre galaxies

1.2- Project Category: 2

1.3- Abstract:
We will use METIS to measure the stellar velocity fields and dispersions in sample of submillimetre galaxies (SMGs) at z~3. These measurements will allow us to determine whether the SMGs are dynamically supported by rotation or by velocity dispersion, determine accurate dynamical masses, and place these objects on the fundamental plane (FP). With these measurements we will trace the emergence of the FP at high redshift and origin and evolution of the most massive and luminous galaxies.

1.4- Publication agreement: yes

2.1- PI: Paul van der Werf

2.2- CoIs: Maarten Baes, Bernhard Brandl

2.3- Institute: Leiden Observatory

2.4- Country of Employment: NL

2.5- Career Stage: faculty

2.6- E-mail: pvdwerf@strw.leidenuniv.nl

3.1- Source of targets: ALMA, Herschel, SCUBA2, LABOCA

3.2- Preparatory work on targets required?: yes, ongoing/planned infrared/submm surveys (Herschel, SCUBA2, ALMA)

3.3- Target brightness: 0.1, 0.4, mJy, N

3.4- Target size: extended source, 25, 250

3.5- Number of targets: 30

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 8000 - 13000, L

5.2- Spectral Resolution: 2000-3000

6.1- Instrument: METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 4, N/A

7.2- Longest continuous observation time on a target or field: 4

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 90

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

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9.1- Synergy with other programmes: ALMA, JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
N-band spectroscopy at R=2000 or higher required; IFU mode highly desirable; L-band diffraction-limited imaging required

9.3- Detailed description or other comments:
Introduction and scientific background

The submillimetre galaxies (SMGs) are a fundamental population of the high-z universe. Even though relatively small in numbers, with their enormous luminosities they contribute a significant fraction of the cosmic star formation rate at z>2. Their number density matches roughly that of massive (L*) ellipticals in the local universe and thus they plausibly form the progenitors of this population (Blain et al., 1999). Simultaneously the SMGs may be the birthplaces of QSOs. Indeed, the redshift distribution of SMGs closely matches that of powerful AGNs, with a peak at z≈2.5 (Chapman et al., 2005).

Little is known about the morphological and dynamical properties of the stellar component of SMGs, due to the faintness of the hosts, and their relatively large distances. This is a fundamental issue, since if the SMGs indeed evolve into present-day massive ellipticals, they must at some point in their evolution begin to obey the standard scaling relations for ellipticals: the fundamental plane, the Faber-Jackson relation and the Kormendy relation. A key science goal is therefore observing the fundamental properties of the stellar component of SMGs, in order to observe the emergence of the fundamental plane.

Scientific Goals

The fundamental plane describes the relation between the effective radius r_e, the surface brightness I_e at the effective radius, and the velocity dispersion σ. METIS provides a unique opportunity in this field. Given the redshift distribution of SMGs, which peaks at $z \approx 2.5$, L-band observations will probe the stellar component, at a rest wavelength of approximately 1 μm, probing the bump in the spectral energy distribution, which is dominated by low-mass stars and therefore a good probe of the distribution of mass (rather than the distribution of light which is probed at shorter wavelengths, which also suffer from extinction effects). Recent HST observations have shown that ellipticals at these redshifts are surprisingly compact: Daddi et al. (2005) find that 4 out of their 7 targets have $r_e<0.8$ kpc, and Toft et al (2007) find $r_e<1$ kpc in half
of their targets. These compact galaxies have however significant masses (>1e11 M_{sun}), so their stellar densities are very high, in fact much higher than in any known type of galaxy in the local universe. These results demonstrate that in order to resolve the effective radii of high-redshift ellipticals, a spatial resolution of at least 0.2 kpc is required, corresponding to an angular resolution of 0.025" at z = 2.5, which compares favourably to the 0.01" angular resolution of METIS at L-band. In order to determine velocity dispersions, the CO bandheads at 2.3 μm can be used, which shift into the N-band for z>2.5.

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Another fundamental relation obeyed by low-z ellipticals is the Kormendy relation, which describes the anticorrelation of compactness and star formation rate of galaxies. Similar studies at high redshift have so far only scratched the surface, but indicate that the Kormendy relation is already in place at z>2 (Zirm et al., 2007; Toft et al., 2007): compact ellipticals are found to be quiescent, while star formatting galaxies are found to be large and less centrally peaked. Characteristically, the most extended galaxy in the Toft et al. sample is an SMG, underlining that the Kormendy relation is valid even for these extreme objects.

Observations

In order to observe the emergence fundamental scaling relations of nearby ellipticals in high-z ellipticals and SMGs, a sample of SMGs, ranging from gas-dominated (faint hosts, large gas mass) to host-dominated, with and without AGNs, must be studied, supplemented with a sample of high-z ellipticals covering a range of masses and sizes. In total a sample of the order of 30 sources will be needed. These will be imaged in L-band, in order to determine the morphogical parameters, and will be observed spectroscopically in N-band in order to determine velocity dispersions and velocity fields. For this application, IFU mode is highly desirable, since we need to determine not only velocity dispersions but also velocity fields, in order to separate the contributions
of rotation and velocity dispersion to the dynamical support of these objects. Since the axis of rotation
of the stellar body is not known, multiple slit position angles (4 or more) would be needed if this was done
with a slit spectrograph. While this is not impossible, the METIS IFU makes this project significantly more
efficient.

While the L-band imaging will take only a few minutes per target, the spectroscopic observations are more challenging. Typical N-band fluxes are expected to be of the order of 0.2 mJy, which METIS/ELT will detect at a spectral resolution of 3000 at 10σ in about 1 hour (Macon-type site is assumed; for a lower, Paranal-type site, the integration times are about twice as long).

The key features that make METIS/ELT unique for these observations are the combination of long wavelengths (to be able to penetrate the dust), angular resolution (to resolve the effective radius in compact massive high-z ellipticals) and sensitivity. Long wavelengths are needed to probe the stellar mass. We note that the angular resolution of JWST at L-band will not be sufficient to resolve the effective radii of compact high-redshift ellipticals.

References

• Blain et al., 1999, MNRAS 302, 632
• Chapman et al., 2005, ApJ 622, 772

• Daddi et al., 2005, ApJ 626, 680
• Toft et al., 2007, ApJ 671, 285
• Zirm et al., 2007, ApJ 656, 66

1.1- Project Title: Intermediate mass black holes

1.2- Project Category: 2

1.3- Abstract:
E-ELT has sufficient spatial resolution to test conclusively whether nearby globular clusters and nuclear stellar clusters harbour black holes with masses in the range 104 to 106 M_sun. This proposal explains a survey using HARMONI on E-ELT could extend the existing census of BHs with its present range of 106-109 M_sun downwards by two orders of magnitude to around 104 M_sun. This will illuminate the connection between stellar clusters and BHs, and eliminate many exisiting explanations for the BH-host scaling relations.

1.4- Publication agreement: yes

2.1- PI: John Magorrian

2.2- CoIs: N/A

2.3- Institute: University of Oxford

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: magog@thphys.ox.ac.uk

3.1- Source of targets: VizieR

3.2- Preparatory work on targets required?: yes, Proper motion surveys are needed prior to work on globular clusters

3.3- Target brightness: 14, 18, Vegamag, I

3.4- Target size: extended source, 30, 300

3.5- Number of targets: 80

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star cluster, galaxy

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: K

5.2- Spectral Resolution: 10000-20000

6.1- Instrument: HARMONI

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 6, spectroscopic calculator defaults, time depending on target sb

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 240

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

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7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
NIR IFU with spectral resolution R=10000 to 20000 essential; good knowledge of psf very desirable.

9.3- Detailed description or other comments:
Nature has at least two ways of creating BHs. Stellar-mass black holes are a natural by-product of the evolution of massive stars. Observations indicate that galactic bulges also harbour so-called "supermassive"""" black holes (SMBHs) at their centres. The formation mechanism of the latter is unclear, but correlations between their masses and host galaxy properties strongly suggest that SMBHs are somehow a natural product of galaxy formation.

There is as yet no firm evidence that BHs exist with masses in the intermediate range of 10 to 106 M_sun. Although there have been many claimed detections, these are invariably based either on questionable extrapolations of existing SMBH scaling relations or on dubious dynamical modelling (see, e.g., van der Marel & Anderson, arXiv:0905.0638).

Nevertheless, there are plausible theoretical and observational grounds to expect that such intermediate-mass BHs (IMBHs) might exist. For example, these IMBHs could plausibly form as a natural by-product of the evolution of dense star clusters, from the first (Population III) stars, or even in the same (unknown) process that produces supermassive BHs (van der Marel, astro-ph/0702433).
Testing whether IMBHs exist and understanding their demographics is an essential part of understanding the formation and co-evolution of galaxies and AGN, and more generally, the overall formation of cosmic structure (e.g., Regan & Haehnelt 2008, arXiv:0810.2802).

A naive extrapolation of the M-sigma relation to small dense stellar

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systems suggests that BHs in the range 103 to 106 M_sun might exist in globular clusters (GCs) and the nuclear stellar clusters (NSCs) usually found at the centre of bulgeless disc galaxies.

1. IMBHs in nuclear stellar clusters

Nuclear stellar clusters are found at the centres of most galaxies across the Hubble sequence. They appear to share similar scaling relationships with their host galaxies as do supermassive black holes (van der Marel, astro-ph/0702433 and references therein), but the connection between NSCs and BHs is unclear.
At least two NSCs harbour BHs (our own Galaxy and NGC 4395), so it is natural to expect that the small NSCs in late-type spiral galaxies could probe the extension of the existing SMBH M-sigma relation down to masses of 105 M_sun or lower.

At present there are only a dozen NSCs with direct, spectroscopic mass estimates (Walcher et al, astro-ph/0409216). With HARMONI, however, our Schwarzschild models of simulated kinematics show that it will be possible to detect an IMBH of 3x104 M_sun embedded within a 106 M_sun cluster out to distances of 20 Mpc. In addition to measuring BH masses, HARMONI""s maps of the clusters"" internal kinematics and stellar populations will allow us to constrain NSC formation scenarios. Boeker et al (2002 ApJ 123, 1389) have identified 59 NSCs in a sample of 77 nearby late-type spirals. The typical half-light radius is 3 pc, which corresponds to 30 to 300 mas at distances 2 to 20 Mpc. Velocity dispersions are of order 20 km/s, so a spectral resolution R=10000 or above is essential. Measuring M_bh in a typical Boeker et al NSC would require 2-4 hours of E-ELT time.

2. IMBHs in globular clusters

The same models can be used to look for IMBHs in globular clusters (GCs) within our own Galaxy.
An important practical difference is that, in these nearby GCs, one can resolve individual stars instead of having to rely on integrated spectra.
The cost of this extra information is that in most cases it is impossible to determine the kinematical centre of the GC from photometric information alone; the presence of just a few bright giant stars can shift the luminosity centre far from the true, dynamical centre (see, e.g., Anderson & van der Marel, arXiv:0905.0627, who point out an embarrassing example). Therefore, our spectroscopic

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observations need to be preceeded by a proper motion survey (e.g., with Gaia or with MICADO) to locate the kinematical centre of the cluster. This proper motion information can be incorporated in the dynamical models to help tighten constraints on the BH mass; it is not in itself likely to be sufficient, however, since the relative errors in velocities from proper motions are quite large.

Proposed targets are Galactic GCs with the highest probability of hosting an IMBH (Table 3 of Miocchi 2007, MNRAS 381, 103) and Magellanic Cloud clusters with profiles consistent with an IMBH (Mackey \& Gilmore 2003, MNRAS 338, 85).
Typical core radii are 10"""" for Galactic and 4""""
for old LMC GCs. The cusp region that would need to be mapped out by the IFU is about 0.01 r_core.01, or 0.2""""x0.2"""", for an assumed M_bh=103 M_sun.

1.1- Project Title: Constraining the formation and the evolution of early-type galaxies

1.2- Project Category: 2

1.3- Abstract:
We propose spectroscopic observations with HARMONI of a sample of ~20 ETGs spectroscopically confirmed at z>1.5 to sample the rest-frame range 0.2mu-0.8mu (including the features MgII2800, CN, CaII H&K, D4000, Hbeta, Halpha, Mgb, Fe, etc.) in order to: 1) estimate the age, the metallicity and star formation history of the stellar
population and to break the degeneracies between these quantities; 2) measure the velocity dispersions from the absorption lines thus answering the question whether early-type galaxies were denser in the past; 3) spatially map the stellar velocity fields and resolve age/metallicity gradients inside the galaxies.

1.4- Publication agreement: yes

2.1- PI: Paolo Saracco

2.2- CoIs: Marcella Longhetti, Adriana Gargiulo, Paolo Ciliegi

2.3- Institute: INAF - Osservatorio Astronomico di Brera

2.4- Country of Employment: IT

2.5- Career Stage: other

2.6- E-mail: paolo.saracco@brera.inaf.it

3.1- Source of targets: GOODS, GDDS, (HST, Spitzer, VLT)

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 20, 23, Vegamag, J

3.4- Target size: extended source, 50, 700

3.5- Number of targets: 20

3.6- Density of targets: N/A

3.7- Target coordinates: RA:03 - 03;Dec:-27 - 01, RA:12 - 12;Dec:-07 - -07

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: 50, 1

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 500 - 2100

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: HARMONI

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

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7.1- Integration time per target or field and per setup: 0.25, 3, 0.8

7.2- Longest continuous observation time on a target or field: 3

7.3- Shortest integration time on a target or field: 900

7.4- Total time: 30

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 60

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
None.

9.3- Detailed description or other comments:
Most of the current efforts in observational cosmology aim at understanding the formation and the evolution of galaxies. In this context early-type galaxies (ETGs, elliptical and bulge dominated galaxies) play a crucial role as they are the most massive galaxies and contain most of the stellar mass of the local Universe (Renzini 2006, ARAA 44, 141). While the recent studies agree with considering completed their build up at z~1 beyond z~1 the picture is still controversial because the spectroscopic identification of ETGs is very challenging for the 8-10 meter telescopes: due to their red absorption line spectra ETGs at z>1 become very faint in the optical and the most prominent spectral features (e.g. the D4000 continuum break and CaII H&K absorption lines) are redshifted in the near-IR at z>1.5.

A new piece of information came recently from the morphological analysis of z>1 ETGs which showed that, for a given stellar mass, the sizes of most of them look more than 3 times smaller than the local ETGs (Daddi et al. 2005, ApJ 631;
Longhetti et al. 2007, MNRAS 374; Cimatti et al. 2008; Saracco et al. 2009, MNRAS 392). Since smaller sizes imply higher densities and, consequently, higher velocity dispersions the compact ETGs observed at z>1 should have velocity
dispersions 1.5-2 times larger than local ETGs.

This new piece of information set two distinct aspects.
The first one regards the formation scenario which has to account for both the highly compact ETGs and the normal (i.e. not compact) ETGs observed at z>1.
The second aspect regards the evolutionary path which ETGs follow after the completion of their assembly, i.e. from z~1-1.5 to z=0. This path cannot be dominated by luminosity evolution since this is not able to bring all the z>1 ETGs onto the local scaling relations. Other mechanism(s) such as minor mergers, tidal interactions and AGN feedback could occur during this evolutionary phase at least for some of them.

>From the observational point of view, the most promising way to tackle this issue consists in measuring the kinematics of highly dense ETGs at z>1 and age dating their stellar content. Kinematics provides evidence for the real stellar mass density and thus for the actual compactness of ETGs constraining the mechanism(s) of their mass growth.
At the same time, such mechanism(s) must also account for the age of the stellar content strictly dependent on the star formation history.

The large collecting area of ELT coupled with the AO spectroscopic capabilities of HARMONI covering the range 0.5-2.5 mu make it possible to carry out the above measures otherwise unfeasible today. We propose to observe with HARMONI a sample of ~20 ETGs spectroscopically confirmed at z>1.5 for which accurate HST imaging confirms their early-type morphology. These observations will allow a detailed analysis of the rest-frame spectral range 0.2mu-0.8mu including the spectral features B2900, MgII2800, MgI2853, CN, CaII H&K, D4000, Hbeta, Halpha, Mgb, Fe, etc. needed to:
1) measure the velocity dispersion from the absorption lines thus answering the question whether early-type galaxies were denser in the past;
2) estimate the age, the metallicity (e.g. Lick indices) and the star formation history of the stellar population and to break the degeneracies between these quantities;
3) spatially map the stellar velocity fields and resolve age/metallicity gradients inside the galaxies.

Spectroscopic observations at R~4000 with a S/N~10 in the observed near-IR (J) continuum will provide velocity dispersion measurements with an accuracy higher than 5%. Since our ETGs have effective radii in the range 100-700 mas we plan
to obtain spectral information at a spatial sampling of 50 mas, the spaxel size offered by HARMONI. Using the ELT ETC we estimate that <3 hours of exposure are needed to reach a S/N~10 on the continuum at J(Vega)~23 (the faintest z>1.5 ETGs of our sample) over an area of radius 29 mas (pixel scale ~51 mas/pix). For such faint galaxy, the UV absorption features observable at lambda(obs)~0.7-0.9 mu can be detected at a S/N~6-7 with similar exposure time. For a typical ETG with J~22 the exposure time reduces to 0.5 hour allowing to observe a sample of about 20 ETGs in a reasonable amount of time.

1.1- Project Title: The mass and fueling of the most massive black holes

1.2- Project Category: 2

1.3- Abstract:
The recognition that AGN feedback has a crucial role in the evolution of galaxies and the properties of the intracluster medium has had a massive impact on extragalactic research. We propose to make IFU observations of five clusters of galaxies in which the central galaxy appears to be actively injecting energy (>1059 erg/s) into the intracluster medium through the action of radio jets. The proposed HARMONI and/or EAGLE observations will allow us to derive the mass of the central black hole in the galaxy as well as the dynamics and chemistry of the gas falling on to it.

1.4- Publication agreement: yes

2.1- PI: Alastair Edge

2.2- CoIs: Brian McNamara, Mark Swinbank, Richard Wilman

2.3- Institute: Durham University

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: alastair.edge@durham.ac.uk

3.1- Source of targets: Current VLT studies (a combination of FORS long slit then VIMOS IFU spectroscopy) plus X-ray, radio and Herschel

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 16, 18, Vegamag, R

3.4- Target size: extended source, 1000, 3000

3.5- Number of targets: 5

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: 10, 500

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 1, 600

5.1- Wavelength range: 650 - 2400

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: HARMONI

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 2, 3, N/A

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 100

7.4- Total time: 15

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 25

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

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9.1- Synergy with other programmes: JWST, VLT/VLTI, SKA/SKAPF, N/A

9.2- Critical aspects / limiting factors for the science case:
The ability to observe both Halpha and the 1-0S series molecular Hydrogen lines are important to this case so we favour HARMONI.

9.3- Detailed description or other comments:
N/A

1.1- Project Title: The formation and evolution of stars and planets with the E-ELT: synergies with ALMA, JWST & SKA

1.2- Project Category: 3

1.3- Abstract:
The observational properties of protostellar systems are increasingly well understood; with studies following their evolution from molecular cloud cores, to accreting stars, and finally to planet-hosting stars.

The processes by which these systems evolve are less well understood, though models show magnetic fields must play a central role in this process. Under the “magnetospheric accretion scenario” star and disk magnetic fields drive bipolar outflows, mass accretion, disk and angular momentum evolution. If spectro-polarimetry is available in the E-ELT, these research areas will take a big step forward, allowing our Solar System to be placed in context with other exoplanetary systems.

1.4- Publication agreement: yes

2.1- PI: Gaitee A.J. Hussain

2.2- CoIs: J.F. Donati (Toulouse), S. Gregory (Exeter), J. Bouvier (Grenoble), Alexis Smith (St Andrews)

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: ghussain@eso.org

3.1- Source of targets: VLT, GAIA, and many other exoplanet and star formation studies

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 8, 15, Vegamag, U

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 15 per week

3.10- Target type: other, stars and disks

4.1- Spatial resolution: diffraction, 4

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 400 - 1000, 2000 - 2300

5.2- Spectral Resolution: 20000-50000

6.1- Instrument: CODEX

6.2- Desired special mode: polarimetry, polarimetry feed into CODEX/SIMPLE/METIS - precision of between 0.1%-0.001% can be achieved using multi-line techniques

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 2, 20, per target; seeing=0.8

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 120

7.4- Total time: 600

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: SKA/SKAPF, N/A

9.2- Critical aspects / limiting factors for the science case:
Polarimetric capabilities are essential to this case. Optical and NIR observations using polarimetric feeds into CODEX, METIS and/or SIMPLE would give E-ELT full spectro-polarimetric capabilities. NIR data is especially useful to detect magnetic fields in pre-main sequence Class I and II systems.

9.3- Detailed description or other comments:
Spectro-polarimetry of pre-main sequence and main sequence systems can be used to map surface magnetic fields. In pre-main sequence systems we can also measure the fields inside disks and accretion streams around the central protostars, driving magnetospheric accretion models forward.

--Star Formation--
The first maps of classical T Tauri stars display a range of magnetic field distributions, from simple fields to complex multipolar distributions; this has repercussions for the efficiency with which these stars interact with their disks (Donati et al. 2007, 2008, Hussain et al. 2009). These first studies are already driving forward magnetospheric accretion models (Gregory et al. 2008, Long et al. 2008). Magnetic field measurements of a Class I protostar obtained last month with NIR intensity spectra suggest that both Class I and II stars possess kG magnetic fields (Johns-Krull et al. 2009). Spectro-polarimetry is required to understand the magnetic field geometries in Class I sources but current facilities are not powerful enough to detect fields in these faint objects.

Disk fields have been detected in the disk-dominated FU Ori system, with longitudinal B~32G indicating the likely presence of kG poloidal fields in the inner regions of the accretion disk.

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Objects undergoing more moderate accretion likely possess weaker disk fields that cannot be measured with current facilities (as they are too faint).

--Planet-Hosting Systems--
Magnetic fields have been detected in the bright (mV~7.6) planet-hosting star, HD189733 (K2V; Moutou et al. 2007). These fields (B~8G) are strong enough to interact with the magnetic field of its hot Jupiter, driving cyclotron maser emission that should be detectable at radio observations (Smith et al. 2008). With current spectropolarimeters (ESPADONS/CFHT and ESO-3.6-m/HARPS) only the brightest planet host stars (mV<8) can be studied in this manner, though with sufficient S:N and polarimetric sensitivity many more extrasolar planet hosting systems can be targeted.

In the next decade our understanding of planet-forming disks and extrasolar planets will progress enormously. Advances will include:
a) Disks: Key goals of ALMA and the JWST are to trace the formation and evolution of circumstellar/protoplanetary disks and their chemistry. In young (Class 0 and I sources) they will also measure the launching radius of bipolar outflows, while in Class I and II sources they will detect the gaps cleared by planets as they start to form; providing clues to star and planet formation processes.
b) Planets: Kepler, Gaia and Sphere will detect and probe planetary properties and statistics of extrasolar planetary systems down to Earth-sized planets.
c) Planet-star interactions: A key science goal of LOFAR is to provide the first direct detections of extrasolar giant planet magnetic fields. Sensitivities of ~mJy are required at radio wavelengths (10-240 GHz) to detect the predicted cyclotron maser emission produced via the interaction of planetary magnetospheres with stellar magnetospheres. The size of the radio emission scales with both the stellar magnetosphere field strength and is dependent on its geometry (Jardine et al. 2008). As a pathfinder for the low frequency part of the SKA project, it should detect extrasolar planetary magnetic fields in 10s of systems (Best et al. 2008, Smith et al. 2009). SKA would find extrasolar planetary fields in 100s of systems.

THE E-ELT
a) Class I & II sources: E-ELT spectro-polarimetry at optical and NIR wavelengths would produce the first magnetic field maps of magnetic fields in Class I stars (V/Ic~0.1%) as well as their surrounding disks (V/Ic~0.01% signature size expected) testing the latest magnetospheric accretion and disk models in a way that cannot be done with submm observations of disks. With the collecting area of E-ELT the disk fields would not only be detected but also mapped, enabling us to model the star-disk interaction and disk processes in unprecedented detail.

Polarimetric spectra covering different sets of lines would probe magnetic fields in different regions: from different heights in the stellar atmosphere (dark spots, photosphere, bright plage), to magnetic fields in accretion streams and disks. Magnetospheric accretion models are in development; their predictions would be tested for the first time with these observations.

b) Planet-hosting systems: In 2018 magnetic field detections from planet-hosting stars will still be missing (except for the handful of systems brighter than mV~8).

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SKA will detect signatures from the magnetospheric interaction between star and planet but the strength and frequency of the radio signature depends strongly on both the star and planet magnetic fields (Jardine et al. 2008). If we know the stellar magnetic field then the strength and geometry of the planet's field can be measured, thus providing some of the first insights into the internal structure of extrasolar planets.

Optical spectro-polarimetry using the ELT would provide the missing part of the puzzle. With its greater collecting power and similar levels of polarimetric sensitivity as current instruments, longitudinal fields of B~ 3-5 G would be detected on planet-hosting stars down to mV~12. In conjunction with the SKA, this will trace both star and planet magnetospheres – with complementary observations from space and ground-based projects characterizing planetary atmospheres and their chemistry. These observations would provide key insights into the evolution of planetary magnetospheres – in a statistically significant sample.

While the EPICS instrument design has a goal to detect linear polarization from hot Jupiters; this will mainly detect the albedo of the planet, not its magnetism (unless there are strong polar fields). Magnetic properties of planet-hosting systems with spectropolarimetry on the E-ELT would provide a massive leap in understanding the properties of planets including their atmospheres.

References:
Donati et al. 2005, Nature, 438, 466
Donati et al., 2007, MNRAS, 380, 1297
Donati et al., 2008, MNRAS, 386, 1234
Best et al., arXiv:0802.1186
Gregory et al. 2008, MNRAS, 389, 1839
Hussain et al., arXiv:0905.0914
Jardine et al. 2008, A&A, 490, 843
Johns-Krull et al., arXiv:0905.4784
Moutou et al. 2007, A&A, 473, 651
Long, Romanova, Lovelace 2007, MNRAS, 374, 436
Smith et al. 2009, MNRAS, 395, 335

1.1- Project Title: The brightest supernovae in the Universe - high redshift pair-instability SNe

1.2- Project Category: 1

1.3- Abstract:

The recent discovery of ultra-bright type II and Ic supernovae has challenged the paradigms of the deaths of massive stars. With radiated energies 1051, they may be a pair-insability explosion in a star of ~100 solar masses. Their remarkable brightness means they may be detectable out to redshifts ~6 by a combination of ground and space based surveys (LSST, JWST, EUCLID/IDEM). Spectra of candidates are within reach of the E-ELT, which would confirm their redshift and study the Universe's most spectacular explosions, and use them as tracers of the star formation history of the Universe.

1.4- Publication agreement: yes

2.1- PI: Stephen Smartt

2.2- CoIs: Rubina Kotak

2.3- Institute: Queen""""""""""s University Belfast

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: s.smartt@qub.ac.uk

3.1- Source of targets: LSST, JWST, EUCLID/IDEM,

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 23, 25, ABmag, H

3.4- Target size: point source

3.5- Number of targets: 1

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +90

3.8- Moving target?: no

3.9- Variable target?: yes, few per year

3.10- Target type: SN

4.1- Spatial resolution: 10, 2

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4.2- Field-of-view: 1x1arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 1000 - 25000

5.2- Spectral Resolution: 300-500

6.1- Instrument: HARMONI

6.2- Desired special mode: N/A

6.3- Desired AO mode: LTAO

7.1- Integration time per target or field and per setup: 0.5, 6, Range of target magnitudes - uncertain within this range

7.2- Longest continuous observation time on a target or field: 6

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 300

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, Plus LSST, EUCLID/IDEM - any survey that goes deep, wide and red

9.2- Critical aspects / limiting factors for the science case:
Critical factor is finding candidates from wide field, deep, red sensitive surveys

9.3- Detailed description or other comments:

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The discovery of several remarkably bright, H-rich (hence, type II) SNe has reinvigorated the debate of the physical mechanisms that can produce explosions. The first of these ultrabright type II SNe recognized was SN2006gy, followed by SN2005ap, SN2008es, and SN2006tf. The integrated radiated energies are around 1051 ergs and the physical cause of the exceptional luminosity is not yet established. The total energy of these explosions has not yet been measured as the ejecta masses are uncertain, but typical kinetic energies of type II SNe also tend to be of order 1051 ergs. In the case of SN2006gy and 2006tf (IIn SNe), Smith et al. (2007, 2008) propose that the luminosity results from a physically similar process to that which produces II-P SNe lightcurves (as discussed in Section 4) but with extreme values for radial extent and density. The shock kinetic energy is thermalized in an opaque, dense shell (which acts like a photosphere) of radius ~150 AU and mass of ~10—20 M
sol (Smith & McCray 2007). The radius and enclosed mass are too large to be a bound stellar envelope, even when compared to the most extreme RSGs. Thus, Smith et al. (2008) propose that such dense shells were created in LBV-like giant eruptions and mass ejections, within a few years (perhaps up to decades) before final explosion. In this model, the progenitor is required to be a massive LBV, one that is massive enough to have undergone giant outbursts, and by implication, probably greater than 50Msol . Agnoletto et al. (2009) developed a model in which interaction is the luminosity source, with an ejecta mass of 5--15 impacting 6--10 of opaque clumps of previously ejected material. Again this suggests an LBV-type progenitor object.
The other two ultrabright type II SNe (more correctly classed II-L as they show no narrow absorption or emission components) SN2005ap and SN2008es are equally luminous, again with total radiated energies 1051 ergs (Quimby et al. 2007, Miller et al. 2009). Gezari et al. (2009) offer an alternative explanation for SN2008es of a progenitor with a lower mass, extended H-rich envelope (R ~ 6000Rsol) having a steady, dense superwind with mass-loss rate Mdot ~ 10^-3Msol year−1. For SN2005ap, Quimby et al. (2007) suggest the collision shock and thermalization and also the possibility of a jet explosion (GRB-like) within a H-rich massive progenitor.
Lightcurves powered by radioactive decay of 56Ni were also considered (Smith et al. 2007, Gezari et al. 2009), but this requires a huge mass of 56Ni in the ejecta (~20Msol). The sharp decline in the late-time lightcurves and lack of strong [FeII] lines now suggests this is unlikely. Such a large 56Ni mass could only be produced in a pair-instability supernova in which the high temperatures in a massive core (He cores of 40Msol) induces electron-positron pair production. This absorbs thermal energy, and the core collapses further, which results in a further temperature rise and runaway thermonuclear burning in a massive core (Woosley & Weaver 1986; see also Woosley, Heger& Weaver 2002 for the details of the physics involved and review of the history of this idea). In theory, 10—20Msol of 56Ni can be produced and ejected (Heger & Woosley 2002) in a pair-instability supernova or ~5Msol in a core-collapse of a massive star (Umeda & Nomoto 2008). A modification of this mech
anism is pulsational pair instability in which a massive core undergoes interior instability again due to electron-positron pair production (Woosley, Blinnikov & Heger 2007). This leads to an explosion that ejects several solar masses of material, but is not enough to unbind the star. Several pulsational explosions can occur and the collisions between the shells could conceivably produce 1050 ergs. Again, the shock kinetic energy diffuses thermally within an optically thick, high-density, compact sphere. This produces the high luminosity rather than it being due to a large mass of 56Ni. The model of Woosley, Blinnikov & Heger (2007) requires a large core mass from a star of initial mass

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95—130Msol. The collisions between the massive shells produces radiative energies in a similar manner to that dicsussed in Smith & McCray (2007).
The radio lightcurve modulations seen in some SNe have been suggested to be due to the interaction of the ejecta with the progenitor stars' surrounding gas shells, which were ejected in S-Doradus-type variability (Kotak & Vink 2006). This would point to stars that had been in the LBV phase close to the epoch of collapse. Additionally, a direct LBV progenitor was also proposed for SN2005gj to explain the multiple components in the absorption trough of Hα (Trundle et al. 2008). In addtion , the discovery of SN2007bi, an ultrabright type Ic SNe (M_B ~ -21) suggests that these exceptionally luminous explosions also occur in massive Wolf-Rayet progenitors. The physical mechanism that produces the ultrabright type IIn and II-L SNe is still controversial and unresolved. Viable explanations are the explosion of the most massive stars we know, though they still retain a significant H-rich envelope or have recently undergone large mass ejections. Such objects are clearly reminiscen
t of known LBVs in the Local Group. However if their cores can produce pair instability explosions, at solar metallicity it would be an extreme shock to the current theoretical models.

Whatever the cause it seems likely that these ultra-bright type II (and some type Ic SNe) are from the most massive stars. Their remarkable brightness means they may be detectable out to redshifts ~6 by a combination of ground and space based surveys (LSST, JWST, EUCLID/IDEM). For example the EUCLID wide survey will be sensitive to these SNe out to z ≈ 2-4 (at mAB~23-24.6 at JH) and as they bright in the near UV continuum (with exceptionally bright Lyman-α emission) they may be detectable to z ≈ 5 in the Deep fields. Cooke et al. (2009) (and also Cooke 2008) suggest that deep surveys such as Hyper-SuprinmeCam will detect 5-10 z~6 ultrabright IIn SNe and LSST could detect ~4000 z>2 events every years. The deep fields of LSST (and JWST) may detect several tens at z~6 and above.

Their progenitors are proposed to be low metallicity massive stars and ongoing contemporary studies are likely to determine their rate in the local Universe. They may thus provide a complementary measure of the star formation history of the Universe and a probe of the most exotic stellar deaths currently known. Due to their long lightcurve durations (of order a few hundred days), time dilation at z ≈ 2-5 means that normal high cadence observations required for SNe are not required. A small number of revisits (minimum 2) would be sufficient to detect these in significant numbers (possibly a few thousand in the z ≈ 2-3 range and of order 100 at z ≈ 5) and alert large facilities for photometric and spectroscopic follow-up (i.e. JWST and E-ELT).

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1.1- Project Title: Resolved morphologies of z ~ 2 galaxies: unique views on mass assembly at early epochs

1.2- Project Category: 2

1.3- Abstract:
We propose deep near-IR diffraction-limited imaging with E-ELT/MICADO of galaxies at high redshift (z ~ 1 - 3) to map their rest-frame morphologies, stellar populations, and dust content. This will provide the most detailed constraints to date on the processes involved in the stellar mass assembly and early evolution of young galaxies, on scales as small as ~ 60 - 100 pc. This will allow us to investigate the formation of early disks and spheroids, and will provide clues on the formation of globular clusters, thick disks, and spheroids in today""s galaxies.

1.4- Publication agreement: yes

2.1- PI: Natascha M. Forster Schreiber

2.2- CoIs: MICADO consortium

2.3- Institute: MPE

2.4- Country of Employment: DE

2.5- Career Stage: other

2.6- E-mail: forster@mpe.mpg.de

3.1- Source of targets: VLT, VISTA, ALMA (others possible too)

3.2- Preparatory work on targets required?: yes, imaging surveys + spectroscopic redshift follow-up

3.3- Target brightness: 19, 25, Vegamag, K

3.4- Target size: extended source, 100, 2000

3.5- Number of targets: 1000

3.6- Density of targets: 5

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 1x1arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: I, J, H, K

5.2- Spectral Resolution: bbimaging

6.1- Instrument: MICADO

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 4, 10, N/A

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 75

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

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9.1- Synergy with other programmes: ALMA, N/A

9.2- Critical aspects / limiting factors for the science case:
AO PSF stability in time and across full field of view (should be better than 10% variations)
Widest field possible for higher efficiency in surveys of morphologies of high-z galaxies (no less than 40" x 40")

9.3- Detailed description or other comments:
N/A

1.1- Project Title: High-redshift baryons toward quasars and gamma-ray bursts.

1.2- Project Category: 2

1.3- Abstract:
The QSO/GRB absorption-line technique provides a sensitive measure of the gas that is independent of redshift and brightness of both the background source and the absorber host-galaxy. How do extreme environments affects gas accretion? So far this problem has been studied by selecting absorbers and then following up the line-of-sight environments; but there have been no systematic studies in the reverse direction, that is, by selecting the
environment and then looking for the absorbers. The "Quasars behind Clusters" (QbC) Survey is a new and long-term program that has delivered its first results on the the effect of group and cluster-size environment on the gaseous content of high-redshift galaxies. In the next few decades surveys like the LSST will have provided massive numbers of galaxy clusters and GRB/QSOs suitable for extending such an experiment on the future E-ELT and thus test scenarios of galaxy evolution and its interplay with dark matter with exquisite accuracy..

1.4- Publication agreement: yes

2.1- PI: Sebastian Lopez

2.2- CoIs: The QbC Collaboration

2.3- Institute: Universidad de Chile

2.4- Country of Employment: CL

2.5- Career Stage: faculty

2.6- E-mail: slopez@das.uchile.cl

3.1- Source of targets: LSST

3.2- Preparatory work on targets required?: yes, cluster photo-z confirmation

3.3- Target brightness: 20, 25, Vegamag, B

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy cluster, IGM, AGN, GRB

4.1- Spatial resolution: seeing, 5

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 300 - 1000

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: CODEX

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.5, 1, N/A

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7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 1800

7.4- Total time: 75

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: other, LSST

9.2- Critical aspects / limiting factors for the science case:
Spectral resolution

9.3- Detailed description or other comments:
In times when cosmology suspiciously appears to be a solved problem of modern astrophysics, most of the efforts nowadays concentrate on improving our still poor understanding of galaxy formation and evolution. With no doubt, powerful new instrumentation has led to great observational advances in understanding galactic-scale gas accretion and outflows. However, most of the baryons involved in these galaxy/intergalactic-medium feedback mechanisms are in form of gas (e.g., Fukugita, Hogan \& Peebles 1998) that is far too diffuse to be observed in emission. Instead, this gas can be detected via the absorption it imprints into the spectra of bright background sources like quasars (QSOs) and Gamma-Ray Burst (GRB) optical afterglows.

This project is based on the QSO/GRB absorption-line technique to probe the metal-rich gas at different redshifts and environments. The main goal is to provide clues to models of galaxy formation and evolution.

The rich environments of galaxy clusters set extreme conditions for galaxies and their evolution, and therefore differences from field galaxies are expected. However, due to the lack of high-redshift cluster datasets, one of the most promising ways of studying galaxies and their interstellar medium, through the absorption-line technique, has not been used in a systematic fashion. With tens of thousand QSO-Cluster pairs obtained from cross-correlating the RCSand SLOAN datasets, the QbC survey has open for the first time the possibility of using this technique to probe the cold halos of high-redshift cluster galaxies. By obtaining additional high resolution spectra Lopez et al. (2008) showed that dN/dz for strong systems in clusters is enhanced with respect to the field, while the weak absorber population is consistent with the field galaxies. This was interpreted as the signature of violent cluster-galaxy and galaxy-galaxy processes that destroy the weak absorber halos, while keeping the more shielded, stronger absorbers. Given the observational constraint on dN/dz, the sizes of these truncated halos were estimated using simulations of dark matter halos (Padilla, Lacerna, Lopez et al. 2009).

The mid-term goals of the QbC are to Identify absorber redshifts, expand the survey to the more recent RCS and SDSS data releases, and use this large imaging and spectroscopic dataset to study gravitational lensing of the QSOs. However, in the next few decades surveys like the LSST will have provided massive numbers of galaxy clusters and GRB/QSOs that will be suitable for extending such an experiment with exquisite accuracy. With many QSO/GRB lines of sights per cluster, far too faint for current spectroscopy on 8m telescopes, we will be able to probe the dark matter through not only the cluster-centric dependence of the absorption properties of the gas, but also its transverse structure around the cluster galaxies.

1.1- Project Title: Pulsars – An Exemplar of Extreme Physics

1.2- Project Category: 1

1.3- Abstract:

Pulsars, rapidly rotating magnetised neutron stars, represent normal matter at its most extreme in terms of temperature, magnetic field and density. Furthermore they are surrounded by a ultra-relativistic plasma with Lorentz factors exceeding 1010. Optical observations of pulsars are limited by their intrinsic faintness but it is these observation which are likely to reveal the most about the physics and hence astrophysics of pulsars. Consequently the E-ELT era will potentially revolutionize our understanding of pulsars.

1.4- Publication agreement: yes

2.1- PI: Andy Shearer

2.2- CoIs: Opticon HTRA Network

2.3- Institute: Centre for Astronomy NUI, Galway

2.4- Country of Employment: other

2.5- Career Stage: faculty

2.6- E-mail: andy.shearer@nuigalway.ie

3.1- Source of targets: VLT, VISTA, ALMA, SKA

3.2- Preparatory work on targets required?: yes, pre-imaging survey

3.3- Target brightness: 24, 30+, Vegamag, R

3.4- Target size: point source, 100, 1000

3.5- Number of targets: 100+?

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +90

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: N/A

4.1- Spatial resolution: diffraction, 1

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 1, 100

5.1- Wavelength range: 600 - 2500, R

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5.2- Spectral Resolution: bbimaging, nbimaging

6.1- Instrument: MICADO

6.2- Desired special mode: precision photometry, precision astrometry, polarimetry, photometry and polarisation has to be time resolved

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 5, 10, N/A

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: 0.001

7.4- Total time: 100+

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, 10000+

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
This study will need detectors capable of measuring down to 1 millisecond as well as instruments capable of measuring thepolarisation of faint signals (m_R~ 29) at the 1% level.

9.3- Detailed description or other comments:
Background
Neutron stars represent normal matter at its most extreme. Their surface temperatures are in excess of 106 K; their surface magnetic field can be as high as 1015 G and their average density is approximately the same as the atomic nucleus. Pulsars, rotating neutron stars with an active magnetosphere, are also responsible for powering supernova remnants and providing a mechanism for generating the highest energy cosmic ray particles and gamma rays. It is thought, from energetic considerations that the 'spin-down' energy of the pulsar is responsible for both the pulsar emission

and for the powering any associated pulsar wind nebula. The canonical model for creating a pulsar is that they are the by-product of a Type II supernova. However the story is complicated by an incomplete knowledge of pulsar statistics – how many are there? What is the beaming geometry and hence what effect will this have population statistics – Fermi for example has already detected a number of
'radio-quiet' pulsars. Many supernova remnants do not have a central pulsar, e.g. Cas A that has a condensed central object (CCO) but its nature is not known. Another class of pulsar – anomalous X-ray pulsars (AXPs) do not have sufficient spin energy to account for their X-ray luminosity. Their inferred magnetic field strength is high (up to 1015 G) and it is the decay of this field that is thought to power the pulsar[1][2]. AXPs from their association with supernova remnants are presumed to young objects. Consequently the canonical model is too simplistic – how many pulsars are borne as AXPs? As normal radio pulsars? As CCOs ? Or of other as yet unknown condensed objects?
Pulsars are normally detected at radio wavelengths (nearly 2000 known) although increasingly higher energy observations, such as from Fermi/GLAST, have shown to be important for understanding their nature. In the optical/near IR bands very few pulsars have been detected to date [4] – primarily due to their intrinsic faintness however it is expected that over the next decade the number of pulsars detected in the optical will increase – in no small part due the number of Fermi detections. From optical data we can determine a number of crucial aspects of the behaviour of the pulsar magnetosphere. From the energy spectrum we can infer, by assuming the radiation is of synchrotron origin, the energy spectrum of the emitting electrons and the wavelength where synchrotron self-absorption takes place - expected to occur in the near infrared. From polarisation data we can infer the location in the magnetosphere where the radiation originates - again we assume a synchrotron origin a
nd that the structure of the magnetic field is a retarded dipole. Ideally to extract this information through optical observations we need instruments and detectors that are sensitive from B band through to 2 microns and that these instruments measure the polarisation on timescales of < 10 milliseconds. [3][4]

Normal Pulsars

We estimate, see figure sent by separate e-mail and talk given at the ESO DRM workshop in May 2009, that there are about 20 radio pulsars that could be detected by the E-ELT. Furthermore we expect this number to have doubled by 2018 through the results of the Fermi mission. From E-ELT observations we would address the following pulsar problems

1. What is the geometry of the optical emission region?
2. What fraction of gamma ray pulsars are also optical emitters?
3. How does the efficiency of the optical emission compare with gamma ray efficiency?
4. What are the links between radio pulsars and optical pulsars – initially through comparisons between the polarisation sweep in the optical and in the radio as well as studies of giant radio pulse emitters.

>From these studies we will have a better appreciation of the both physics of the ultra-relativistic plasma surrounding and active pulsar as well as a better understanding of the pulsar astrophysics. The optical / near-IR observations are important as it is here that we directly probe the energy spectrum of the emitting plasma and we can also measure all Stokes parameters leading to its full characterisation – intensity, linear/circular polarisation and time.

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Other classes of pulsars
Magnetars have already been observed in the optical and near-IR leading to significant constraints on their emission mechanism [5] in the E-ELT era these studies can be consolidated with a detailed understanding of their light curves and the polarisation profiles. These observation will lead to a better understanding of the behaviour of plasmas under the influence of extremely strong magnetic fields. Other classes of pulsar - CCOs, SGRs and transient pulsars might also be optical emitters but are likely to be faint objects.
Extra Galactic Pulsars
The E-ELT raises an intriguing possibility of observing extra galactic pulsars out to a distance of about 3 Mpc. Such observations would be carried out in a two-stage process. Firstly identify young supernova remnants [5] through near-IR Fe[II]/ Pa_alpha and radio observations (ALMA?, SKA?) and then carry out time resolved optical/near-IR observations to search for the pulsar – the Crab pulsar for example would be at m_V~29 at M31. Such a study would enable a determination of SNR / CCO statistics from a uniform population and in this way look towards understanding the nature of type II supernovae.
References
[1] Mereghetti, Sandro, Recent results on magnetars, : arXiv:0904.4880 (2009)
[2] Mereghetti, Sandro, The strongest cosmic magnets: soft gamma-ray repeaters and anomalous X-ray pulsars, Astronomy and Astrophysics Review, Volume 15, Issue 4, pp.225-287 (2007)
[3] Shearer et al, High Time Resolution Astrophysics and Extremely Large Telescopes, in HIGH TIME RESOLUTION ASTROPHYSICS: The Universe at Sub-Second Timescales. AIP Conference Proceedings, Volume 984, pp. 225-232 (2008)
[4] Shearer, Andy, High Time Resolution Astrophysics and Pulsars, in High Time Resolution Astrophysics, Astrophysics and Space Science Library, Vol. 351. Edited by D. Phelan, O. Ryan, and A. Shearer. Berlin: Springer, 2008. ISBN 978-1-4020-6517-0, 2008, p.1
[5] Dhillon et al, Optical pulsations from the anomalous X-ray pulsar 1E1048.1-5937, MNRAS, 394, L112
[6] Alonso-Herrero et al, The [Fe II] 1.644 Micron Emission in M82 and NGC 253: Is It a Measure of the Supernova Rate?, AJ, 125, 1210 (2003)

1.1- Project Title: Exozodiacal discs: characterising the inner parts of planetary systems

1.2- Project Category: 3

1.3- Abstract:
Directly detecting the innermost parts of planetary systems faces two main challenges: angular resolution and dynamic range. Exozodiacal discs, which are direct tracers for the presence of

planets and planetesimals in habitable zones, can currently not be detected at densities below about 300 times the density of our solar system's zodiacal disc. A high dynamic range imaging capability on the ELT could provide the required performance to characterise such discs with an unprecedented accuracy. This would not only provide crucial information on the global architecture of planetary systems, but also help prepare future space missions dedicated to Earth-like planet imaging.

1.4- Publication agreement: yes

2.1- PI: Olivier Absil

2.2- CoIs: J.C. Augereau, D. Defrère, C. Hanot, J. Surdej

2.3- Institute: University of Liège

2.4- Country of Employment: BE

2.5- Career Stage: postdoc

2.6- E-mail: absil@astro.ulg.ac.be

3.1- Source of targets: Spitzer, Herschel, JWST

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 0, 7, Vegamag, K

3.4- Target size: extended source, 5, 100

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 5, 2

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: K, L

5.2- Spectral Resolution: bbimaging

6.1- Instrument: MICADO, EPICS, METIS

6.2- Desired special mode: coronography, other, Aperture masking / pupil remapping

6.3- Desired AO mode: XAO

7.1- Integration time per target or field and per setup: 0.1, 1, accumulation of short integrations in BURST-like mode

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 0.001

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
The main requirement for this programme is to reach the highest possible dynamic range at the full angular resolution of the telescope.

9.3- Detailed description or other comments:

To reach the highest possible dynamic range in diffraction-limit observations, one very promising technique consists in remapping the pupil in a non-redundant way with single-mode fibers (see e.g. Perrin et al. 2006, MNRAS 373). This is an evolved version of the aperture masking mode that is nowadays implemented at several large telescopes (VLT/NACO, Keck, Gemini, Palomar). Laboratory experiments have recently been carried out to validate this concept (e.g., Kotani et al. 2009, Optics Express 17(3)). In addition to the detection of exozodiacal discs, this technique has the potential to directly detect planets themselves in the innermost parts of planetary systems, with a potential dynamic range up to 1.000.000:1. Note that an interferometric mode on the ELT could be implemented early-on, when the pupil is not yet completely filled with mirrors.

Note that this programme could also (partly) be carried out using a coronagraphic mode on one of the following instruments: MICADO, EPICS and METIS. Diffraction-limited imaging is then necessary, i.e., most probably using extreme adaptive optics.

This programme would most conveniently be carried out in the K or L bands, where warm dust produces thermal emission while the thermal background from the Earth"s atmosphere is not too bright. Longer wavelengths could also be considered, still. By observing a large number of targets (~100 among the hundreds of nearby stars around which cold dust has already been searched for with Spitzer, Herschel or JWST), this observing programme could provide a first good statistical knowledge of bright exozodiacal discs, and help understand the connection between outer Kuiper-belt-like discs and inner exozodiacal discs. This would considerably improve our understanding of the global architecture and history of mature planetary systems, including dynamical events such as planetary migration, Late Heavy Bombardments, etc.

Furthermore, the characterisation of exozodiacal discs has been recognised by NASA"s Exoplanet Task Force as one important pre-requisite to the direct imaging of Earth-like planets.

1.1- Project Title: GRBs as tracers of massive star formation - spatially resolved GRB host spectroscopy

1.2- Project Category: 2

1.3- Abstract:

In recent years it has become clear that gamma-ray bursts (GRBs) form excellent probes of starformation in faint dwarf galaxies: in afterglow spectra the signatures of ISM, shells around OB associations, outflows from the host and even the circumburst medium (a few parsecs from the progenitor) can be identified. Through the immense UV output of GRBs, unstable fine-structure lines are excited, whose subsequent decay form a powerful way to derive 3-dimensional

information. We propose to couple these properties to emission properties of the starforming regions produceing the GRB, by using the resolving power of e-ELT. In turn this will greatly aid our understanding of the evolution of GRB progenitors and massive stars in general.

1.4- Publication agreement: yes

2.1- PI: K Wiersema

2.2- CoIs: N/A

2.3- Institute: University of Leicester

2.4- Country of Employment: UK

2.5- Career Stage: postdoc

2.6- E-mail: kw113@star.le.ac.uk

3.1- Source of targets: VLT, Gemini, UKIRT, WHT

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 22, 27, Vegamag, R

3.4- Target size: extended source, 100, 2000

3.5- Number of targets: 10

3.6- Density of targets:

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: ISM

4.1- Spatial resolution: 75, 2

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

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4.4- Plate scale stability: .,

5.1- Wavelength range: R, 400 - 2000

5.2- Spectral Resolution: 500-1000

6.1- Instrument: MICADO, HARMONI

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 3, current observed GRB host galaxy luminosity function

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 16

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, VLT for primary target selection

9.2- Critical aspects / limiting factors for the science case:
access to red optical wavelengths (~500nm - 1 micron) to detect the relevant starfoirming region emission lines (H alpha, [O III], [NII], [SII])

9.3- Detailed description or other comments:
Long-duration gamma-ray bursts (GRBs) are related to energetic type Ib/c core-collapse supernovae.
We now have a rough picture of the origin of GRBs: through a catastrophic event (the SN), a jet of highly relativistic material is ejected. When this outflow slams into the circumburst medium, it

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gives rise to the "afterglow". Whereas we can study the physics of the bright afterglow in detail, the precise nature of the progenitor is more difficult to unravel. The requirement of no stellar envelope at collapse (to avoid the jet from being smothered) as well as a large amount of angular momentum in the stellar core (enough to form an accretion process at core-collapse to produce the relativistic jet) narrows down the family of progenitor models considerably. The most recent, highly advanced numerical models consistently point to rapidly rotating, low metallicity massive stars as GRB progenitors, through a rather exotic evolutionary channel involving highly effective chemical mixing within the star, particularly effective at low metallicity.

But how can we study GRB progenitors observationally - their average redshift is 2.8? The answer lies in host galaxy properties: we can test the low metallicity requirement of GRB progenitors by measuring metallicities of GRB hosts; we can get lifetime constraints from the redshift distribution of GRBs; or lifetime constraints from the age of the dominant stellar population in GRB hosts; or from positions of GRBs in their hosts etc. etc.

These same datasets give us more insight into starformation in dwarf galaxies as well: GRBs occur in low mass, starbursting dwarf galaxies which are often missed in flux-limited surveys. Often we can acquire highly detailed information on the ISM in the host, as well as the properties of the circumburst medium, from aftegrlow spectroscopy. In these spectra we frequently detect unstable fine-structure lines of Fe II, Si II, C II, O I - excitations that are seen to decay within hours. These transitions can be linked to the extreme UV output of GRBs, exciting these transitions through indirect UV pumping. Through these transitions we can acquire highly detailed, quantative information on these dwarf irregular host galaxies: a 3D picture of the gas temperature, density and abundances as a function of distance to the burst can be formed from several parsecs to kiloparsecs from the burst. This is particularly important as the bulk of starformation at low redshift takes place in these type of galaxies It is still unclear what triggers the sudden star formation in those small starbursts, and how feedback through galactic winds influences these galaxies. GRB spectra fill in the blanks, as they accurately probe the starforming regions in their hosts.

To quantify relations between GRB progenitors and their hosts, and to couple the absorption properties measured in GRB afterglow spectra to properties in emission we need to measure: (1) abundances (as local as possible to the burst), (2) the starformation history in the host (starburst or continuous) and the position of the GRB with respect to the starforming regions, and (3) the massive star properties (e.g. WR/O star ratio) from emission line fluxes. These three properties give input to numerical progenitor models, and can even be used to fine-tune the progenitor properties of specific bursts.

In this proposal we aim to answer the following 3 key questions:

1) Do GRB hosts from their massive stars through a (merger induced) starburst or more gradually? Are the starforming regions forming GRBs "special"?
2) Are the GRB afterglow spectra good tracers of host galaxy properties?
3) How do GRB and supernova environments compare? Why do not all SNe form a GRB?

We propose to use e-ELT to detect starforming regions in low-redshift GRB hosts, and take spatially resolved spectra to answer the questions above.

1.1- Project Title: Very distant galaxies observed through gravitational telescopes

1.2- Project Category: 2

1.3- Abstract:
We propose to use the natural magnification provided by lensing clusters to study the formation and evolution of lebsed distant galaxies at 1<z<5, discovered as giant arcs and arclets, with great details. Multi-Object IFU spectroscopy with EAGLE will allow us to resolve HII regions of physical scales < 200 kpc and, in the study of the resolved velocity structures in these galaxies will help us understand their mechanism of formation. Remaining IFUs will survey the highest magnification region near the critical lines in order to search for magnified emission line objects at z>7

1.4- Publication agreement: yes

2.1- PI: Johan Richard

2.2- CoIs: Mark Swinbank, Jean-Gabriel Cuby, Jean-Paul Kneib

2.3- Institute: ICC, Durham

2.4- Country of Employment: UK

2.5- Career Stage: postdoc

2.6- E-mail: johan.richard@durham.ac.uk

3.1- Source of targets: VLT, SDSS, PanStarrs

3.2- Preparatory work on targets required?: yes, lensing cluster models

3.3- Target brightness: 21, 23, ABmag/arcsec2, J

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3.4- Target size: extended source, 1000, 10000

3.5- Number of targets: 20-50

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: 100, 2

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: 40, 5x5arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: J, H, K

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: EAGLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: MCAO

7.1- Integration time per target or field and per setup: 8, 8, seeing 0.8

7.2- Longest continuous observation time on a target or field: 8

7.3- Shortest integration time on a target or field: 1800

7.4- Total time: 400

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 25

7.6- Are the observations time critical?: no

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8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
IFU packing at the center of the cluster (especially for the critical line mapping)

9.3- Detailed description or other comments:
Not only are galaxy clusters important laboratories for studying galaxy and structural evolution in their own right, but their virial mass (~>1015 Msol) and high concentration make them act as gravitational telescopes}, magnifying distant galaxies which serendipitously lie behind them. This natural magnification can be upto a factor of 50x in flux (a boost of over 4 magnitudes), allowing us to probe much fainter limits and much further down the luminosity function than otherwise possible. The boost in flux of lensed galaxies is accompanied by a gain in spatial scale (the galaxies are stretched due to the magnification). This allows a more detailed study of the internal properties than otherwise possible. Even with current technology, some of the most detailed studies of galaxies at z=3--5 have come from studies of highly magnified objects, even reaching spatial resolutions of 100pc in the source plane - thus beginning to resolve giant Hii regions.

Gravitational lenses are therefore key targets for ELT. The additional magnification of the source due to the lensing effect boosts the
effective performance of the telescope since gains are made to both the brightness of the source and the effective resolution. In particular,
even for conservative lensing magnifications of a factor 10x, the effective diffraction limit of the telescope is reduced by a factor
three. This gives EAGLE the potential of resolving individual Hii regions down to below
100-200pc resolution in the target galaxy
(conservatively assuming the AO delivers 100mas PSF or better). Since the Hii regions already have high contrast in their emission lines, the gain in sensitivity pushes the telescope performance into a new regime. The combination of EAGLE and the gravitational lens results delivers the performance that could only be achieved by a 300m telescope!

EAGLEs multiple IFU strategy is ideally suited to this application. For example, the multiIFUs can be configured to target all of the giant arc
in the cluster in a single exposure. At the same time, the central contiguous IFU can be used to target the caustic region in search for
first light (z=7-20) galaxies, and the smaller IFU units can be used to gather redshifts for faint arclets in order to accurately define the

cluster lensing potential.

These targets naturally fall into two distinct science classes:

-z=1-5: The epoch of galaxy formation.

Most of the stars in the universe are formed at this epoch. 8-10m telescopes are allowing us to probe the global properties at these early times, and to map the demographics of the galaxy population. However, to find out how and why galaxies differ so much from their local counterparts, we need to study the internal structure of galaxies, observing their star forming regions, their chemical abundance details and dynamics. All this will allow us to establish how and why galaxies differ so much from the present day.

The magnification provided by gravitational lensing boosts the sizes of distant galaxies allowing individual Hii regions to be identified. While the lenslet size of 10mas corresponds to ~600pc at z>2, the boost of gravitational lensing allows us to see in much more detail. Linear magnifications of a factor 3 (ie., factor 9 boost in flux) are typical. Such objects, LBGJ2135-0102 (aka the ``cosmic eye""") are clearly resolved in both dimensions, and are not so distorted that we cannot reconstruct the original galaxy morphology.

Thus lensing magnification allows us to achieve a source-plane ~100pc per element. This resolves individual Hii regions which have typical sizes 20-200pc in galaxies in the local Universe (Gonzalez et al. 1997). The strategy is complementary to "field" galaxy
studies since the number of targets is limited (few 100).

- First Galaxies - critical line mapping

Although the first galaxies are intrinsically faint, fortuitous alignment of the gravitational lens allows us to resolve them in detail. The greater distance to these objects can be offset using systems with greater intrinsic magnification. Thus the lensing boost enables the detection of the most distant galaxies at even higher redshift. Detection is possible by the Ly-alpha emission line even if continuum is too faint for detection.

Magnification boosts of $\times10-50$ are possible near the critical line, the theoretical locus of points in the image plane corresponding to the caustic of infinite magnification. By co-ordinating IFU observations along the critical curves, it is possible to search for magnified high redshift galaxies with observed (lensed) Ly-alpha fluxes of 10-18 ergs/s/cm2 allowing for detailed spectroscopic follow-up. Systematic searches along these curves will rely on the ability to create contiguous fields with minimum pointings.

Although there is an increase in flux there is a corresponding decrease in area, and therefore an overall change is the total
number of objects (depending on the shape of the faint end slope of the LF). The most massive and best studied clusters in the local universe have Einstein radius of ~20-50" By mapping the entire

critical line with EAGLE IFUs, the total area covered intrinsically in the source plane at very high redshift corresponds to ~0.2-0.4 arcmins-2.

-Requirements:

Observing setup: The most massive clusters with the largest Einstein radii and the best constrained mass models will have (by selection) the most giant arcs/arclets, and ""spare"" IFUs can be placed on the highest magnification region near the critical line -- tackling the problems above. The typical magnitudes of the giant arcs/arclets is 21-23 mags/arcsec2, and therefore a signal-to-noise sigma>5 can be reached in the J band continuum in ~8 hours based on the E-ELT ETC (assuming 0.8"""" seeing, airmass=1.15, individual exposures of 0.5 hrs, an extended source and R=4000 spectral resolution). For the critical line mapping, the same exposure time reaches line fluxes <10-18 between the OH lines, allowing to search and resolve highly magnified Lyman-alpha lines.

The number of arcs and arclets suitable for the proposed science is ~10-20 per cluster field (e.g. Richard et al.09), with an additional ~20 IFUs placed on the critical curves. The accurate location on the sky of these critical lines can only be determined in the case of clusters for which detailed mass models are available. This is now the case of 50 massive clusters, which could be observed for 8 hours each, making a total exposure time of 400 hours.

Object sampling and IFU packing: Objects are more tightly packed in the clusters case, and contiguous area mapping is clearly desired. Furthermore, the Einstein radius of the most massive clusters known is <50"""" and so the field of view required is much smaller. The aim is to be able to pack the IFUs into such a small area.

Filter combinations: In both the field and cluster case, there is a strong case for needing different filters behind each IFU. If the science case is both high-z galaxy formation (arc/arclets) as well as first light galaxies, then the targets span a range of redshifts from z~2--20. At z~2--5 nebular emission ([Oii], Hbeta, Halpha) fall in JHK whilst for z=6--20 Ly-alpha is covered from I to K-band.

Object size: the angular extent of lensed galaxies ranges from unresolved (first galaxies at the highest redshifts) to ~10-20"""" (z=1--5 giant arcs).

1.1- Project Title: Spectroscopy of massive stars at extremely low metallicity

1.2- Project Category: 3

1.3- Abstract:
The evolution of massive stars at low-metallicity is of key importance to understand the early evolution of the universe, including its re-ionization, galaxy formation, and chemical evolution of young galaxies and of the intra-galaxy medium. Also, low-metallicity massive stars have been proposed to be progenitors of long-duration gamma ray bursts. We propose to use the E-ELT to study the massive star population of IZw 18, the lowest metallicity galaxy known so far in the local Universe. This will provide unprecedented observational constraints to calibrate the evolution of high-mass stars, in a metallicity regime that has been unaccessible so far.

1.4- Publication agreement: yes

2.1- PI: A. de Koter

2.2- CoIs: C. Evans, H. Sana, N. Langer, D. Lennon, J. Puls, A. Herrero, J. Vink

2.3- Institute: Amsterdam University

2.4- Country of Employment: NL

2.5- Career Stage: faculty

2.6- E-mail: A.DeKoter@uva.nl

3.1- Source of targets: NED

3.2- Preparatory work on targets required?: yes, Pre-imaging with spatial resolution of 10mas

3.3- Target brightness: 22, 24, Vegamag, I

3.4- Target size: point source

3.5- Number of targets: 30

3.6- Density of targets: N/A

3.7- Target coordinates: RA:09 - 10;Dec:55 - 55

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 10, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 500 - 2500

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: MICADO, HARMONI

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 4, 4, 0.8" seeing, airmass 1.15, E-ELT ETC (Spectroscopy) v2.14

7.2- Longest continuous observation time on a target or field: 4

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 32

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, 2E5

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:

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Spatial resolution (thus AO): 10mas, system throughput (collecting area+ global efficiency) to reach requested SNR

9.3- Detailed description or other comments:
The evolution of zero- and low-metallicity massive stars is fundamental to understand star- and galaxy-formation in the early universe, long-duration gamma ray bursts and and chemical evolution of young galaxies.

To be able to predict the properties and evolution of massive stars at cosmological distances it is fundamental to understand how global properties (e.g. luminosity, mass and rotation rate) and atmospheric properties (e.g. surface temperature and chemical composition) of massive stars determine the strength of their stellar winds and amount of ionizing radiation. Using this empirical information, theoretical predictions towards extremely low metal contents may be calibrated.

For progress towards this goal, massive O, B, LBV and WR stars in the Large and Small Magellanic Clouds have been studied intensively in the past decades (e.g., Hunter et al. 2007, Mokiem et al. 2007, Trundle et al. 2007). With the latest generation of 8-10m class telescopes massive stars in more distant dwarf galaxies can now be studied, allowing us to probe a wider span in environmental properties, albeit so far at a low spectral resolution and mostly within the Local Group (e.g., Bresolin et al. 2007, Evans et al. 2007). Though quite a number of exciting objects have been identified, detailed quantitative spectroscopic analysis have remained cumbersome for obvious reasons: low SNR and modest spectral resolution, complicating (or preventing) among others the correction for nebular emission.

Although some improvements are expected thanks to the 2nd-generation of instruments on the VLT, the current/close-future instrumentation will not be capable of significantly extending the range of metallicity where quantitative spectroscopic analysis of resolved high-mass stars is possible. The reason for this is simple: low-metallicity galaxies in the nearby Universe are still to far away so that both the spatial resolution and the sensitivity are critically lacking.

With Z~0.02 Zsun, IZw18 is the lowest-metallicity galaxy now sow far in the local Universe (Skillman & Kennicut 1993). The study of its massive star content will provide unprecedented observational constraints to confront and calibrate the evolutionary models of high-mass star, in a metallicity regime about one order of magnitude lower than typically accessible so far. Isolating individual massive stars at the distance of IZw18 (18 Mpc, Aloisi et al. 2007) will typically require a spatial resolution of 10~mas, which can only be achieved using ELT-class telescopes with full AO support.

The proposed program will be executed in two steps. A pre-imaging campaign will allow us to resolve the high-mass stellar population, and to identify its massive star population (based on color information). Given the size of IZw18 (approx 20 arcsec), is is perfectly suited for the field-of-view of MICADO, although the pre-imaging could possibly be done with the JWST. Using the E-ELT

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ETC, we estimated that the pre-imaging with MIKADO can be executed within 1 hour integration time (3 to 4 filters).

HARMONI Low-Resolution mode will then be used to acquire integral-field-spectroscopy of the most interesting region of the galaxy, allowing us to collect in a few exposures visible to NIR spectra of 20 to 50 high-mass stars. Using the E-ELT ETC for spectroscopy, we estimated that a SNR of 30 can be reached in about 4h at spectral resolving power of 5000 for I=23mag stars (corresponding to the expected most-massive stars in IZw 18).

1.1- Project Title: The Role of Active Galactic Nuclei in the Growth of Galaxies

1.2- Project Category: 2

1.3- Abstract:

Once considered rare and exotic phenomena, AGNs are now thought to play a crucial role in the formation and evolution of galaxies. Key observational evidence for this is the finding that every nearby massive galaxy harbours a central super-massive black hole with a mass directly proportional to that of its spheroid. This discovery indicates that all massive galaxies have hosted AGN activity at some time over the past ~13 Gyrs and that galaxies and their SMBHs grew concordantly, despite nine orders of magnitude difference in size scale. This observation program aims at exploring how SMBHs grow and the mechanism that regulates the SMBH–galaxy spheroid relationship across a wide range of redshifts, luminosities, and host-galaxy types.

1.4- Publication agreement: yes

2.1- PI: D.M. Alexander

2.2- CoIs: Y. Clenet, M. Lehnert, M. Puech

2.3- Institute: Durham University

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: d.m.alexander@durham.ac.uk

3.1- Source of targets: Chandra, XMM, VLT, JWST, LOFAR, ALMA, Spitzer, Herschel

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 17, 24, Vegamag, K

3.4- Target size: extended source, 100, 1000

3.5- Number of targets: 1000

3.6- Density of targets: 2

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: AGN

4.1- Spatial resolution: 75, 2

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: 20, 2x2arcsec

4.4- Plate scale stability: 1, 1200

5.1- Wavelength range: 700 - 2500

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: EAGLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 2, 10, 0.8" seeing, airmass 1.15", MOAO PSFs and using M Puech"s websim simulator

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 600

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, VLT/VLTI, SKA/SKAPF, ALMA, VLT, JWST can assist in obtaining redshift information while JWST and SKA can assist in identifying AGNs based on infrared and radio observations

9.2- Critical aspects / limiting factors for the science case:
To accurately constrain the energetics of outflows, black hole and bulge velocities, it is necessary to take long high-resolution observations. Multiplex instruments therefore provide the most time efficient approach to gather sufficiently detailed information on large samples of objects to provide statistically significant results.

9.3- Detailed description or other comments:
Undoubtably one of the most significant astronomical discoveries over the last decade is the finding that every massive galaxy hosts a supermassive black hole (SMBH; typically >106 M_sol) with a mass directly proportional to that of its spheroid (e.g., Tremaine et al. 2002). These seminal results imply that the growth of SMBHs and their galaxy spheroids were connected in some way, despite nine orders of magnitude difference in size scale! Exploring how SMBHs and spheroids grow, and the mechanism that regulates the tight M_BH-M_SPH relationship, is one of the fundamental goals of observational cosmology and a prime driver for the development of many new observatories and structure-formation models.

The most likely mechanism to regulate M_BH-M_SPH growth is AGN-related winds, jets, and outflows, which provide an "arm" for the black hole to orchestrate star formation in the host galaxy through feedback effects (i.e., heat/radiation pressure; shocks/mechanical energy). For example, leading models of galaxy formation have shown that large-scale outflows, originally launched in the vicinity of the SMBH, can liberate sufficient energy (of order 1057-1061 ergs) to unbind gas from the host galaxy, terminating star formation. However, the identification of large-scale outflows in the distant (z>0.5) Universe, when these processes were believed to be most important, are limited to a few bright objects (e.g., Nesvadba et al. 2006, 2007, 2008). It is therefore far from clear how ubiqitious large-scale outflows are and, hence, it is also far from clear whether AGN-related

outflows were instrumental in controlling the growth of galaxies. Furthermore, it also isn"t clear whether th
e M_BH-M_SPH ratio has remained constant throughout cosmic time or whether the growth of the SMBH significantly leads or lags that of the galaxy spheroid. Several studies have suggested that the M_BH-M_SPH ratio is higher in the high-redshift Universe than found localy (e.g., McLure et al. 2006; Peng et al. 2006); however, these studies have focused on objects known to host massive SMBHs and therefore could be strongly biased toward this result (e.g., Lauer et al. 2007).

Therefore, although understanding the origin and regulation of the M_BH-M_SPH relationship remains a key goal in observational cosmology, we lack good-quality observational constraints to address this issue and distinguish between the large number of potential models. However, obtaining the key observational constraints to determine the ubiquity and energetics of large-scale outflows, and trace the relative M_BH-M_SPH growth, is far from trivial and requires extremely sensitive high-resolution instrumentation (the primary reason for the current lack of good-quality constraints). Large-scale energetic outflows are probably most efficiently identified using integral-field units (IFUs) since they provide spatially resolved spectral information, which can yield unprecendeted constraints on gas kinematics over (sub-)kpc scales. Sufficiently high spatial and spectral resolution IFU observations also allow for the gravitational-bound spheroid/galaxy component to be disentangled from
that of an energetic outflow, providing direct constraints on both the host-galaxy mass *and* the outflow energetics. SMBHs can also be indirectly "weighed" using the so-called "virial" black-hole mass estimator (e.g., Kaspi etal. 2000), which provides SMBH masses on the basis of the broad emission-line width and AGN luminosity.

The key focus here is to outline the case for a study to explore the ubiquity of large-scale outflows and constrain the relative M_BH-M_SPH growth over the redshift range z~0.5-3.5, where ~75% of the cosmic stellar growth has occurred. Since AGN signpost sites of SMBH growth, the main targets for this study are distant AGNs. To provide definative constraints on the ubiquity of large-scale energetic outflows and SMBH-spheroid growth it is necessary to observe typical AGNs rather than rare luminous quasars. Currently, the most efficient identification of typical AGNs is made with sensitive X-ray surveys, which select AGNs in an almost obscuration-independent manner; future deep radio and infrared surveys (e.g., LOFAR, SKA, and JWST) will also find large numbers of AGNs, which would also be targeted. For example, in the deepest 2Ms Chandra surveys (e.g., Alexander et al. 2003; Luo et al. 2008), even moderate-luminosity AGNs are identified out to z~2-5, yielding overall AGN sourc
e densities of order ~5000-10,000 deg-2. The expected host galaxy (and SMBH masses) of these systems are of order M_GAL~1010-1012 solar masses (M_BH~107-109 solar masses), corresponding to those of typical massive galaxies. These parameters drive the need for the following instrumentation:

* spectral resolution of R>3000, to allow for the measurement of the velocity dispersion of galaxies with M_SPH~1010 solar masses (v~100 km/s) and comparatively low-level outflows (e.g., to identify outflow energies of 1043 erg/s over 5 kpc)

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* spatial resolution of <0.1 arcsec to allow outflow and galactic kinematics to be traced on sub-kpc scales (e.g., 0.05 arcsec corresponds to ~300-400pc at z~0.5-5). This resolution will provide spatially resolved velocity information on the accelerated gas, which can help distinguish between different outflow models (i.e., disk winds, radiation pressure, jets)

* large field of view to probe full galaxy and immediate environment (~5 arcsec corresponds to ~30-40 kpc at z~0.5-5)

* wide wavelength coverage into the near-IR waveband to allow for rest-frame optical emission lines (e.g., [OIII]5007) to be detected out to z~3.5

* multiplex instrumentation to allow for the necessarily long exposures per object (up-to 10hrs) to significantly detect the gas and stellar kinematics while at the same time compile large enough object samples to provide statistically significant results across a wide range of parameter space

These constraints lead towards a sensitive multi-deployable IFU instrument such as EAGLE on the E-ELT. With ~20 individual IFUs, in a 200hr EAGLE-E-ELT program it will be possible to constrain the gas and stellar kinematics (i.e., outflow energetics, bulge velocities, SMBHs) in ~500-1000 AGNs selected from X-ray, radio, infrared surveys. The large-number statistics will allow the sample to be split into distinct redshift (~5 bins), AGN luminosity (~5 bins), and host-galaxy type bins (~2 bins), while also retaining enough objects per bin (~10-20 objects/bin) for statistically significant results.

1.1- Project Title: A direct meassure of the pc-scale dusty torus structure in AGN centres.

1.2- Project Category: 1

1.3- Abstract:
A unification scheme for the variety of known AGNs has been proposed by Antonucci (1993): the active nucleus is surrounded by dust clouds in a torus-shaped distribution which determines dramatic spectral differences depending on our line of sight towards the central engine. Due to the very compact nature of the torus, observations in combination with theoretical models have not been able to clarify the overall picture of its physical conditions. We propose non-interferometric imaging and spectroscopy using METIS at the 42-m E-ELT to observe the physical extension and dust composition of the torus in AGNs across a range of redshifts.

1.4- Publication agreement: no

2.1- PI: Edo Ibar

2.2- CoIs: Chris Evans

2.3- Institute: UK Astronomy Technology Centre

2.4- Country of Employment: UK

2.5- Career Stage: postdoc

2.6- E-mail: edo.ibar@stfc.ac.uk

3.1- Source of targets: VLT, SDSS, NED, Chandra, XMM/Newton

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 1, 1000, mJy, N

3.4- Target size: extended source, 1, 100

3.5- Number of targets: 500

3.6- Density of targets: 0.3

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: AGN

4.1- Spatial resolution: diffraction, 3

4.2- Field-of-view: 30x30arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: L

5.2- Spectral Resolution: 500-1000

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6.1- Instrument: METIS

6.2- Desired special mode: precision photometry, N/A

6.3- Desired AO mode: LTAO

7.1- Integration time per target or field and per setup: 1e-5, 1e-3, arimass 1.15, pixel scale 10, flux 10mJy

7.2- Longest continuous observation time on a target or field: 1e-4

7.3- Shortest integration time on a target or field: 1

7.4- Total time: <2

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 70

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: yes, some sources with saturated photometry, N/A

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
The high resolution required, in combination with the large collecting area of the E-ELT, might saturate photometry of bright sources too quickly. Spectroscopic studies will be privileged in case photometry is too bright.

9.3- Detailed description or other comments:
Introduction:

Active galactic nuclei (AGNs) have been studied for many decades resulting in much observational evidence for a large diversity of AGN classes: quasars (QSOs), blazers, BL Lac objects, FR I & II, Seyfert galaxies, etc. A unification scheme for the variety of known AGNs has been proposed by Antonucci (1993), based on the differences observed in Seyfert galaxies – a class of local, low-luminosity, radio-quiet active galaxies. According to this unification model, the active nucleus is

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surrounded by dust clouds in a torus-shaped distribution which determines dramatic spectral differences depending on our line of sight towards the central engine.

Probably the most convincing evidence for the unification model comes from spectro-polarimetric observations of heavily-obscured active sources, which reveal hidden central emission via reflection from material located above the torus opening angle. This suggests that obscured AGNs presenting only narrow forbidden lines have the same fundamental nature as the unobscured systems with broad permitted lines (>1200 km/sec; Hao et al. 2005). This simple model is supported by a large number of different observations: spatial anisotropies in extended ionising structures (Falcke et al. 1998), photoelectric absorption and reprocessed emission at X-ray wavebands (Wilman & Fabian 1999), near-IR detections of broad emission lines in optically obscured sources (Ruiz et al. 1994), warm mid-IR excesses from reprocessed AGN emission (Nenkova et al. 2002).

The unification model, supported by the evidence from X-ray surveys that have revealed a large fraction of the AGN population is obscured, demands a geometrically thick distribution where the vertical height, h, should be similar to its radius, r, i.e. h/r ~ 1. On the other hand, the mid-IR spectra of these objects have placed strong constraints on radiative transfer models, which suggested a prefered confinement to individual clouds rather than an homogeneous distribution of gas and dust (Krolik & Begelman 1988, Nenkova et al. 2002). Taking into account these two conditions, dynamical models have struggled to maintain such a system without collapsing, a problem produced by frequent, inelastic and supersonic collisions between clouds (Beckert & Duschl 2004). Star formation has been suggested as a possible mechanism for an extra input of energy in the system.

The torus is expected to be an extension of the accretion disc and might act as its feeding source. The dust absorbs optical/ultraviolet (UV) photons from the accretion disk and then re-emits as a modified black-body, with T ~ 300–800K, in the near-/mid-IR waveband. Its inner radius is governed by the sublimation temperature of graphite, ~1500K (Barvainis 1987). Using near-IR reverberation mapping techniques (K to V band time lags) for a handful of local Seyfert galaxies, Suganuma et al. (2006) found estimates for inner radii of 0.01–0.07 pc (10 to 80 light yrs) consistent with being proportional to the root square of the central optical luminosity, but ~3 times smaller than that expected from graphite sublimation (Kishimoto et al 2007). This discrepancy suggests typically larger dust grains, ~0.2μm, in the innermost torus regions. The colder, outer parts of the torus can be studied using mid-IR interferometry using the Very Large Telescope Interferometer – VLTI. Stud
ies have suggested the torus might extend to diameters in the range 3–10pc (Jaffe et al. 2004, Prieto et al. 2005), although these interferometric techniques have found large spectral differences between 8–13 μm with respect to silicate absorption at ~10μm (Beckert et al. 2008).

Theoretical models in combination with all these findings have not been able to clarify the overall picture of the physical conditions in these compact cloudy regions. This is principally limited by the very compact nature of the torus, which makes imaging extremely challenging, even in the nearest AGNs. We propose using non-interferometric imaging with the 42-m Extremely Large Telescope (ELT) to observe the outer extension of the torus in local AGNs across a range of redshifts.

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Technical Requirements:

An AGN at a distance of 20 Mpc with a torus extended for 10 pc diameter is expected to have an angular size of 0.1 arcsec. In order to resolve the torus we need the ELT working near the diffraction limit in the near/mid-infrared range.

The mid-IR imager and spectrometer, METIS, observing in the wavelength range 3–13 μm (L, M, N) will provide the resolution (18”x18” FoV) we need to resolve the torus around AGN. If the performance at the diffraction limit is reached, we expect a resolution of ~50 milliarcsecond (mas) which suits our requirements perfectly. We would like to observe a large sample of faint, local AGN in order to determine the physical extent of these dusty regions or to put robust statistical upper limits on their sizes.

The spectroscopic capability of METIS in the same L/M (2.9-5.3μm) and N (7.6-13.8μm) bands, with a spectral resolution of R ~ 3000, will allow a detailed analysis in combination with numerical models for the dust composition of the torus. In particular, the broad silicate absorption band at 9.7 μm could tell us about the level of extinction, and the possible existence of Polycyclic Aromatic Hydrocarbon (PAH) features could provide evidence for ongoing star formation in these dusty regions. On the other hand, narrow-line nebular emission would provide information about the velocity fields and therefore enclosed mass available for accretion.

In the N band, the METIS spectrometer (0.4”x1.6” FOV) will provide data with overwhelmly better resolution and quality than VLTI, thereby transforming our knowledge of the very central region of AGNs.

1.1- Project Title: Probing jet formation near the event horizons of black holes

1.2- Project Category: 1

1.3- Abstract:

Accreting black holes produce the fastest known flows in our Galaxy: relativistic jets. Current understanding favours a single jet formation process for all accreting black holes - supermassive ones in AGN and stellar-mass ones in X-ray binaries, although how these jets are formed and accelerated is still debated. IR fast timing and polarimetric observations of X-ray binaries on the E-ELT will allow us to witness individual infalling and outflowing streams of matter on scales close to

the black hole event horizon and probe changes in the magnetic field structure as the jets are formed, shedding new light on this mystery.

1.4- Publication agreement: yes

2.1- PI: David Russell

2.2- CoIs: Piergiorgio Casella, Tom Maccarone, Rob Fender

2.3- Institute: University of Amsterdam

2.4- Country of Employment: NL

2.5- Career Stage: postdoc

2.6- E-mail: D.M.Russell@uva.nl

3.1- Source of targets: LMXB catalog (e.g. Ritter & Kolb 2009), SIMBAD, ATel for newly discovered sources

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 10, 22, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: 50

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 1000 per sec

3.10- Target type: other, X-ray binary

4.1- Spatial resolution: seeing, 1

4.2- Field-of-view: 1x1arcmin

4.3- Multiplexity and pick-off FoV: N/A

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4.4- Plate scale stability: N/A

5.1- Wavelength range: M

5.2- Spectral Resolution: bbimaging

6.1- Instrument: other

6.2- Desired special mode: polarimetry, high time-resolution, time-resolution for photometry is 0.001 seconds. For polarimetry, time-resolution of 0.01 seconds is desired.

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.2, 2.0, a range of conditions and source brightnesses

7.2- Longest continuous observation time on a target or field: 0.2

7.3- Shortest integration time on a target or field: 0.001

7.4- Total time: 250

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 0.08

7.6- Are the observations time critical?: yes, our targets can be transient; a TOO is required for some but not all targets

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: yes, 10000

9.1- Synergy with other programmes: ALMA, SKA/SKAPF, other, X-ray e.g. ASTROSAT, IXO, GEMS (approved X-ray polarimeter) although these are potentials. Synergy with all these facilities will not be required

9.2- Critical aspects / limiting factors for the science case:
No extra ones

9.3- Detailed description or other comments:

Relativistic jets are a common feature to accreting compact objects. On large scales, the jets and their interactions with the local environment are studied extensively. The fastest known jets (with Lorentz factors >~ 100) are studied in GRBs and their afterglows. The most powerful jets (over long periods of time) are seen from AGN - accreting supermassive black holes (BHs). Accreting stellar-mass BHs in X-ray binaries (termed microquasars) produce a variety of different types of jet (bright discrete plasma ejections and steady, continuously replenished jets) at different accretion rates, and are therefore very constraining for models of jet formation taking into account time-dependency. The process of jet formation and acceleration in the extreme gravitational fields of BHs is likely the same for BHs of all masses, since various mass scaling relations are both theoretically predicted and observed. However, the jet launching process itself is arguably the most hotly debated question in accretion physics today. It is uncertain whether the energy channeled into the jet originates from the accretion energy or is tapped from the spin of the BH. Even the role played by the BH event horizon is uncertain, since very powerful jets have been observed in neutron-star X-ray binaries, thus suggesting that a hard surface does not prevent a relativistic jet to be launched.

Microquasar jets are resolved at radio wavelengths, but it is the higher energy emission in the near-IR that comes from the inner regions of the jets where they are launched. At optical wavelengths the accretion disc usually comes to dominate, but in the near-IR regime the optically thin synchrotron emission from the inner jets dominates for BH and NS X-ray binaries in outburst.

Variability as fast as 1~5 milliseconds has been observed in the X-ray radiation from both NS and BH X-ray binaries. Such a variable accretion flow, on timescales which are very close to the light travel time of the BH event horizon (or NS surface) size scale (~0.1 milliseconds), is presumably powering the observed relativistic jets. Thus an instrument with this time resolution can probe the jet physics over the whole expected range of timescales, offering possibly the best tool to study how the variability in the accretion flow is transferred into the relativistic jet. Changes in the jet speed and brightness are usually explained in terms of internal shocks, caused by variability in the accretion flow, but this has never been observed directly. The accretion flow variability is relatively well studied, thanks to the high time resolution and statistics available in X-rays. What is needed, in order to obtain a breakthrough in this field, is to achieve similar time resolution and statistics in the infrared, in order to complete the observational picture and allow a detailed modeling.

IR fast timing is now starting to become available, and it has recently proved its potential, with the unambiguous detection of sub-second variability from a relativistic jet (Casella et al. 2009), following similar studies in optical (e.g. Gandhi et al. 2008). These first data, obtained on a bright BH with the ESO ISAAC/VLT, allowed to estimate the jet speed, as well as the size of the IR-emitting region, harnessing a time resolution as high as tens of milliseconds. Further observations will monitor the variable jet, providing key information on how changes in the accretion flow influence the jet properties, thus helping constraining the launching and powering mechanism. The high S/N that can be obtained with the E-ELT will provide an outstanding amount of information on a large number of sources, allowing population studies and thus generalizing the results.

Models and MHD simulations of jets being accelerated and collimated close to BHs (or NSs) predict a range of magnetic field configurations. Linear polarisation of emission from this region can for the first time observationally test these models. From the level and angle of polarisation it is possible to infer the ordering and orientation of the magnetic field in relation to the resolved radio jets. Near-IR polarimetric studies of both BH and NS sources so far using 4 - 8 m telescopes (e.g. Russell & Fender 2008) show a rapidly varying polarisation level. With unprecedented high S/N on very short timescales on the E-ELT, we will resolve in time the changes in the magnetic field structure in the region of the jets where they are formed.

These data will probe the physics of accretion in strong gravitational fields where GR effects are dominant, and are likely to revolutionise the field of jet physics.

- Feasibility -

Actual statistics and observing time will depend on the detector sensitivity and source brightness. The numbers we give in the form are thus indicative. We estimate about ~50 sources to be bright enough to allow full time-resolution studies. Given an average 1-hour long observation (0.2 to 2.0 range), and assuming 5 pointings per source, we obtain a total observing time of 250 hours, as to obtain a comprehensive observational picture. Important scientific results will be obviously obtained since the first observed (presumably very bright) source (thus the fraction 0.08% quoted in the form to obtain useful results).

We stress that already an instrument as ISAAC, with its fast-timing and polarimetric modes (albeit non simultaneous), if mounted on the E-ELT, would enormously boost this field, allowing observations on a large number of sources. Similarly, outstanding scientific results could be obtained by implementing a fast-timing mode on existing or planned infrared detectors (in a similar fashion to what has been proposed for HAWK-I, see internal ESO proposal, PI V. Ivanov). This would allow for this technique be available during the early phases of E-ELT operations, when AO (not needed here) will not be fully available yet. This while waiting for a possible, dedicated second generation instrument, which will allow a full breakthrough in the field.

Because of the ToO nature of these observations, a queue-mode is needed to optimize scientific results.

1.1- Project Title: Spectro-polarimetry with the E-ELT: Magnetic fields in late-type stars & brown dwarfs

1.2- Project Category: 3

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1.3- Abstract:
A spectro-polarimetric capability on the E-ELT would enable us to probe magnetic fields in low mass stars, from solar analogues down to the hydrogen burning limit. Magnetic field detections on these stars would enable us to probe internal processes in these stars that would directly feed back into stellar atmosphere and interior models, thus significantly advancing our understanding of stellar structure and evolution.

1.4- Publication agreement: yes

2.1- PI: G.A.J. Hussain

2.2- CoIs: K.G. Strassmeier, S. Hubrig, N. Piskunov, H. Korhonen, T. Dall, D. Baade, S. Berdyugina, C. Keller, A. Reiners, A. Hatzes, Quirrenbach, T. Henning

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: ghussain@eso.org

3.1- Source of targets: Surveys of open clusters

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 9, 16, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 10 per day

3.10- Target type: star

4.1- Spatial resolution: diffraction, 4

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 300 - 700, 800 - 2500

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: other, CODEX and/or SIMPLE

6.2- Desired special mode: polarimetry, 0.1% to 0.001% down to mV=16.00

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 10, 0.8

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 600

7.4- Total time: 50

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
Polarimetric capability down to 0.01% in Stokes V, Q and U (or 0.001% using multi-line adding techniques such as Least Squares Deconvolution).

9.3- Detailed description or other comments:

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--Solar analogs in open star clusters--

In late-type stars, magnetically driven winds enable stars to lose angular momentum over the course of their main sequence lifetimes. It has long been established that the efficiency with which stars spin down is mass dependent, with low mass, fully convective stars taking 10 times longer to spin down than their higher mass (>0.5 MSun) counterparts.

The efficiency with which stars spin down is highly dependent on the geometry of their magnetic fields, i.e., how their starspots are distributed (e.g. Strassmeier, 2009, A&AR 17/3, in press). Doppler imaging (tomographic) techniques applied to time-series of Stokes V spectra have been used to map magnetic fields across the surfaces of the brightest, most active rapidly rotating stars with surprising results. Strong field of over 100G covers almost the entire observable surface in active stars, while independent molecular band studies indicate the presence of large spots covering up to 50% of their surfaces. Recent results have suggested that the geometry of magnetic fields depends on rotation rate and convection zone depth, with low mass, fully convective stars showing simpler fields (Donati et al., 2008, MNRAS 390, 545; Reiners & Basri, 2009, A&A 496, 787). However, magnetic field detection techniques often have to use multi-line cross-correlation techniques to enhance the
signal-to-noise ratio in order to get a sufficient signal in Stokes V (polarization signature is ~10-4 Ic). Stokes Q and U signals are even expected to be a factor of 10 weaker.

The E-ELT could detect and map magnetic fields in even low activity stars, i.e. in true solar analogs. Currently we are limited to the handful of brightest (mv<10) and most active stars. To understand the Sun's evolution, we need to study stars at comparable activity levels and convection zone depths. These stars can be found in open clusters of well defined age but at magnitudes too faint for high-resolution spectropolarimetry with an 8-10m class telescope. In this way, we would understand how their magnetic field geometries change with age and mass and how this affects angular momentum loss and stellar evolution beyond the Voigt-Russell theorem. These results would feed directly back into dynamo and flux emergence models and thus help to better understand long-term activity behaviour on the Sun.

Multi-wavelength spectropolarimetry in the optical and in the NIR would allow the atmospheric magnetic field to be mapped in three dimensions using different diagnostics, e.g., employing multiple atomic and molecular species formed at different heights, thus building a 3-D picture of magnetic fields in stars other than the Sun. This will set a new milestone in our understanding of stellar magnetism. It may already be doable with 8-10m class telescopes in the most active, rapidly rotating late-type stars, but not for a slowly rotating star of solar age.

--Fully convective stars: probing magnetic fields in "giant planets"--

Photometric studies of clusters indicate that low-mass stars typically spin down on a timescale of about 100 Myr; this applies to masses down to about 0.4MSun. Very-low-mass fully-convective stars spin down 10 times more slowly; with brown dwarfs having spin-down times that continue to

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increase as mass decreases. Models based on these studies however tell us little about how exactly angular momentum is lost and why stars suddenly start to lose much less angular momentum once they get fully-convective. There are competing theories on the type of dynamo mechanism operating in fully convective stars. To distinguish between these theories it is necessary to measure differential rotation and the magnetic field configuration of stars from the late-M type stars to stars at the very low mass end (see Donati et al., 2006, Science 311, 633). Only the brightest M-type stars can currently be studied in this manner.

Recent results suggest that very low mass stars down to ~0.09MSun possess strong kG fields (Reiners, Basri & Christensen, 2009, ApJ 697, 373). However these are just based on Stokes I observations; analysis with Stokes Q, U and V is needed to understand more. Very low mass stars below the hydrogen-burning limit may possess magnetic fields, but these are impossible to detect with 8−10m class telescopes. A straightforward goal with the E-ELT would be to detect and then map magnetic fields on the surfaces of brown dwarfs both above and below the hydrogen burning limit.

E-ELT Aims:
• Trace the solar dynamo as a function of time by using solar analogs. Does the magnetic field influence low-mass stellar evolution?
• Employing multiple atomic and molecular species would allow building a 3-D picture of magnetic fields in stars other than the Sun for the first time.
• Detect and map magnetic fields in brown dwarfs both above and below the hydrogen burning limit.
• Map the magnetic field geometry of a cool star in unprecedented detail using all four Stokes parameters.

1.1- Project Title: Compact binaries in large-scale surveys

1.2- Project Category: 1

1.3- Abstract:
The next 5-10 years will see a slew of large-scale sky surveys mapping large parts of the sky at a wide range of wavelengths and with a variety of variability information. These will allow us to select samples of compact binary systems that serve as the principal benchmark for binary evolution pathways to exotic objects such as supernovae and GRBs. For a subset of these targets, follow-up spectroscopy will be needed to identify the nature of such photometrically selected targets and turn such samples into well-selected populations.

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1.4- Publication agreement: yes

2.1- PI: D.Steeghs

2.2- CoIs: T.Marsh, B.Gaeniscke, G.Nelemans, P.Groot, V.Dhillon, P.Jonker, C.Knigge

2.3- Institute: University of Warwick

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: d.t.h.steeghs@warwick.ac.uk

3.1- Source of targets: VST, VISTA, GAIA, Pan-STARRs, SkyMapper, LSST

3.2- Preparatory work on targets required?: yes, Broad-band constraints from surveys across the E.M. spectrum (see list in previous Q)

3.3- Target brightness: 22, 24, ABmag, V

3.4- Target size: point source

3.5- Number of targets: 1000

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per hour

3.10- Target type: star

4.1- Spatial resolution: seeing, 3

4.2- Field-of-view: 1x1arcmin

4.3- Multiplexity and pick-off FoV: 1, slitlet

4.4- Plate scale stability: N/A

5.1- Wavelength range: 340 - 2500

5.2- Spectral Resolution: 2000-3000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: high time-resolution, reduce readout deadtime to allow for time-sampling

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.10, 4.0, 0.8", z=1.15, V=22-24

7.2- Longest continuous observation time on a target or field: 4

7.3- Shortest integration time on a target or field: 360

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 25

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: other, GAIA, LISA, IXO, ATLAST

9.2- Critical aspects / limiting factors for the science case:
- sensitivity in the blue end of the optical range (<450nm), preferably as close to the UV cut-off as possible
- detector modes conducive to efficient observing with short exposures

9.3- Detailed description or other comments:
To effectively mine the large number of planned surveys, a considerable amount of follow-up spectroscopy will be needed to identify the types of systems discovered and to turn photometrically selected samples into well understood populations of objects. Furthermore, a subset of particularly interesting objects will be discovered that warrant more detailed spectroscopic follow-up at sufficient time and wavelength resolution. While this demand for follow-up spectroscopy will affect

many areas, it is particularly important in order to reliably identify samples of relatively rare and complex objects such as accreting compact objects in close binary systems.

Binary evolution affects all populations, and many of the underlying fundamental processes such as common envelope evolution are poorly understood. We need to identify and characterise populations of binaries of different type such that we can then directly test the underlying binary evolution paradigms. Optical and NIR spectroscopy is most often required to type an interacting binary system, while time-resolved studies are needed to deliver a few further essential properties such as the orbital period and constraints on the masses of the binary components.

The chosen setup on this form is mainly geared towards the initial characterisation of such objects through low to moderate spectroscopy with time sampling sufficient to sample binary periods in the few hour range. This should be seen as a generic setup and depending on the particular type of binary a different compromise between time and spectral resolution will be needed. Given the depth of planned surveys (~23-25th mag) and the need to obtain both moderate resolution spectra as well as sub-hour time sampling, an ELT will be needed.

We would mainly like to stress a few critical aspects and capabilities that would be needed for this type of science. Given the presence of a large number of very useful spectral lines in the blue end of the optical window, we would like to highlight the need to ensure instrument sensitivity to go as close to the atmospheric cutoff as possible (but can be seeing-limited). Secondly, since time variability can be an important diagnostic, dead-time between exposures should not be too large. Then a large number of low S/N exposures may be combined to achieve good S/N spectra yet still resolving relevant timescales such as the binary orbit.

1.1- Project Title: The evolution of the mass-luminosity relationship for planetary mass objects

1.2- Project Category: 3

1.3- Abstract:
We propose to measure the dynamical mass of brown dwarfs and planetary-mass objects in various stages of evolution. Our goal is to study the relationship between fundamental parameters (mass, luminosity, temperature) and age, providing key information to model and understand the evolution of substellar objects. We aim to search for, resolve and establish the orbital parameters of extremely low luminosity binaries in the nearest star clusters and associations. We will probe systems at or below the current benchmark T1/T6 EpsEriB system.

1.4- Publication agreement: yes

2.1- PI: Rafael Rebolo

2.2- CoIs: N/A

2.3- Institute: Instituto de Astrofisica Canarias

2.4- Country of Employment: ES

2.5- Career Stage: faculty

2.6- E-mail: rrl@ll.iac.es

3.1- Source of targets: VLT/VISTA

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 22, 25, Vegamag, J

3.4- Target size: point source

3.5- Number of targets: 200

3.6- Density of targets: 0.01

3.7- Target coordinates: RA:4 - 5;Dec:13 - 17

3.8- Moving target?: no

3.9- Variable target?: yes, 2 per year

3.10- Target type: exoplanet, star

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

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5.1- Wavelength range: J, H, K, 0.8 - 2.4

5.2- Spectral Resolution: bbimaging, 500-1000, 5000-10000

6.1- Instrument: MICADO, HARMONI

6.2- Desired special mode: precision astrometry, N/A

6.3- Desired AO mode: LTAO

7.1- Integration time per target or field and per setup: 0.1, 13, ETC is lacking in spectral types for cool objects. Used blackbody, but this is a poor approximation and an underestimate of the peak J/H flux for cool objects. 42m at Paranal. 0.1 hours for MICADO BB imaging to SN=20 @ J~26 (AM=1.3). 3600s for HARMONI low resolution spectroscopy (R~5000 binned to R~500) with SN=10 at J=25 (would be fainter J for real T-dwarf spectrum). 13 hours for HARMONI R=10000 spectroscopy at J=25 (and BB -- equivalent to fainter J for real objects) at SN=10.

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 30

7.4- Total time: 650

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: yes, Observations must be repeated regularly (~ every 6/12 months) to map orbits

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
Image quality

9.3- Detailed description or other comments:

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Ultracool binaries are systems formed by objects of very late M, L and T spectral types (with even cooler objects beyond the T-type sequence expected to be identified before E-ELT first light). The properties of these objects evolve drastically with age as they inextricably contract and cool off (see e.g. Burrows et al. 2001, Rev. Mod. Phys. 73, 719). For example, a 30-Mjup brown dwarf (1 solar mass ~ 1047 MJup) will display Teff =1500 K at the age of 0.1 Gyr, while at 5 Gyr will display Teff =600 K and a 10-MJup planet will show Teff = 800 K and 320 K (this is actually cooler than the coolest objects imaged to date outside of the solar system (T8, 700–800 K, Vrba et al. 2004, AJ, 127, 2948; or T8.5, ~650 K, Warren et al. 2007, MNRAS, 381, 1400), respectively at these two ages. As such, a sub-stellar object's appearance is degenerate on mass and age. Therefore, systems with a known mass and age are critical to our understanding of how brown dwarfs/giant planets evolve. Ul
tracool binaries in clusters provide the ideal targets for this purpose, allowing a dynamical mass to be combined with a reliable age from more massive cluster members. Depending on the age of the cluster, these ultracool binaries may be either brown dwarfs (older clusters) or massive giant planets (young clusters/star forming regions).

Several ultracool binaries are known in the solar neighbourhood. Frequently they are companions to a main sequence primary star. This is the case of eps Indi Bab, the nearest (d=3.6 pc) known binary brown dwarf (McCaughrean et al. 2004, A&A 413, 1029) formed by two brown dwarfs of spectral type T1 and T6, with masses close to 50 and 30 Mjup respectively. The physical separation is ~2.6 AU and the orbital period is ~15 yr. Another remarkable case is the system Gl 569 Bab. Using AO techniques at the Keck telescope, Zapatero Osorio et al. (2004, Ap J 615, 958) measured the orbital motion of the two components of the binary Gl 569B which are separated by ~0.09". Radial velocity measurements of each of the components of this system have allowed the first dynamical determination of the mass of a brown dwarf. The AO spectroscopy also allowed a rather complete characterization of the system (effective temperature, luminosity, gravity) including a chemical composition analysis. A f
ull understanding of the evolutionary status of ultracool binaries will require a precise age determination, which is difficult for field objects. Identification of similar binaries in stellar associations and stellar clusters of well known age combined with a full dynamical and spectroscopic characterization will be crucial for a full understanding of the formation and evolution of substellar objects.

In young stellar clusters, brown dwarfs and isolated planetary-mass objects form copiously (see e.g. Caballero et al. 2007, A&A 407, 903) and photometric and radial velocity studies indicate that the binary frequency of substellar objects in young clusters is rather high. It has been claimed that the overall binary fraction in young clusters like the Pleiades could be as high as 50% (Pinfield et al. 2003, MNRAS 342, 1241). Evidence for ultracool binaries in the nearest young stellar associations has also accumulated in recent years, including detection of giant planets around brown dwarfs (e.g. Chauvin et al. 2004, A&A 425, L29; Béjar et al. 2008, ApJ 673, L185).

We propose to conduct with MICADO and HARMONI a systematic deep survey for ultracool companions around brown dwarfs and planetary-mass objects in the nearest very young (1—10

Myr) stellar associations (e.g. Taurus, rho Oph, Orion) and young (100—600 Myr) star clusters (e.g. Pleiades, Hyades).

Nearby brown dwarf binaries appear to show separations in the range 5—20 AU (Bouy et al. 2003, AJ 126, 1526). At the distance of Taurus (145 pc) or the Pleiades (145 pc), these physical separations translate into angular separations of 30—120 mas. Tens of brown dwarfs are already known in these clusters ranging in J-band from 14—20 mag. These primaries display spectral types of very late M, L and T-type. We propose to search with MICADO for cool companions of T-type, which will display J-band mag in the range 22—26 (with similar magnitudes in H and K-bands), as well as cooler objects of Y-type which may display fainter J-band magnitudes and cooler effective temperatures (~300 K). Given the typical distance of these clusters, the angular separations of the components of such binaries will range from several to tens of milliarcsecs.

The typical masses of the low-mass components in these T-type cluster binaries will range from 1—2 Mjup (in very young stellar associations) to 10—15 Mjup in the intermediate age clusters mentioned above. Few T-dwarfs have been identified in clusters so far (e.g. Zapatero-Osorio et al. 2002, ApJ 578, 536; Lodieu et al. 2008), but many more will be identified after dedicated surveys are carried out with VISTA and 8-10 m class telescopes in the coming years. Potential binaries will be confirmed using MICADO second epoch observations with just a few months baseline. Low resolution spectroscopy with HARMONI will confirm the binary nature of the system and determine spectral energy distributions. Observations spread over several years using higher spectroscopic resolution will allow us to determine the spectral and spatial components of the orbit (α,δ and v). We therefore truly exploit the 3-d nature of HARMONI observations to simultaneously map the complete orbital solution
of the low mass binaries. We stress this programme rather unique aspect to provide masses and spectra for objects in the planetary-mass domain with well known ages.

1.1- Project Title: Spectroscopic study of primitive near-Earth asteroids: how did water get to Earth?

1.2- Project Category: 3

1.3- Abstract:

The primary goal of this project is to characterize the surface composition of a select sample Near-Earth Asteroids (NEAs) with primitive solar system composition. These NEAs represent a unique

laboratory in which to study the effects of thermal processing on primitive asteroid surfaces and an opportunity to detect aqueous alteration.

1.4- Publication agreement: yes

2.1- PI: Marco Delbo

2.2- CoIs: Humberto Campins, Javier Licandro

2.3- Institute: Observatoire de la Cote d""Azur

2.4- Country of Employment: FR

2.5- Career Stage: faculty

2.6- E-mail: delbo@oca.eu

3.1- Source of targets: e.g. Minor Planet Center, SDSS

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 16, 19, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 20

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: yes, 60

3.9- Variable target?: no

3.10- Target type: solar system body

4.1- Spatial resolution: diffraction, 3

4.2- Field-of-view: longslit

4.3- Multiplexity and pick-off FoV: N/A

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4.4- Plate scale stability: 0, 0

5.1- Wavelength range: 400 - 2500, V

5.2- Spectral Resolution: 100-300

6.1- Instrument: OPTIMOS

6.2- Desired special mode: precision photometry, N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.5, 3, N/A

7.2- Longest continuous observation time on a target or field: 3

7.3- Shortest integration time on a target or field: 1800

7.4- Total time: 30

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 70

7.6- Are the observations time critical?: yes, NEAs are only observable within time critical windows during close earth approaches

8.1- Does the execution of observations require real-time decisions?: yes, they are moving objects, N/A

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: yes, 1 day

9.1- Synergy with other programmes: JWST, and VLT

9.2- Critical aspects / limiting factors for the science case:
spectral coverage in the UV, magnitude limit.

9.3- Detailed description or other comments:
The study of NEAs is relevant for a number of practical and scientific reasons (e.g., Binzel et al. 2002), which fall into two main categories.
1) Their proximity to Earth makes NEAs of special interest. Some NEAs can be potential resources (water and raw materials) for human space activities, as well as impact hazards to Earth. NEAs are

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also the targets of past space missions (NASAs NEAR and Japans Hayabusa.) and future missions, including one proposed to the European Space Agency, called Marco Polo, most likely to asteroid 4015 Wilson-Harrington. The research we are proposing will provide valuable data for the planning of future missions.
2) Understanding NEAs is crucial to understanding the origin and evolution of our Solar System, including the origin of water and life on Earth (e.g., Binzel et al. 2002). Furthermore, understanding the sources of NEAs is equivalent to finding the sources of the majority of meteorites that fall on Earth.

The targets of this study are NEAs with primitive chemical composition: i.e. containing organics and volatile compounds of present in the pristine solar system. In order to understand the mineral and organic composition of our targets, we need visible and ultraviolet spectra.
The importance of visible and ultraviolet spectra to understanding the nature of NEAs has been illustrated in our recent study of an NEA, called 3200 Phaethon (Licandro et al. 2007).

REFERENCES:
Physical Properties of Near-Earth Objects, Binzel, R. P., et al., 2002, In Asteroids III, Eds. W. Bottke et al. University of Arizona Press: Tucson, pp. 255, 271.
The nature of comet-asteroid transition object (3200) Phaethon, Licandro, J. H. Campins, T. Mothe Diniz, N. Pinilla-Alonso, & J. de Len, 2007, A&A, 461, 751.

1.1- Project Title: Resolving the known debris disc population

1.2- Project Category: 3

1.3- Abstract:
Photometric surveys have discovered a wide range of debris discs through detecting excess emission. These discs are remnants of planet formation processes; studying their distribution can constrain planet formation theories. Clumps, asymmetries and warps in a disc can reveal the presence of unseen planets at orbital distances greater than those probed by current planet finding techniques. With METIS we can measure the dust distribution of known discs at radii <30AU where planets are expected. As well as identifying planets and constraining the dust''s origin, this would have profound implications for life on any planets in the habitable zone.

1.4- Publication agreement: yes

2.1- PI: Rachel Smith

2.2- CoIs: Mark Wyatt, Laura Churcher

2.3- Institute: Institute of Astronomy, University of Cambridge

2.4- Country of Employment: UK

2.5- Career Stage: postdoc

2.6- E-mail: rsed@ast.cam.ac.uk

3.1- Source of targets: Spitzer FEPS programme, Herschel DEBRIS survey.

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 0.1, 100, mJy, N

3.4- Target size: extended source, 50, 1000

3.5- Number of targets: ~40

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 50, 5

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: N, Q

5.2- Spectral Resolution: bbimaging

6.1- Instrument: METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.3, 1.2, assuming a 42m dish at a Paranal-like site, with airmass of 1.5, and seeing limited performance

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 50

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
Good spatial resolution is critical to resolve the disc structure.

9.3- Detailed description or other comments:
>From the epoch of IRAS the known population of debris discs, believed to be the remnants of planet formation processes, has increased greatly. These discs have primarily been detected photometrically by the detection of emission beyond that expected from the stellar photosphere in catalogue data or with new surveys, such as FEPS on Spitzer. The aim of this proposal is to resolve known debris discs. These discs have been confirmed through 24 and 70um photometry with Spitzer, and have been chosen as the targets most likely to be resolved in N and Q band imaging with METIS. We will complement our sample with new sources discovered through the DEBRIS survey on Herschel (an unbiased search of the nearest 500 main sequence A-M stars for dust emission). Based on our previous experience of debris disc observation with 8m instruments we can determine which debris disc targets are those most likely to be resolved with METIS, and the length of time required for the disc''s resoluti

on. The improved sensitivity offered by METIS + EELT over currently available instrumentation will allow the resolution of discs 100-1000 times fainter than the current resolved population. With these limits we will be probing discs only ~10 times the levels of emission to the Solar System"s asteroid and Kuiper belts.

With resolved imaging we can determine not only the radial size of the disc but search for evidence of offsets, asymmetries or clumpy substructure which could be evidence of unseen planets in the system. The disc of Fomalhaut for example was observed to have a eccentric ring with the eccentricity interpreted as the product of interaction with an undetected planet. A putative planet at the correct radial location has recently been detected through direct imaging. The mid-infrared regime is very sensitive to temperature, and so imaging in the mid-infrared allows the detection of low-level asymmetries which can be the result of planets on an eccentric orbit (for example, the disc of HR4796 has a ~5% brightness asymmetry between sides of the disc that have been interpreted as evidence for a planet on a ~0.02 eccentricity orbit).

Imaging at N band will allow us to probe the very hottest discs, those with dust sufficiently close to the star that the disc emission in the N band is significant. The temperatures required for significant N band emission are consistent with ~1AU regions around Sun-like stars, and regions ~5AU around hotter A-type stars. Such regions are typically beyond the resolution of 8m instruments, but are completely resolved with mid-infrared interferometry. Observations with METIS will allow imaging of the ~1AU region around Sun-like stars for the first time. The distribution of the dust in these regions will provide crucial constraints on the formation and evolution of planets in the habitable zone. For example, is the dust confined to a narrow region like our own asteroid belt, or is it spread over a wide area which could be indicative of scattering of comets into the inner system? The distribution of asteroids and comets in the terrestrial planet region could have profound i
mplications for life in these systems, as repeated extinction level events are likely to prevent the evolution of complex lifeforms. In younger systems, can we resolve the clumpy structure resulting from the final oligarchic growth stages of terrestrial planet formation (such as the massive collision that formed the Earth-Moon system)? Constraints on the radial distribution of the dust from SED fitting are very poor, as they rely on assumptions about the grain properties. Only with resolved imaging can we unambiguously determine the distribution of the emitting grains, and therefore determine how the dust interacts with any planets in the system (by searching for gaps, edges and clumps in the distribution) and ascertain the origin of the dust (in sublimation or collisions, by determining its radial distribution and size distribution).

Many of the known discs do not emit significantly in the N band. Q band observations will be crucial to resolving the bulk of the known disc population; most known discs are analogous to the Kuiper belt, with large radii and temperatures <200K. In our sample of 40 known discs, only 14 are predicted to have significant N band emission; to fully characterise the known debris disc population it is vital to have high resolution imaging in the Q band. Discs which only emit at longer wavelengths are predicted to lie in regions ~10AU around Sun-like stars, or further around hotter A-type stars (distances comparable to the Kuiper belt in the Solar System). Comparison with the solar system would suggest such regions would host gas or ice giants, however the known

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exoplanet population has revealed a variety of exoplanetary system architecture. Most observational searches for exoplanets are biased towards the discovery of close-in massive planets. Observations of debris discs in t
he Q band will allow us to search for key signatures for planets in regions beyond the typical limits of current planet detection techniques. Detection of planets on wider orbits will provide vital constraints on theories of planet formation and the evolution of planetary systems.

1.1- Project Title: Searching for debris discs in terrestrial planet regions.

1.2- Project Category: 3

1.3- Abstract:
Recent statistical studies of debris disc systems have concentrated on emission at the far-infrared to sub-millimetre, where it is easier to separate from the stellar photospheric emission. Only a few main-sequence stars have confirmed excess in the N band, where its temperature indicates it is likely to reside in the regions where we would expect terrestrial planets to have formed. We aim to characterise the N band debris disc population through a survey of nearby stars for N band excess emission with METIS probing down to a level of 10x zodiacal emission in the solar system.

1.4- Publication agreement: yes

2.1- PI: Rachel Smith

2.2- CoIs: Mark Wyatt, Laura Churcher

2.3- Institute: Institute of Astronomy, University of Cambridge

2.4- Country of Employment: UK

2.5- Career Stage: postdoc

2.6- E-mail: rsed@ast.cam.ac.uk

3.1- Source of targets: Spitzer FEPS programme, Herschel DEBRIS survey, DARWIN target list.

3.2- Preparatory work on targets required?: no

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3.3- Target brightness: 10, 1000, mJy, N

3.4- Target size: extended source, 10, 50

3.5- Number of targets: ~200

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 10, 3

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: N

5.2- Spectral Resolution: bbimaging

6.1- Instrument: METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.1, 1.2, a 42m dish at a Paranal-like site, with airmass of 1.5, and seeing limited performance.

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 78

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7.5- Percentage of the total time sufficient to obtain scientifically useful results: 35

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: other, Synergy with DARWIN outlined in science case

9.2- Critical aspects / limiting factors for the science case:
Good spatial resolution is critical to resolve the disc structure.

9.3- Detailed description or other comments:
Studies of debris discs, believed to be the remnants of planet formation, can provide an insight into planet formation processes, the evolution of circumstellar environments, and even reveal the existence of otherwise undetected planets. Many disc surveys to to date have focussed on dust emitting strongly in the far-infrared or submm, for example studies with Spitzer (FEPS: Formation and Evolution of Planetary Systems survey) and Herschel (DEBRIS: Disc Emission via a Bias-free Reconnaissance in the Infrared/Sub-millimetre survey). In particular the DEBRIS survey, with an unbiased source selection of 500 nearby stars across the spectral range A-M aims to determine the prevalence of debris discs, the variation in sizes, masses and temperatures of discs, any relationship between discs and exoplanets, and any links between stellar properties and the possession of a debris disc.

A small yet significant sample of discs are known to have dust emitting at ~10um (2+/-2% of Sun-like stars are known to possess hot dust with f_IR/f_star >0.0001 from Spitzer observations). As temperature is a strong indicator of the radial offset of the dust from the central star, these discs are believed to have dust close in, possibly in regions conventionally associated with terrestrial planets (for example HD69830 has dust at ~1AU, outside the orbits of three known Neptune mass planets). This dust may represent a single dust population around the star (no cold dust has yet been detected around HD69830), or could represent the inner population of a multiple component disc (as is the case for eta Corvi, which in addition to a hot dust population at ~2AU has a known cold dust disc at ~150AU). Observations with the CHARA array in the near-infrared have revealed sources with known cool debris discs also have dust on ~0.1AU scales; further evidence that dust can be distribu ted over a range of radial locations. Whether there is a physical link between different dust radial locations (for example, is the hot dust being scattered in from the colder belt?) is yet to be determined.

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Theoretical models of the evolution of debris discs can reproduce the main features of the known population of debris discs from longer wavelength studies. A fall-off in the level of excess emission observed with time is interpreted as evidence for a collisional evolution, in which mass is moved through a size distribution of planetesimals through mutual collisions until it reaches a small enough size to be removed from the system by radiative pressure forces. The observed fall-off with time occurs in line with the mass loss from the system, reducing the number of emitting grains. Variations in levels of excess observed around otherwise similar stars (close in age and spectral type) can be understood in terms of variations in the initial disc location and mass. This model for disc evolution predicts a maximum fractional excess for a disc of given radius and age, as initially massive discs will simply have shorter collisional lifetimes. Several Sun-like stars with hot du st (bright at < 25um) exhibit high levels of emission inconsistent with this steady-state model maximum disc emission, indicating a transient event must be responsible for the observed emission. In fact around all but the youngest Sun-like stars, the hot dust emission is consistent with a transient origin. Whether this is a reflection of the true debris population in the inner reaches of extrasolar systems, or if this is an effect of observational bias (only the brightest excesses detected) has yet to be determined.

The existence of dust in the inner regions of main sequence stars has profound implications for planetary systems, and the potential of life on any planets in the habitable zone. Our canonical picture of debris discs would predict that debris emission arises from planetesimals on dynamically stable orbits undisrupted by any planets in the system. Therefore any space occupied by a debris disc cannot also hold a planet. Large amounts of dust in the inner reaches of an extrasolar system can be indicative of a high flux of asteroidal and/or cometary bodies into this region, and this could effect the habitability of planets within a habitable zone (extinction events could be common). If the dust is transient in origin, it could be the result of a Late-Heavy Bombardment-like event, or the sublimation of a massive super-comet. Both these events could lead to a temporary influx of dust or larger bodies falling on planets in the inner system.

Interpreting the hot dust emission is crucial to our understanding of the inner regions of other planetary systems. Previous searches for 10um excess emission have relied on photometry. However, such studies are intrinsically limited by uncertainties in the stellar photospheric contribution, which mean that Fdisc>0.1F* for a detection. This limitation can be overcome if the disc flux can be directly detected with high resolution imaging. The EELT is ideally suited to such a study, and we predict that we will be able to detect emission down to Fdisc = 0.0001F* at 0.05arcsec. This will allow us for the first time to push the levels of disc detection to within a factor of 10 of the Solar System''s asteroid and Kuiper belt levels, and will allow us to determine the distribution of excesses in the 10um waveband. These observations will give an improved understanding of the mid-infrared properties of nearby stars. Quantifying the prevalence of low level dust in inner regions of extrasolar systems will allow us to determine how common features like the Solar System''s zodiacal cloud are. The detection of thermal emission from Earth-like planets in DARWIN observations will be fundamentally limited by such low level dust emission, and so we shall aim to observe all the stars in the DARWIN baseline mission. Furthermore resolved imaging of low levels

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of dust on few AU scales can allow the indirect detection of another Earth, through the mapping of resonant structures similar to the Earth''s resonant ring.

1.1- Project Title: Imaging the birth of relativistic jets

1.2- Project Category: 1

1.3- Abstract:
Microquasars are accreting stellar-mass black holes (or neutron stars) in our Galaxy that produce powerful relativistic jets, analogous to supermassive black holes in AGN. Unlike AGN, the mass accretion rate in microquasars, and consequently the jet power/properties, varies by several orders of magnitude on timescales of days to months. With MICADO we will measure the size-scales of the NIR-emitting, compact jets close to where they are launched, providing tight constraints for models of jet formation, and directly resolve discrete jet plasma ejections and witness their interaction with the ISM. In addition, we will resolve the orbit itself in ~10 microquasars.

1.4- Publication agreement: yes

2.1- PI: David Russell

2.2- CoIs: Sera Markoff, Frank Eisenhauer, Roberto Abuter

2.3- Institute: University of Amsterdam

2.4- Country of Employment: NL

2.5- Career Stage: postdoc

2.6- E-mail: d.m.russell@uva.nl

3.1- Source of targets: LMXB catalog (e.g. Ritter & Kolb 2009), HMXB catalog, SIMBAD, ATel for newly discovered sources

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 6, 18, Vegamag, K

3.4- Target size: extended source, 0.01, 1000

3.5- Number of targets: 50

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per month

3.10- Target type: other, X-ray binary

4.1- Spatial resolution: diffraction, 1

4.2- Field-of-view: 30x30arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 100, 60

5.1- Wavelength range: I, J, H, K

5.2- Spectral Resolution: bbimaging

6.1- Instrument: MICADO

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.5, 5.0, a range of conditions, source brightnesses and astrometric accuracy required

7.2- Longest continuous observation time on a target or field: 0.5

7.3- Shortest integration time on a target or field: 1

7.4- Total time: 500

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 0.1

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7.6- Are the observations time critical?: yes, our targets are transient; a TOO trigger is required for some, but not all, targets

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: yes, 10000

9.1- Synergy with other programmes: SKA/SKAPF, other, X-ray e.g. IXO, GEMS (approved X-ray polarimeter), CTA (TeV gamma-rays) although these are potentials - synergy with all these facilities will not be required

9.2- Critical aspects / limiting factors for the science case:
No extra ones

9.3- Detailed description or other comments:
In AGN, relativistic jets are produced by complex interactions of plasma and magnetic fields during accretion onto a supermassive black hole (BH). Both the jets themselves (which emit via synchrotron and inverse Compton radiation) and their interactions with the intergalactic medium (such as radio lobes) have been studied for decades. On much smaller scales, accreting stellar-mass black holes (or neutron stars) in X-ray binaries in our Galaxy also produce relativistic jets, as the compact object is fed by a non-degenerate companion. Outbursts are seen when these systems (nicknamed microquasars) increase in luminosity by 4 - 8 orders of magnitude. Mass is accreted at high rates during this time, and the relativistic jets increase in power until being drastically quenched near the maximum Eddington accretion rate. Outbursts can last weeks to years; by analogy AGN take millions of years to perform these outburst cycles, because the dynamical timescales scale roughly with size (
interchangeable with mass for black holes).
The radio through IR emission of microquasar jets correlates with the highest energy X-rays, associated with the accretion flow very close to the black hole. This intimate link between the smallest and largest scales of inflow/outflow is shedding light on hotly debated questions about the relationship between the accretion disk and jets, how jets are launched, and the effects of strong gravity.

Three fundamental, and related, questions regarding microquasar jets remain unanswered:
(1) How are these jets launched?
(2) How is energy distributed between kinetic bulk flow and internal energy (in particles and magnetic fields)
(3) What is the composition of the jets?

The jets are radiatively inefficient, meaning the bulk of the jet power is in the kinetic flow, but estimating the total power is difficult as the level of inefficiency is uncertain. The matter content is also uncertain - the jets could be largely baryonic (protons and electrons) or leptonic (positrons and electrons). Determining the power and internal makeup of the jets will help address the larger question of jet launching and partition of internal energy. The two main methods to constrain the jet power and matter content are (I) to compare the properties of the compact jets (the broadband spectrum and the timing behaviour, for example) with theoretical models, and to analyze interactions between the jets and the interstellar medium (ISM). Simple, well known black hole mass scalings allow us to infer some properties of the much more powerful jets of AGN from studies of microquasars.

Microquasar jets produce synchrotron emission from radio to likely even X-ray wavelengths. The high-energy emission from these jets originates at the compactest scales, near their acceleration and collimation zone. In the NIR regime, the jets tend to dominate the continuum emission for black hole and neutron star sources in outburst. At higher energies in the optical and UV the accretion disc usually dominates.

With unprecedented spatial resolution, astrometric accuracy and sensitivity of MICADO on the 42 m E-ELT, we will for the first time be able to measure the position of the inner compact jets as a function of frequency. With an astrometric accuracy of ~30 micro-as, it is possible to measure the relative size scale of the jet when the emission is optically thin. When the emission changes to optically thick, the change in position and size provides tight constraints on the lepton density and distribution, as well as the magnetic field strength within the jets, because the jet opacity depends on all three.
This will provide the best constraints yet on the power, and thus the internal physics, of microquasar jets. Moreover, by combining these data with multiwavelength radio-to-gamma-ray observations, we can establish the magnetic field strength and other internal physics currently unknown.

In addition to the compact jets seen during the rise/decay-phases in outburst, transient discrete plasma ejections occurring at the peak accretion rate on mas and arcsec-scales will be directly imaged (and their superluminal movement tracked!) with MICADO. These resolved jets have been imaged in radio and X-ray; so far 8-10 m class telescopes have been unable to image them because of the faintness and/or small size scales (except ambiguously in one case in 1996 which was not repeated). With the E-ELT we will measure the relativistic velocity (providing constraints on the inclination as well) and morphology of these jets in the NIR on mas and arcsec scales. Interactions with the ISM will help to reveal the power contained in the jets.

There are ~20-30 targets currently known that are close/powerful enough for this study. With the advent of the SKA pathfinder missions like LOFAR, which will cover 2/3 of the sky each night, we expect at least 10 new microquasars to be identified per year in the northernmost Southern sky. Other missions such as X-ray/gamma-ray monitors currently online will discover even more sources to target. We wish to perform monitoring of these sources over several weeks - the time-dependency of both the compact and extended jets will provide the tightest constraints on the jet properties.

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The orbital separation (between compact object and companion star) is >~ 30 micro-as in ~10 known microquasars. It will therefore be possible with the astrometry of MICADO to map the orbit of an X-ray binary for the first time. For some targets the star dominates the NIR emission, so it will be possible to see the position of the star move around the orbit. The orbital separation in micro-as, the eccentricity/inclination and the orbital period will be tightly defined, leading to accurate determinations of the system parameters including the mass of the compact object and the star.

We estimate 0.5-5.0 hours of on-target monitoring, on 5 separate dates (epochs) during an outburst are required to achieve the above goals, depending on the seeing, airmass, source magnitude and apparent orbital separation of the target. With an average of 2 hours per target times 5 dates x 50 targets that is a total of 500 hours to complete the programme. Just 30 minutes of observation on one target will likely yield groundbreaking new scientific results.

1.1- Project Title: Extragalactic Stellar Science with Blue Supergiants

1.2- Project Category: 2

1.3- Abstract:
Blue supergiants are among the brightest normal stars in galaxies. Quantitative spectroscopy of objects in a variety of star-forming galaxies will be used to put observational constraints on I) galactochemical evolution in different environments - in the field, in galaxy groups and in a galaxy cluster; II) the evolution of massive stars over a wide range of metallicities; III) the extragalactic distance scale.

1.4- Publication agreement: yes

2.1- PI: Norbert Przybilla

2.2- CoIs: there will be CoIs

2.3- Institute: Dr. Remeis Observatory Bamberg

2.4- Country of Employment: DE

2.5- Career Stage: postdoc

2.6- E-mail: przybilla@sternwarte.uni-erlangen.de

3.1- Source of targets: VLT, VST, HST

3.2- Preparatory work on targets required?: yes, pre-imaging

3.3- Target brightness: 18, 23, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: ~20-100/galaxy

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +90

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 250, 2

4.2- Field-of-view: 5x5arcmin

4.3- Multiplexity and pick-off FoV: 20-100, fiber

4.4- Plate scale stability: N/A

5.1- Wavelength range: 4000 - 17000

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: GLAO

7.1- Integration time per target or field and per setup: 1, 10, seeing 0.8", airmass <1.3, grey to dark time

7.2- Longest continuous observation time on a target or field: 1

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7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
AO-assisted spectroscopy has to be available to observe targets in galaxy clusters

9.3- Detailed description or other comments:
Intermediate-resolution spectroscopy of a large number of blue supergiants in ~20 galaxies out to the Virgo/Fornax clusters of galaxies is intended. Non-LTE analyses of the spectra will provide stellar parameters and detailed chemical abundances for a wide variety of elements. With these, the endpoint of galactochemical evolution in these systems at present day can be investigated via abundance gradients/patterns. For the first time it will be possible to study the impact of environment on galaxy evolution at high detail and accuracy. With the same data it will be feasible to put observational constraints on evolution models for massive stars of a wide range of metallicities from ~1/20 to ~2xsolar. Finally, application of the flux-weighted gravity-luminosity relationship will facilitate to calibrate the extragalactic distance scale free of systematics as metallicity and reddening, which trouble Cepheid distances.
Targets in nearby galaxies (d<5Mpc) can be investigated under seeing-limited conditions. Observations covering the visual spectral range with OPTIMOS will be the first choice because of the instrument''s high multiplex. At larger distances crowding becomes an issue and AO-assisted observations will be required. EAGLE will be the preferred instrument for observations out to ~10Mpc, asking for analysis capabilities for near-IR spectra of blue supergiants (which are being developed). Observations of single stars in the Virgo or Fornax clusters of galaxies will need an even higher spartial resolution capability,
consequently HARMONI will be the spectrograph of choice. The project would benefit from a high and dry site, which would reduce the telluric contamination in the near-IR.

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1.1- Project Title: An ELT study of dusty debris disks around M dwarves, Hyades members and field stars

1.2- Project Category: 3

1.3- Abstract:
Our program aims at providing mid-infared direct imaging of debris disks around main sequence stars older than 10-20 Myr. While most of high resolution mid-infrared studies have focused on young stars and transitional disks, our goal is to set new constraints on the spatial architecture of planetary systems for old cluster members (Hyades), M dwarves and field stars reported as debris disks candidates by Spitzer photometric and spectroscopic surveys. These targets, caracterized by a modest infrared excess, have not been resolved so far with current ground-based instruments due to sensitivity and contrast limitations. Resolving these systems in the mid-infrared range (N and Q bands) will provide direct access to the spatial organization of warm and cool dust around very mature stars, revealing potential interactions with well-formed planets (asymetries, warps, disk clearing, stable resonances...) and possibly opening the way towards dust mineralogic studies for the best candi
dates. With a resolution down to 50 mas in N band, the ELT is probably the machine to study in great detail a volume-limited sample of nearby planetary systems.

1.4- Publication agreement: yes

2.1- PI: Lucas LABADIE

2.2- CoIs: Sebastian WOLF, Javier LICANDRO, Carlos EIROA, Humberto CAMPINS, Thomas M. HERBST

2.3- Institute: Instituto de Astrofisica de Canarias

2.4- Country of Employment: ES

2.5- Career Stage: postdoc

2.6- E-mail: labadie@iac.es

3.1- Source of targets: SPITZER, IRAS, ISO

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 20, 1500, mJy, Q

3.4- Target size: extended source, 200, 1000

3.5- Number of targets: 40

3.6- Density of targets: N/A

3.7- Target coordinates: RA:5 - 17;Dec:-45 - +45, RA:20 - 23;Dec:-30 - -65, RA:04 - 08;Dec:+7 - +13

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: 10, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 8000 - 13000, 17000 - 24000, Q, N

5.2- Spectral Resolution: bbimaging

6.1- Instrument: METIS

6.2- Desired special mode: coronography, N/A

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: 0.5, 1.0, 0.8" visible seeing , 2000-3000 Jy/arcsec2 in Q band

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 800

7.4- Total time: 80

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

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7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:

Highly sensitive mid-infrared imager covering N and Q bands with state-of-the art detector. Effective spectral coverage up to 24 microns. Telescope design optimisation and site selection minmizing the thermal emission of the telescope.

9.3- Detailed description or other comments:
The natural continuation to the discovery of more than 200 exoplanets is to understand their origin and formation process and ultimately how conditions for life could develop in these systems. The currently adopted models predict that planets form from circumstellar material in the protoplanetary disk surrounding young stars, but their formation timescale is still not well constrained. A well-established evolutionnary step is the transition from an optically thick and gas-rich circumstellar disk supplying material for planet formation, to an optically thin an less massive disk of dust - the ``debris disk'' - responsible for a detectable mid and far infrared excess (Aumann et al. 1984). Because the produced dust is not primordial and likely arise from a reservoir of unseen, but actively colliding larger bodies (exo-asteroids, comets), debris disks found over a wide range of stellar ages and spectral types are important indicators of the level of interaction between unseen pl
anets and planetesimals bodies. Their study can inform us on the bulk composition of exoplanets and on their formation timescales, on the nature and location of dust producing events, on the level of brightness of the exozodiacal cloud, and on the general architecture of planetary systems. Following IRAS and ISO surveys, the Spitzer Telescope has provided new capabilities in the 5 - 170 microns spectral range for photometric and spectroscopic studies of faint excesses from warm (~300 K) and cool (~100 K) dust. Several surveys conducted with IRAC, MIPS and IRS (see Chen 2005; Rieke 2005; Bryden 2006; Beichman 2006; Meyer 2008; Trilling 2008; Plavchan 2009, Carpenter 2009) have searched for debris disks over a wide span of stellar ages and spectral types, and could establish their frequency and intensity around AFGKM stars at various stellar ages. Though Spitzer studies have brought new insight into our view on debris disks, in most cases they could not provide any informatio
n on the actual spatial dust distribution because of the lim!
ited angular resolution. Then, high angular imaging is a key approach to identify the global disk morphology, potential resonances with planets (Wyatt 2003), signatures of planet formation

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(asymetries, warps, disk clearing...), dependencies of the dust mineralogy with its position in the disk (Okamoto et al. 2004), or - last but not least - to discard false detections. It is thus imperative to determine the spatial properties of the dust through resolved imaging and collect this information also at 10 and 20 microns, i.e. in a spectral domain where can be accessed the self-emission of warm dust present in the planet forming regions. The spatial scale at which Vega-like stars can be studied is quite critical: current 8-m class telescopes only permitted so far to probe the most external regions of planetary disks. With the 42-m E-ELT, it will be possible to achieve, at 10 and 20 microns, imaging and spectroscopy of the 1-10 AU region of nearby stars at an intermediate spatial
resolution between the VLT and the large interferometers like MATISSE/VLTI. Coronographic techniques will allow us to probe fainter structures at low spectral resolution in older and dimmer disks, while IFU instruments will provide mid-infrared spatially resolved spectra of extended emission to search for signatures due to silicates resonances or gas lines in young transitional disks. Since only few young debris disks have been clearly resolved in the mid-IR so far, the immediate goal of this proposal is to exploit the resolving power and the sensitivity of the E-ELT to image the debris disk of a large sample of AFGKM stars at different ages. This science case will also constitutes a starting point for future spectroscopic studies of the best identified candidates (spatial extent, brightness...).

The selected baseline has been to compile a list of debris-disk candidates, already detected by Spitzer at 24 microns, as a function of spectral type, age, excess, distance, parent association or cluster, and to estimate their detectability with the E-ELT mid-IR imager based on various spatial configurations of the dust.

We have based our simulations on available technical data (PSF, sky brightness...) and have intentionally limited for the moment our simulations to the Q band where MIPS data are available. >From the results of our simulations, we are confident we can address the following sub-cases. They are particularly challenging since most of the targets are older than 10-20 Myr, which disks have been so far unaccessible to current mid-infrared imagers.

The case of Hyades cluster: the Hyades is the nearest star cluster to the Sun with a well estimated age of ~600 Myr. It is a unique region for studying the evolution of planetary systems at a periode corresponding approximately to the Late Heavy Bombardment (LHB) era in our Solar System, i.e. a phase where the inner and newly formed rocky planets underwent intense collisions and bombardment from asteroid-size bodies, resulting into the production of a large amount of smaller particles. The detection and characterization of the inner regions of possible debris disks at this stage of evolution could help us in understanding the universality -- or singularity -- of LHB-events during the process of planets formation.

Spitzer searches for debris disks in the Hyades were not successful so far excepted for one candidate HD 28355. However, these non-detections in a sample of 22 low-mass stars might be due to the sensitivity threshold of ~10-15 % above the photosphere that Spitzer/MIPS can achieve. Spatially disentangling the two contributions by using coronographic techniques at high resolution would reduce this limitation for particular geometries of the disk.

The case of M dwarves : the question of planets around M dwarfs has been explored by several RV surveys (see Mayor et al. 2009), which detected super-Neptunes and super-Earths around them. Since M dwarfs are the most common stars in our Galaxy, they represent an important sample to be considered to investigate the process of planet formation over a wider range of stellar masses. Their

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disk evolution timescales are not well known, mainly because these are underluminous objects with less massive disks difficult to observe. A successful statistical study of M-stars environment with more sensitive instruments would have large implications for the overall population of planetary systems in the Galaxy. Presently, only four M-stars (TWA7, J08093547-4913033, J08091770-4908344, AT Mic) have an excess detected at 24 microns, all having an estimated age <30 Myr. However, non-detections for older M stars (see Gautier et al. 2007) could be biased by calibration uncertainties, which limit
the detectable excess to ~15 % as in the case of faint Hyades sources. As part of our program, we propose to resolve the dust emission within 5 to 50 AU both for M stars with excess detected by precision photometry (see above) and down to 1 AU for close candidate (< 5 pc; e.g. candidates from Gautier et al. 2007) or for controversial detection (e.g. GJ 182).
The case of field stars : Field stars have the advantage of being relatively close candidates, which relaxes the sensitivity and resolution constraints. Space based surveys have targeted and studied a large number of field stars, detecting extended emission around many of them and providing first statistical results on debris disks frequency. Although the age of field stars is less precise than for clusters members, objects with detected excess are natural candidates for our high resolution imaging program.

1.1- Project Title: Understanding early phases of Star Formation

1.2- Project Category: 3

1.3- Abstract:
During the very first phases of star-formation (Class 0 in transition to Class I) the proto-stars have no appreciable luminosity. Moreover, the proto stellar cloud is opaque to visible light. In recent years reddening of anonymous field stars behind such clouds has been used to construct extinction maps of the clouds, a fundamental breakthrough in studying the density of compact proto-stellar clouds and globules. Here I propose a similar approach, that is to use relatively bright anonymous field stars located behind the clouds in combination with a high resolution near-IR spectrograph to study the velocity distribution of cold molecular gas. Such absorption measurements are only feasible if the spectral resolution is of order of the intrinsic linewidth: so far little work was possible as CRIRES at the VLT is the first astronomical instrument ever commissioned capable of pursuing this novel approach to study and understand the very first phases of stellar evolution. Howe
ver, for a general approach, i.e. to get ~50 line of sights through a cloud, the sensitivity jump provided by a 42m telescope is fundamental.

1.4- Publication agreement: yes

2.1- PI: Hans Ulrich Kaeufl

2.2- CoIs: Andreas Burkert, Universitaetssternwarte Muenchen, ,

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: hukaufl@eso.org

3.1- Source of targets: 2mass, Imaging Projects (see abstract)

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 12, 17, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: 1

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: ISM

4.1- Spatial resolution: 10, 2-3

4.2- Field-of-view: longslit

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 1500 - 2500

5.2- Spectral Resolution: >100000

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6.1- Instrument: SIMPLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: LTAO

7.1- Integration time per target or field and per setup: 0.5, 1.0, N/A

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 500

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 10

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, N/A

9.2- Critical aspects / limiting factors for the science case:
Background stars are obscured by extended dark clouds. So Laser support in AO, best full correction required

9.3- Detailed description or other comments:
Molecular Clouds in the very first stages of star formation show at best sub-mm emission. The easiest and most obvious observational feature is extinction. In the galactic plane they can form large dark regions such as e.g. Bok Globules. Near infrared JHK imaging has allowed to study the extinction of anonymous field stars often found in great numbers behind dark clouds in the galactic plane. These extinction measurements have allowed to construct, with high precision and amazing resolution, maps of the gas and dust content of such clouds (e.g. Alves, Lada& Lada Nature, Volume 409, Issue 6817, pp. 159-161 (2001)). Meanwhile this technique has become a standard tool. Still, other important parameters to understand the collapse of cold dark clouds into proto-stars, such as the velocity structure on small spatial scales, are unknown.

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With SIMPLE at an ELT it is possible to apply a similar approach. Anonymous bright field stars can be used to velocity-map the molecular gas by absorption spectroscopy. H_2, the most abundant molecule, however, has no dipole moment and thus is next to impossible to observe under the circumstances prevailing in a cold dark molecular cloud. The most abundant molecule, which can be observed, is CO. Another abundant species is H3+. Here I propose to use stars with a K-mag ~ 12-17 to search for $\Delta \nu = 2$ transitions of the lowest rotational states of CO or H3+, as for sure, e.g for CO and for the temperatures expected almost all molecules will populate the $j=0$ and $j=1$ for CO of the vibrational ground state. The obvious lines are then R0, R1 and R2 in the K-band. It is extremely beneficial, but not strictly necessary, that SIMPLE is cross-dispersed so that the CO and H3+ lines will be observed, while the underlying star can be observed with the full coverage. T
he latter enables spectral modeling of the anonymous star to allow precise discrimination between stellar chromospheric absorption and the absorption by the star forming cloud. Such observations are only possible, if the spectral resolution is sufficient to resolve the lines. SIMPLE has a spectral resolution equivalent to $2-3 km/s$ which is certainly of order of the lower limits on turbulence, rotation and differential rotation for a molecular cloud. Thanks to the 2Mass catalog and to the imaging survey work done so far e.g. with SOFI at the ESO NTT, suitable background stars with precise photometry are available.

The background star will most likely also show chromospheric CO and other lines; this, however, can be easily discriminated as
* at 4000K hardly any molecule will be in both rotational and vibrational ground state
* the stellar spectrum can be modeled to yield a precise stellar radial velocity;
* the molecular cloud gas will be at a different velocity

Recent results with CRIRES at the VLT from various groups have demonstrated, that such stellar spectra can be modeled to a precision of order of %s. In collaboration with CRIRES power users there is access to very precise codes to model the absorption spectra in stars, enabling us, to remove all stellar features with high precision and confidence.

For the case of two dark clouds (examples picked randomly, just to elaborate feasibility) were recently studied in imaging (c.f. astro-ph 0612221, Kainulainen et al.) in the Chamaeleon Complex using ISAAC at the VLT. One of these sources is in front of a reasonably bright star suitable for this observation even with VLT-CRIRES. Already from one
spectrum we will be able to provide important dynamical constraints for the understanding of cloud collapse.

Preparatory work, however seriously brightness limited is already ongoing (e.g. Kaeufl et al in preparation for the example above or Goto et al, private communication).

1.1- Project Title: Testing the rotational mixing theory for massive stars

1.2- Project Category: 3

1.3- Abstract:
Rotation has become an important element in models of the evolution of massive stars, specifically via the prediction of rotational mixing. The consequences of rotational mixing are, among others, important for Gamma Ray Bursts, First Stars, and chemical evolution of galaxies. We propose to use the E-ELT to study the effects of metallicity on rotation by observing comprehensive and unbiased populations of 2000 late-O and early B-type stars in dwarf galaxies in the Local Group and in the the Sculptor Group. Only by using the large muliplexity capability of OPTIMOS can this amount of data (needed to test predictions of rotational mixing) be secured in reasonable amounts of time.

1.4- Publication agreement: yes

2.1- PI: A. de Koter

2.2- CoIs: C. Evans, H. Sana, J. Puls, N. Langer, D. Lennon, J. Vink, A. Herrero, The FLAMES massive star consortium

2.3- Institute: Amsterdam University

2.4- Country of Employment: NL

2.5- Career Stage: faculty

2.6- E-mail: A.DeKoter@uva.nl

3.1- Source of targets: NED, VLT

3.2- Preparatory work on targets required?: yes, pre-imaging and preliminary low-res spectroscopy to build up the best target list for the E-ELT.

3.3- Target brightness: 18, 21, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 2000

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 15;Dec:-15 - +30

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per month

3.10- Target type: star

4.1- Spatial resolution: 100, 2

4.2- Field-of-view: 10x10arcmin

4.3- Multiplexity and pick-off FoV: 200, 0.5x0.5arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: 400 - 750

5.2- Spectral Resolution: 20000-50000

6.1- Instrument: OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: GLAO

7.1- Integration time per target or field and per setup: 1, 1, 0.8" seeing, airmass 1.15, E-ELT ETC (Spectroscopy) v2.14

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 3600

7.4- Total time: 90

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: yes, observation on time scales from a few days to about 1 yr is needed to identify binarities (see science case)

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

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8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
Multiplexity (100 objects at least, 200 preferred), Spectral resolution (20000), Wavelength coverage (400-700nm), collecting area+system throughput (to reach required SNR in a reasonable amount of time), some seeing enhancement (100mas psf)

9.3- Detailed description or other comments:
The current theory of massive star evolution predicts that rapid rotators enrich their surface with thermonuclear processed material, in particular nitrogen, through rotationally induced mixing (e.g. Maeder & Meynet 2001, Yoon et al. 2006). The consequences of rotational mixing are essential for many fields of astrophysics, including Gamma Ray Bursts, First Stars, and chemical evolution of galaxies.

A quantitative test of this theory is complicated as it requires the homogeneous analysis of a large set of main sequence B- and late-O stars on. Earlier O and more evolved stars are less suited as due to mass loss they are expected to suffer spin down and/or to have removed a considerable fraction of their envelopes, which adds uncertain physics and hence complicates the test.

A recent large survey of surface nitrogen abundances and rotational velocities of B stars in the Large Magellanic Clouds (Hunter et al. 2008, 2009) constitutes a first test of the theory of rotational mixing. It is found that the majority of stars seems to behave as expected, but that there are two classes of massive main sequence stars - nitrogen normal evolved rapid rotators and nitrogen enriched intrinsically slow rotators - that can not be understood in the framework of rotational mixing. The nature of these two groups is unclear, however, binary evolution might explain the nitrogen evolved rapid rotators and either (or both) magnetic fields and binarity might explain the nitrogen enriched intrinsically slow rotators.

The theory predicts distinct effects of metal content on the efficiency of rotational mixing - a lower metallicity leads to a more enhanced nitrogen abundance - and the probability of the occurrence of stars that rotate so rapidly that due to extreme mixing they evolve homogeneously - a lower metallicity causes homogeneous evolution to set in at lower mass and at a lower critical rotation rate, leading to more homogeneously evolving single stars. Homogeneously evolving stars at metallicities below that of the Small Magellanic Clouds have been proposed to be gamma-ray burst progenitors.

To test these key predictions of the evolution of rotating massive stars in a metallicity domain below that of the Small Magellanic Cloud it requires the study of unbiased populations of several hundreds of B stars in dwarf galaxies in the Local Group. Such numbers are required as the

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expected fraction of homogeneously evolving stars is small (of the order of one percent). Suitable populations have already been identified in dwarf galaxies in the Local Group and in the Sculptor Group using e.g., VLT/FORS observations, albeit based on low resolution spectroscopy and limited by the seeing conditions (Bresolin et al. 2007, Evans et al. 2007, Castro et al. 2008).

The proposed program will be executed in two steps. High spatial resolution pre-imaging (psf~100mas) will be obtained using the VLT 2nd generation instrumentation with Ground-Layer AO (such as planned for HawkI on UT4) or HST/JWST facilities. This will allow us to individually resolve and to identify the massive star population (based, e.g, on color information) of the five galaxies in our sample. The large multiplexity capabilities of OPTIMOS will then be used to collect about 400 OB star spectra per galaxy. Such a sample should allow us to identify at least 20 homogeneously evolving stars, thus providing a clearly cut (4.5 sigma significance level) observational test of the rotational mixing theory if none are found.

A typical SNR of 50-100 and a spectral resolving power of 20000 are needed to reach good accuracy on critical parameters such as the rotation rate and the chemical composition. This can be reached in a total integration time of 3600 sec for a typical magnitude of V=18-21. Because of the need to identify spectroscopic binaries, we plan to re-observe each target configurations about 5 times on a time scale of a few days to 1 year. Under the assumption that one could collect 200 OB star spectra per observations and that one needs 3 setups to reach a sufficient wavelength coverage, one would require (1h exp.time x 3 setups x 2 configurations x 5 exposures x 5 galaxies) 90h integration time to complete the proposed project. We note that the total time is strongly dependent on the final capabilities of OPTIMOS, as both the wavelength coverage per setup and the number of objects observable at once are critically affecting the total time needed.

1.1- Project Title: Search for very active comets and other transient phenomena in extrasolar planetary systems

1.2- Project Category: 3

1.3- Abstract:

We propose to perform the continuous, intensive survey of nearby (distance < 10–15 pc) extrasolar planetary systems at different ages, especially with Solar-type stars as central objects with the aim to detect comets exhibiting the dust/gas emission at very high level, as well as other transient phenomena, triggering such an emission, like collisions between bodies belonging to the same or different populations of these extrasolar systems. The ultimate goal will be to shed light on the formation, evolution and steady state of exo-planetary systems and to better understand the origin of the solar system.

1.4- Publication agreement: yes

2.1- PI: Waclaw Waniak

2.2- CoIs: Piotr Guzik, Michal Drahus

2.3- Institute: Astronomical Observatory, Jagiellonian University, Krakow

2.4- Country of Employment: other

2.5- Career Stage: faculty

2.6- E-mail: wwaniak@w.krakow.pl

3.1- Source of targets: VLT, VISTA,SDSS

3.2- Preparatory work on targets required?: yes, pre-imaging

3.3- Target brightness: 30, down, Vegamag, R

3.4- Target size: extended source, point source , ~10

3.5- Number of targets: ~10

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per month

3.10- Target type: other, extrasolar comet

4.1- Spatial resolution: diffraction, >2k

4.2- Field-of-view: 5x5arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 0.5, 5 arcsec

5.1- Wavelength range: 360 - 2500

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5.2- Spectral Resolution: 500-1000

6.1- Instrument: EPICS

6.2- Desired special mode: coronography, as high central attenuation as possible

6.3- Desired AO mode: XAO

7.1- Integration time per target or field and per setup: 10, 30, seeing better than 1.5 arcsec, airmass<1.5, low sky background in J band

7.2- Longest continuous observation time on a target or field: ~whole night

7.3- Shortest integration time on a target or field: ~1

7.4- Total time: ~2000

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 70

7.6- Are the observations time critical?: yes, extreme faintness of the objects

8.1- Does the execution of observations require real-time decisions?: yes, In general it is hard to predict. But some possibility of rescheduling of the observing program to more frequently monitor detected extrasolar comets/transient events would be welcomed. , multiband differantial imaging, differential spectral deconvolution for IFS data

8.2- Would you welcome remote observing capabilities?: yes, at least on line eddition of the Observing Blocks

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
diffraction limit for the optics, XAO, narrow multiband or IFS, detectors with as high dynamic range and as low noise as possible.

9.3- Detailed description or other comments:
Introduction

An exceptional progress in research of the origin and evolution of planetary systems can be noticed in a few last decades through discoveries of over 200 exo-planets, a number of circumstellar discs and the population of star-grazing comet-like bodies in exo-planet host stars (see e.g.

Smith&Terrile 1984, de Winter at al. 1999). The possibility of detection and measuring of these objects turned the investigation of the genesis and evolution of our solar system from the “archaeological” approach, where the study of debris coming from the early ages (e.g. comets) was the only source of information to the “observational” epoch, where probing of exo-planetary systems on different stages of evolution can shed light on the beginnings of the solar system. Although the overwhelming majority of the exo-planets are massive bodies detected due to their gravitational perturbations exerted on host stars, the next generation instruments like CHEOPS for VLT and EPICS for E-ELT as w
ell space experiments like DARWIN and TPF promise the possibility of detection of terrestrial planets revolving their host stars inside habitable zones. It is quite natural for human race to search for extraterrestrial intelligent beings. Unfortunately, having such an ambitious goal scientists pay relatively little attention to such slender bodies like extrasolar comets. But their role in searching for terrestrial, and especially live bearing exo-planets is hard to overestimate. Existence of comets in extrasolar planetary systems highly increases the chance that the evolution of these systems had been proceeding similarly to the evolution of our system and the final state resembles the present-day solar system. Cause of delivering water and relatively complex organic compounds to planets, discovery of comets may signal that Earth-like bodies detected in same exo-planetary system can be indeed habitable.

Goals

The ultimate goal of the proposed project could be research of active comets in extrasolar planetary systems i.e. study of their dynamics, composition and interaction with other bodies of those systems. A continuous, years lasting survey of nearby (distance <10-15 pc) stars hosting protoplanetary discs or exo-planets could result in detection of young comets not yet swept out to extra-solar Oort clouds as well as comets typical for our planetary system. The by-product of such a survey could be detection and characterisation of other transient events in extrasolar systems like disruptions triggered by tidal forces, phase-transitions and collisions between bodies. These transient phenomena could be effectively searched due to production of gas/dust material in huge amount and with time scale of months, which would be directly detectable from the Earth. A good example could be the collision of Hale-Bopp like comet with Jupiter like planet, otherwise than the collision experienc
ed by the small and fragmented nucleus of comet Shoemaker-Levy 9 with Jupiter. Detection of the traces of paleo- or post-evolution phase volcanism at the level much higher then known from present-day Earth or Io could not be excluded.

It is impossible to expect that we will be able to measure precisely physical properties of a particular comet. On the contrary, we will hardly manage to roughly characterise the object as being e.g. more or less dusty. And all this knowledge will be restricted to the small, generally postperihelion part of the orbit. But even such an incomplete data could be confront with the metallicity of the host star to shed light on the process of circulation of elements from the interstellar mater to stars and protoplanetary discs, and then via the dust envelopes of evolved stars back to the interstellar matter.

Methods

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The majority of extrasolar planets detected to date is so massive that the gravitational perturbations exerted on host stars can be easily measured by means of the Doppler shifts in their spectra. This best approach in case of Jupiter-like and best promising for terrestrial planets in the near future is completely useless in detecting of kilometre size bodies like comets and asteroids. Similarly, planetary transits and microlensing used to search for typical planets are totally impotent in searching for small objects. Only cometary activity similar to shown by solar system comets is able to warrant the success of the observing campaign. Some aspects of the detection strategy based on assumption that extrasolar comets exhibits "typical" cometary activity have been already considered. Lecavelier des Etangs et. al. (1999) argued that searching for occultations of host stars by dust tails of extrasolar comets will be a very effective approach which can probe mu ch more distant systems than direct methods of detection. Jura (2005) gave the evidence that the direct detection of extrasolar comets will be possible in the near future due to light of the central star scattered be cometary dust. The general conclusion is that each instrument/method able to detect terrestrial planets should warrant successful search for exo-comets. What is more, comets are better candidates to be directly discovered than terrestrial planets due to the fact that dust/gas emission is typically controlled by the solar irradiation budget. Hence, comet brightness increases much more faster than planet brightness, if heliocentric distance decreases. Second reason is phase dependence of the object brightness. In contrary to planets, phase function for cometary dust is smooth and presents forward scattering effect. What is more, light emission of cometary molecules is isotropic.

Direct AO imaging of extremely faint objects placed in the close vicinity of bright stars is difficult cause of diffraction pattern and speckle noise which is orders of magnitudes higher than the typical photon noise. Fortunately, the growing number of approaches to the problem of busting these effects gives chance to reach the photon noise limit. The best promising methods seem to be simultaneous differential multiband imaging (see e.g. Marois et al. 2000), IFS differential imaging supplied by spectral deconvolution technique suppressing diffraction pattern or correlation with template spectra of the searched objects (see e.g. Sparks&Ford 2002). The last approach can not only ensure that the object under consideration is a comet (strong molecular emissions) but also help in rough classification of exo-comets.

To test the chance of direct imaging of an extrasolar comet we carried out an educational guess taking comet 17P/Holmes during its spectacular outburst (our R images were taken on October 26, 2007) and put it together with the solar type star at a distance of 10 pc. This comet was chosen as a typical example of the transient, naked eye event having frequency of the order of 10-1 year and easy to make photometry due to restricted angular dimension of the dust coma. We considered a series of 7000x10 sec exposures with E-ELT equipped with IFS (spectral resolution of the order of 500 and 0.001 arc sec spaxel) working in R and J bands together with multi-conjugate XAO unit giving Strehl ratio of 0.9 and apodized Liot stop with the gaussian profile having the central attenuation of 10-3. A CCD camera with typical dynamic range, dark current and RON of 3 e-/pix was used as a detector. Typical extinction and sky brightness for La Silla, Paranal and Calar Alto were adopted. Our aim was to check whether the object is detectable at the photon noise limit. Hence, we assumed that all usable techniques were implemented to reject speckle noise, diffraction pattern and other image imperfections. Computations have shown that exo-Holmes would be barely detectable in R,J bands being 2.44 AU from the central star (original distance). But pushing the separation below 1.5 AU

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ensures easy detection (5 x noise level), especially if we assume that dust emission rate is inversely proportional to the square of astro-centric distance and we observe in R band, where the sky background is much dimmer than in J. The dynamic range of detector appeared to be crucial for the detection limit. The extraordinary large number of exposures for 16 bit classical CDD induces that RON dominates the total noise, even for optimistic assumption about it. Thus, better choice would be to use the photon counting cameras like EM avalanche CCDs or MAA fed by MCPs.

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Marois, Ch., Doyon. R., Racine. R., Nadeau, D. 2000, PASP, 112, 91
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Sparks, W.B., Ford. H.C. 2002, Astrophys. J., 578, 543
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1.1- Project Title: Optical/IR pulse profiles of magnetars

1.2- Project Category: 1

1.3- Abstract:
We propose to use the E-ELT in a multi-colour, high-speed imaging mode to measure the optical/IR pulse profiles of the ~20 known soft gamma repeaters (SGRs) and anomalous X-ray pulsars (AXPs). The energy source powering the emission from these objects remains one of the most important unsolved problems in high-energy stellar astrophysics. Two main models have been proposed to explain their behaviour: accretion from a fossil disc or the decay of an ultra-strong magnetic field, i.e. they are magnetars. It is possible to discriminate between the fossil disc and magnetar scenarios by searching for optical/IR pulsations, whose properties would be markedly different in the two cases.

1.4- Publication agreement: yes

2.1- PI: Prof. Vik Dhillon

2.2- CoIs: N/A

2.3- Institute: University of Sheffield, UK

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: vik.dhillon@sheffield.ac.uk

3.1- Source of targets: Gamma-ray and X-ray satellite all-sky monitors, radio telescope all-sky monitors (e.g. LOFAR, SKA)

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 25, 30, Vegamag, R

3.4- Target size: point source

3.5- Number of targets: 20

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 1-10 per sec

3.10- Target type: star

4.1- Spatial resolution: 100, 2

4.2- Field-of-view: 1x1arcmin

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: U, B, V, R, I, J, H, K

5.2- Spectral Resolution: bbimaging

6.1- Instrument: other, High-speed, multi-colour imager

6.2- Desired special mode: high time-resolution, Frame rates of up to 10 Hz required

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 10, N/A

7.2- Longest continuous observation time on a target or field: 10

7.3- Shortest integration time on a target or field: 0.1

7.4- Total time: 60

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, Real-time assessment of the data

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: SKA/SKAPF, other, LOFAR, future X-ray and gamma-ray satellites

9.2- Critical aspects / limiting factors for the science case:
High time resolution. Access to the optical part of the spectrum. Multi-colour imaging, preferably simultaneously in the optical and IR

9.3- Detailed description or other comments:
Please delete the first submission and use this one, as I inadvertently truncated the scientific case!

We propose to use the E-ELT in a multi-colour, high-speed imaging mode
to measure the optical/IR pulse profiles of the ~20 known soft gamma
repeaters (SGRs) and anomalous X-ray pulsars (AXPs). The energy
source powering the emission from these objects remains one of the
most important unsolved problems in high-energy stellar
astrophysics. Two main models have been proposed to explain their
behaviour: accretion from a fossil disc or the decay of an

ultra-strong magnetic field, i.e. they are magnetars. It is possible to discriminate between the fossil disc and magnetar scenarios by searching for optical/IR pulsations, whose properties would be markedly different in the two cases.

Pulsars are neutron stars which emit pulsed radiation. They can be classified into three groups, according to the mechanism which powers their radiation: rotation-powered pulsars, such as the 1000+ radio pulsars, where the spin-down provides the observed luminosity; accretion-powered pulsars, such as the 100+ X-ray pulsars, where accretion of material from a binary companion powers the (mainly X-ray) radiation, and magnetars, such as the ~20 soft gamma-ray repeaters (SGRs) and Anomalous X-ray Pulsars (AXPs), where the energy source is believed to be the decay of an ultra-strong magnetic field. However, there are alternatives to the magnetar model. It is possible that SGRs and AXPs are powered by accretion from a fossil disc produced by the fall-back of material from the supernova explosion that formed the neutron star. The magnetar hypothesis is arguably the preferred model for AXPs, due in part to the observation of SGR-like bursts in AXPs by Gavriil et al. (2002) which appeared to unify the SGRs and AXPs. The fossil disc scenario has recently received a boost thanks to the discovery of a disc around the AXP 4U 0142+61 by Wang et al. (2006). The nature of this disc is uncertain, however, with Wang et al. (2006) arguing it is passive, i.e. non- accreting, and hence unable to power the X-ray luminosity, and Ertan et al. (2007) arguing that the disc is active, i.e. accreting, and hence able to power the X-rays. It is straightforward to distinguish between the magnetar and fossil disc scenarios by searching for pulsed optical/IR emission. The optical/IR emission in the magnetar model is believed to come from the same magnetospheric process that produces the radio emission in radio pulsars, but boosted in frequency to the optical by the stronger magnetic field (Eichler et al. 2002). The optical/IR emission would then be expected to pulse as the magnetosphere rotates with the neutron star. Pulsed emission is much more difficult to explain in the fossil disc scenario, as this model predicts mainly persistent optical/IR emission from the disc via viscous heating (Ertan et al. 2007). There are ways round this, of course, e.g. by hypothesizing that some of the optical emission is from X-ray irradiation reprocessed in the disc. In this picture, however, one would expect the optical pulsations to have the same, or lower, pulsed fraction than the X-rays. One might also expect there to be evidence of a phase shift between the X-ray and optical pulsations due to the light-travel time between the source of the X-rays and the reprocessing sites, although this is geometry dependent.

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The brightest AXP/SGR has an I-band magnitude of ~24, with the vast majority remaining undetected at optical/IR magnitudes of >25. The light grasp of an ELT is hence absolutely essential to detect these objects, which tend to be highly reddened. At least 3 optical/IR bands should ideally be simultaneously covered in order to use the variation of pulse profile with wavelength to distinguish between different models for the emission mechanism. Note that a pulse profile should ideally contain at least 10 phase bins, which means that in order to adequately cover the ~1-12 s spin periods of AXPs/SGRs requires frame rates of up 10 Hz. A sequence of such fast exposures covering 1-10 hrs (depending on the brightness of the target) would then be folded on the known X-ray period of the pulsar in order to produce a mean pulse profile, as has been demonstrated for the brightest AXP by Dhillon et al. (2005).

1.1- Project Title: Evolution of the Cosmological Metric and of Fundamental Structural parameters of Galaxies

1.2- Project Category: 2

1.3- Abstract:
We plan to use EAGLE to survey the kinematic properties of ~3000 high redshift disc galaxies in ~750 hrs. The goals are : a) to measure the redshift evolution of structural parameters (size, luminosity and surface brightness) of disc galaxies which are hosted in halos of the same mass ; b) to constrain the global expansion rate of the cosmic metric and the value of fundamental cosmological parameters to an accuracy in Dark Energy (DE) parameters comparable to the accuracy of the proposed SNeIa space-based SNAP mission.

1.4- Publication agreement: yes

2.1- PI: Christian Marinoni

2.2- CoIs: Jean-Gabriel Cuby, Mathieu Puech, Matt Lehnert, Simon Morris, EAGLE team

2.3- Institute: Centre de Physique Théorique, Marseille, France

2.4- Country of Employment: FR

2.5- Career Stage: faculty

2.6- E-mail: Christian.Marinoni@cpt.univ-mrs.fr

3.1- Source of targets: HST/ACS (COSMOS), CFHT-LS, VISTA, VLT, etc. (large imaging surveys from various facilities)

3.2- Preparatory work on targets required?: yes, target selection from on-going and planned wide field spectroscopic surveys

3.3- Target brightness: 20, 23, ABmag, J

3.4- Target size: extended source, 500, 1000

3.5- Number of targets: 3000

3.6- Density of targets: ~ 1

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: 75, 37

4.2- Field-of-view: 10x10arcmin

4.3- Multiplexity and pick-off FoV: 20, 2x2arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: J

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: EAGLE

6.2- Desired special mode: N/A

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6.3- Desired AO mode: MOAO

7.1- Integration time per target or field and per setup: 2, 4, seeing 0.65arcsec airmass 1.2 lunar phase irrelevant, thermal background irrelevant, etc.

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 750

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, SKA/SKAPF, N/A

9.2- Critical aspects / limiting factors for the science case:
Massive near IR 3D spectroscopy required

9.3- Detailed description or other comments:
The evolution of galactic discs and of the efficiency of star formation within them are issues central to our understanding of galaxy formation. A major problem that still resists both observational and theoretical investigations, is the lack of clear insight of how the properties of baryonic discs relate to the physical properties of their dark matter halos [1,2]. A complete picture of the evolutionary properties of the population of spirals is usually obtained by applying average statistical estimators, such as the luminosity function [3,4] or the diameter function [5,6], to deep redshift surveys (e.g. ACS/zCOSMOS [7], VVDS [7b]). An obvious limitation of this approach is the current lack of an unambiguous grasp of how the evolution in the visible properties of the galaxies are related to changes in the underlying halo mass, as traced by disc rotational velocity. More specific insights into the mechanisms of disc evolution are traditionally accessible through the study of time-dependent changes in disc scaling relations, such as the luminosity-velocity [8] relation [9,10,11], the luminosity-size relations [7,12,13,14], and the disc thickness [15,16]. Yet owing to photometric selection effects and to the difficulty of obtaining large samples with accurate redshifts and high-resolution imaging, these studies have come to widely divergent conclusions. In a recent study [17,18,19], we have explored and adopted a different observational approach : we derive

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information about size and luminosity evolution of discs of fixed rotational velocity by constructing their respective angular diameter-redshift and Hubble diagrams. The scientific breakthrough lies here in the unique opportunity this method provides of tracing the evolution of structural parameters of disc galaxies hosted in halos of the same mass (velocity) at different cosmic epochs. Since the hierarchical scenario for the growth of structures allows to make testable predictions for the expe cted evolution of structural parameters of discs embedded in!
DM halos of known mass [20,21,22], this approach allows a direct comparison and straightforward interpretation of observational and theoretical results. Besides this goal [19], and in a complementary way, we have shown that the observationally measured and theoretically justified relation between size and disc velocity offers a practical way of selecting a set of high-z standard rods and probe world models via the angular diameter-redshift test. In fact, several authors have shown that large discs, characterised by large rotational velocities, evolve much less in size than in luminosity at $0.5 < z < 1.5$ Different observational studies show that disc sizes at $z \sim 1$ are typically only slightly smaller than sizes measured locally [24,25,26]. This result is also theoretically predicted by simulations [27,28,29,13,22,14], which show that large discs (i.e. fast rotators) have basically completed their evolution already by $z \sim 1$ and undergo very little increase in size afterwards.
More interestingly, we have demonstrated [17] that an eventual evolution in the standard rod, can be unambiguously diagnosed.

The proposed program will allow to perform a SNIa-like cosmological test (using diameter of disc rotators as standard rods) which is much faster (~750 hrs) with the same statistical power as the proposed space-based SNe JDEM/SNAP mission. Specifically, by using information from a sample of ~3000 rotators with $v = 200 \pm 20$ km/s at $0.5 < z < 1.5$ we can constrain both quantity and quality of the dark energy with the same accuracy that was planned for the SNAP mission (3000 SNe). We predict that with the proposed EAGLE IFU survey the density abundance of dark energy will be extracted with an associated uncertainty of ~5% (without priors) while the tight degeneracy in the w0 −wa plane (the parameter space of the dark energy equation of state) will allow to put stringent constraints on the nature of this component. Interestingly, even if evolution is present, we have shown that by applying at the same time the angular diameter-redshift and Hubble diagrams to the same sample of obj
ects (i.e. velocity selected galactic discs) one can derive a characteristic chart, the cosmology-evolution diagram, which maps the relation between global cosmological parameters and local structural parameters of discs, such as size and luminosity. This chart allows to put constraints on cosmological parameters when general prior information about disc evolution is available. In particular, by assuming that discs rotating at the same speed cannot be less luminous at $z = 1$ than at the present epoch ($M(z = 1) < M(0)$), we found [19] that a flat matter-dominated cosmology (Omega_m = 1) is excluded at a confidence level of 2 and an open cosmology with low mass density (Omega_m = 0.3) and no dark energy contribution (Omega_Q = 0) is excluded at a confidence level greater than 1.

We will select targets from available deep redshift surveys. Using both theoretically predicted mass function in a LCDM universe and our observational experience we estimate that we will always

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have more than 20 targets in the 50 arcmin2 fov of EAGLE and in the appropriate redshift range. Either the Halpha line or the [O2] lines will be used, depending on z. Running the EAGLE simulator we estimate at ~ 4hrs the integration time required to retrieve the velocity field at the appropriate accuracy on J_AB ~ 22 objects at z ~ 1. In total, scaling to a goal in accuracy on DE parameters comparable to the SNAP mission, we aim at a sample of ~ 3000 objects in ~750 hrs of observations, overheads included. Further refinement and scaling will be required as our knowledge on cosmological parameters and / or galaxy evolution improves. Earlier results with partial data will rapidly demonstrate either the validity of the method or deviations from the angular diameter - velocity relation, which would in turn raise important questions on the evolution and assembly of galaxies. Also, this programme can be (partly) combined to other programmes or surveys related to galaxy evolution.

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1.1- Project Title: The merging phase in the evolution of compact groups since z~1

1.2- Project Category: 2

1.3- Abstract:
We propose to probe the coalescence phase of compact galaxy groups (CGs) by targeting systems that appear to be in the merging phase at various redshifts up to z~1. Such very compact systems, have complex morphologies and dynamics, also including very low surface brightness tidal features, require very high spatial resolution and high sensitivity to be studied at higher redshifts in comparable detail to the (very few) local examples.
Only an ELT equipped with AO systems would be suited to this investigation at intermediate redshifts. An instrument providing an IFU fed spectrograph on a wide wavelength range would be the ideal tool for this investigation.

1.4- Publication agreement: no

2.1- PI: Sonia G. Temporin

2.2- CoIs: Wolfgang Kapferer, Asmus Boehm

2.3- Institute: Institut fuer Astro- und Teilchenphysik, Universitaet Innsbruck

2.4- Country of Employment: AT

2.5- Career Stage: postdoc

2.6- E-mail: giovanna.temporin@uibk.ac.at

3.1- Source of targets: SDSS, CNOC2, CFHTLS

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 16, 18.5, Vegamag/arcsec2, K

3.4- Target size: extended source, 100, 300

3.5- Number of targets: 4

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy cluster, IGM

4.1- Spatial resolution: 10, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 0.6 - 2.5

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: HARMONI

6.2- Desired special mode: precision photometry, N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 6, 13, 0.8

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 52

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 70

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

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8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
The availability of a sufficiently wide wavelength range at once is highly preferable for this program. Also, an IFU field of view of at least 5"x5" is desirable to avoid an excessive number of exposures to map the targets.

9.3- Detailed description or other comments:
We propose the observation of a sample of compact groups of galaxies (CGs) in a range of redshifts up tp z~1 in order to understand the final phases of their evolution and its outcome.
Most galaxies in the universe are found in groups. Among groups, a special position is occupied by compact groups of galaxies. Their particularly high densities and the low velocity dispersion of their member galaxies are thought to favour particularly interactions and mergers.
Both optical and radio observations of compact groups in the local universe, in particular from Hickson""s sample, have led to the suggestion of some possible evolutionary scenarios for these groups. However, these scenarios are based on the properties of relatively nearby groups that are believed to be seen in different stages of evolution, rather than on the comparison of groups identified in a range of redshifts.
Only thanks to recent galaxy surveys has it become possible to identify compact groups at higher redshifts. Among these, it is of particular interest studying those that most probably represent the last phase of evolution of isolated CGs, namely the coalescence phase, during which most members of a group merge together.
What is the end-product of this merging process? Is it compatible with the properties of the so-called "fossil groups" that we see in the local universe? This last part of CG evolution is expected to be fast, therefore groups caught in the coalescence phase are rare. In fact, only a couple of cases are known in the local universe and have been studied in detail (e.g. CG J1720-67.8; HCG 31).
Reaching the same level of detail in the investigation of morphology and kinematics, as well as stellar populations both in the member galaxies and in their low-surface brightness tidal debris at intermediate to high redshifts require technical performances that can be achieved only with an ELT equipped with adaptive optics. The accessibility of a wide wavelength range including at least part of the optical spectrum and the near-IR regime is necessary to exploit the redshifted spectral features that are routinely used at low redshifts and whose usefulness as diagnostics is already well established, as well as NIR spectral features.
The ideal way to perform this kind of investigation is the use of an integral field unit that would offer at the same time detailed kinematic information for these complex structures, detailed morphology at various wavelengths and maps of ionisation, extinction, age, and metallicity.
This implies the identification and study of the distribution of different components, like ionised gas, stellar populations of variuos ages and
metallicities, intra-group HII regions, etc.

Harmoni is the instrument whose characteristics better approach the requirements of this science case. More than one pointing per target might be necessary to cover the whole area of interest (considering the f.o.v of 8.8"x4.4" quoted for this instrument).

As a by-product of this investigation, the construction of velocity fields of bright condensations within tidal tails would allow us to identify those
with an independent kinematics as self-gravitating tidal dwarf galaxies and to study for the first time their properties in an intermediate redshift
sample. These objects have masses of order of 108 - 109 Msun and are usually only a few kpc in extent.

The comparison of the observations with high resolution hydrodynamical simulations will contribute to the interpretation of the observational
properties of merging CGs.

1.1- Project Title: A rapid-response mode to study the transient Universe

1.2- Project Category: 1

1.3- Abstract:

Transient phenomena pinpoint the most powerful objects in the Universe. Astrophysical timescales can be very short by human standards, requiring robotic intervention to catch the relevant stages. We propose to implement the rapid response mode on the E-ELT, continuing its successful operation at the VLT. Sources include gamma-ray bursts, supernovae, Galactic transients, and newly discovered classes. Triggers will be provided by gamma-ray satellites, neutrino and gravitational wave detectors, and all-sky optical monitors (e.g., LSST, SNAP). Science cases include GRB afterglows (particularly, those faint or obscured), the very early shock breakout of SNe, and the afterglows of SGR giant flares.

1.4- Publication agreement: yes

2.1- PI: Daniele Malesani

2.2- CoIs: Jens Hjorth, Johan Fynbo, Nial Tanvir, Andrew Levan, Paul Vreeswijk, Lise Christensen, Pall Jakobsson

2.3- Institute: Dark Cosmology Centre, Niels Bohr Institute

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2.4- Country of Employment: DK

2.5- Career Stage: postdoc

2.6- E-mail: malesani@astro.ku.dk

3.1- Source of targets: LISA, SNAP, EXIST, Pan-STARSS, LSST, IceCube

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 18, 30, Vegamag, R

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per hour

3.10- Target type: N/A, SN, AGN, GRB, other

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 300 - 2500, 4500 - 10000

5.2- Spectral Resolution: bbimaging, nbimaging, 100-300, 300-500, 500-1000, 1000-2000, 2000-3000, 3000-5000, 5000-10000, 10000-20000, 20000-50000, 50000-100000, >100000

6.1- Instrument: EAGLE, CODEX, HARMONI, OPTIMOS, SIMPLE

6.2- Desired special mode: precision photometry, high time-resolution, other, Rapid response mode

6.3- Desired AO mode: best

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7.1- Integration time per target or field and per setup: 0.5, 3, N/A

7.2- Longest continuous observation time on a target or field: 3

7.3- Shortest integration time on a target or field: 60

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: yes, follow-up of transient phenomena

8.1- Does the execution of observations require real-time decisions?: yes, exposure and setup depend on transient brightness, N/A

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, N/A

8.4- Is it Target-of-Opportunity like?: yes, 30

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
The telescope should be allowed under certain conditions to react autonomously on the fastest possible timescale. The possibility of activating the adaptive optics would be very beneficial for the study of faint point sources embedded in extended emission.

9.3- Detailed description or other comments:
* Supernovae: neutrinos and gravitational waves pinpoint the moment of the stellar collapse, potentially even before any electromagnetic signal emerges. Rapid-response mode allows us to be ready to catch the first photons and study the physics of nascent SNe. X-ray and UV photons have also been discovered to signal the shock breakout (~100-1000 s timescale), providing a "known" trigger mechanism to start observations. Timing between non-electromagnetic and optical signals will be crucial to probe the explosion mechanism. Supernovae will be detectable up to z~2 with E-ELT, allowing cosmography as well as study of star formation.
* Gamma-ray bursts: long-duration GRBs (produced in the deaths of massive stars, and hence directly connect to star formation) allow us to study the ISM in the hearts of high-redshift galaxies and to locate the very first stars and galaxies born after the Big Bang. ESO is currently leading the spectroscopic study of GRB afterglows and with the E-ELT with RRM this lead will be secured also in the next decades. Remarkably, distant GRBs can have very bright afterglows in terms of measured fluxes. Due to its much larger collecting area, the E-ELT will be able to secure R=20000 spectroscopy of even a z=10 afterglow (if as bright as GRB050904 at z=6.3) or R=500 spectroscopy

of afterglows fainter than AB=26.5. Currently, however, we still miss a significant fraction of afterglows, most likely because they are heavily obscured (with AV up to ~10 mag). These systems will be accessible to E-ELT soon after their explosions (when they are brightest), allowing the unprecedented opportunit
y to probe the regions where highly-obscured star formation occurs. The diffraction-limited spatial resolution will allow disentangle the point-like afterglows also when embedded in their host galaxies. Absorption systems in GRB afterglows have shown time variability (due to the effect of the GRB on the ISM), which allows a better dissection of the ISM. In the end, it is clear that E-ELT will be able to study GRBs from the very first stars and use their afterglow light to probe the state of the ISM in the first galaxies as well as the properties of the IGM during the reionization epoch. Dedicated space-borne missions such as EXIST will ensure a wealth of interesting triggers.
* Compact object mergers: these systems are the prime candidates for the production of short gamma-ray bursts, although this is far from being firmly established. Short GRB optical afterglows have proved to be very faint, often buried inside their host galaxies. Again, the large collecting area of the E-ELT and with its high spatial resolution will allow characterizing a much larger fraction of these faint objects if observations are carried out quickly. Binary neutron star mergers are also hypothesized to be the most powerful and neat emitters of gravitational waves, with a distinct signature due to the inspiralling pattern. This emission can also be used a "standard siren" allowing determination of the cosmological parameters if coupled with an independent redshift measurement. Once more, rapid response will allow probing the early stages of the merger, improve our ability to locate these cosmic sources, and to characterize their properties.
* Galactic transients: many types of Galactic high-energy transients (soft gamma repeaters, anomalous X-ray pulsars, accreting binaries, ...) emit burst of high-energy radiation on timescales as shorts as seconds. Many of them are located in the Galactic plane behind large columns of dust. The infrared capabilities and the much improved sensitivity of E-ELT will be able to catch the early optical/infrared emission accompanying these sources, enabling to clarify their physics. Transients in our neighbouring galaxies can be also observed.
* New phenomena: it is conceivable that other, currently unknown types of transient sources will be discovered before 2020 and that these will be of comparable or even larger astrophysical interest than SNe and GRBs are today. For the study of any such new phenomenon a fast, efficient, spectrograph on the E-ELT endowed with an RRM system will be crucial.
Reaction timescales depend on the specific phenomonon. For example, GRB afterglows are brightest soon (seconds to minutes) after the explosion: the sooner they can be observed, the largest the S/N that can be achieved. Timescales of order of 10 minutes would prove excellent, although longer delays (up to 30 min) are also acceptable. The proposed suite of instruments include spectrographs covering the optical and infrared wavelength range at different resolutions, depending on the brightness and redshift of the observed targets, which both span a very broad range. Note that for our science case it does not matter the location of the E-ELT on Earth.

1.1- Project Title: Sizes of asteroids potentially hazardous for our planet

1.2- Project Category: 3

1.3- Abstract:

Size determination of potentially hazardous asteroids (PHAs) is crucial to estimate the impact risk these bodies pose to our planet. Moreover, computation of the orbital evolution of these objects is limited by insufficient knowledge of physical properties required (mainly sizes and thermal inertia) to determine the role played by non-gravitational effects. Measurements of the heat emission from this bodies in the medium infrared allows their size to be determined. The use of sophisticated thermal models allows also the thermal inertia of the surface to be obtained.

1.4- Publication agreement: yes

2.1- PI: Marco Delbo

2.2- CoIs: Alberto Cellino, Paolo Tanga, Gian Paolo Tozzi, Michael Mueller

2.3- Institute: Observatoire de la Cote d''Azur

2.4- Country of Employment: FR

2.5- Career Stage: faculty

2.6- E-mail: delbo@oca.eu

3.1- Source of targets: Minor Planet Center

3.2- Preparatory work on targets required?: yes, e.g. pre-imaging

3.3- Target brightness: 50, 0.01, mJy, N

3.4- Target size: point source

3.5- Number of targets: 5

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +90

3.8- Moving target?: yes, 60

3.9- Variable target?: no

3.10- Target type: solar system body

4.1- Spatial resolution: diffraction, 3

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: 0, 0

5.1- Wavelength range: 5000 - 20000, V

5.2- Spectral Resolution: nbimaging

6.1- Instrument: METIS

6.2- Desired special mode: precision photometry, 5-10% absolute flux accuracy

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.25, 1, N/A

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 900

7.4- Total time: 1

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 100

7.6- Are the observations time critical?: yes, NEAs are only observable within time critical windows during close earth approaches

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: yes, 1 day

9.1- Synergy with other programmes: VLT/VLTI, N/A

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9.2- Critical aspects / limiting factors for the science case:
time critical observations. High accuracy non sidereal tracking required.

9.3- Detailed description or other comments:
The importance of an accurate knowledge of the sizes of near Earth asteroids (NEAs), and in particular of potentially hazardous asteroids (PHAs), is clear for any evaluation of the impact risk that they pose to our planet and for the development of mitigation strategies. In addition, the orbital evolution of these small asteroids (the large majority of which have effective diameters De ≤ 1 km), is intimately linked to their physical properties: the Yarkovsky effect, which depends on the size, shape, spin vector, and surface thermal characteristics, affect their orbital motion. The Yarkovsky effect is the change in the orbital element of small (diameter < 10-20 km) asteroids caused by the anisotropic thermal emission of the body's surface.
Note that the largest source of uncertainty in the Earth impact probability prediction of PHAs, such as 1950 DA, which has a non-negligible probability of impacting the Earth in March 2880, is the lack of information about the strength of the Yarkovsky effect. Another very interesting case is represented by the near-Earth object (99942) Apophis. This object will make an extremely close approach to the Earth in 2029, and currently has approximately a one-in-43,000 chance of impacting our planet in 2036.
The strength of the Yarkovsky effect depends on the size of the body (proportional to the size-1)also on the temperature distribution on the surface of the body, in particular on the asymmetry between the morning and the evening side. The latter is controlled by the spin state of the body and by the thermal inertia of the surface.

Asteroid sizes and thermal inertia can be determined from the measurements of the heat emitted by these bodies in the medium infrared (5-20 um). PHAs are very small objects (D<1km) and their thermal infrared fluxes are in general below 10-100 mJy. Their observations from the ground is limited to the bigger bodies or when these objects undergo very close Earth approaches. However, the latter are not so frequent and it can happen that a given PHA can have its thermal infrared flux below e.g. 1 mJy at 10 um for most of the time. This is the case of 99942 Apophis (see Delbo, 2009). METIS at the E-ELT has the sensitivity to allow observations of PHAs most of the time.

We expect the need to observe about 5 PHAs (depending on the number of alerts) per year.

REFERENCES:
Delbo, M. (2009) E–ELT: expected applications to asteroid observations in the thermal infrared, Earth Moon and Planets, in press.

1.1- Project Title: The inner workings of late-type stars, as revealed by systematic abundance studies of globular-cluster stars

1.2- Project Category: 2

1.3- Abstract:

Late-type stars are the main source of information to constrain the chemical evolution of the Galaxy. Globular clusters (GCs) have served as our best proxy of simple stellar populations to understand how such stars evolve. However, classical modelling has in several ways reached its limits: many GCs have been found to harbour several stellar populations; the evolution of late-type stars is more complicated than the hydrostatic picture predicts; stellar surface abundances do not only reflect the birth cloud""""s composition, but also a variety of internal mixing processes. To fully exploit the stars"""" archaeological potential, the surface abundances need to be corrected for modifications brought on by internal mixing processes of various sorts. Detailed observations of isotopic abundances of, e.g. Li-7 and Li-6, among main-sequence stars in GCs can give vital clues as to which are the dominant processes that shape the surface abundances. Li-6 has not been studied in
GCs. But the recent study of lithium (Li-7) in NGC 6397 (Lind et al., astro-ph/0906.2876) shows a remarkable complexity of phenomena: apart from the well-known dilution caused by the first dredge-up, signatures of atomic diffusion in the presence of weak turbulence and of the Li dip (reminiscent of Population I stars) have been uncovered. Further constraints can be set by a) going to stars fainter than the turn-off point and b) studying different isotopes.

1.4- Publication agreement: yes

2.1- PI: Andreas Korn

2.2- CoIs: Olivier Richard, Frank Grundahl

2.3- Institute: Uppsala University

2.4- Country of Employment: SE

2.5- Career Stage: faculty

2.6- E-mail: andreas.korn@fysast.uu.se

3.1- Source of targets: UCAC2 and others

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 17, 19, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 100s

3.6- Density of targets: 10

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: seeing, 2

4.2- Field-of-view: fiber

4.3- Multiplexity and pick-off FoV: 50, fiber

4.4- Plate scale stability: N/A

5.1- Wavelength range: 450 - 1000

5.2- Spectral Resolution: >100000

6.1- Instrument: CODEX

6.2- Desired special mode: N/A

6.3- Desired AO mode: GLAO

7.1- Integration time per target or field and per setup: 1, 10, could not make sense of the E-ELT ETC, even when using the 8m reference case.

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 100

7.4- Total time: 20

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 80

7.6- Are the observations time critical?: no

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8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
Resolving power must not be compromised.

9.3- Detailed description or other comments:
The effects discussed above should be studies in several GCs, e.g. NGC 6397, NGC 6752 and others, spanning a range in metallicity. Multiplexing is obviously advantageous for GC work. With near-UV capabilities, lines of beryllium and boron would become accessible. This would enhance the possibilities of setting observational constraints on stellar mixing processes.

1.1- Project Title: Star formation with ALMA and the EELT

1.2- Project Category: 2

1.3- Abstract:
Observations across a wide wavelength range suggests that high redshift galaxies are forming stars with much higher rates than today (e.g. Madau et al. 1996, Le Floc"h et al. 2005). A large molecular reservoir is needed to maintain this enhanced star-forming activity, which in many cases remains hidden by large amounts of obscuration.

Measuring the amount of molecular gas in high-z galaxies relies on the detection of the CO line transition, only possible in a handful of cases today. With unprecedented sensitivity ALMA will allow an accurate measurement of the available molecular gas in high-z galaxies, its spatial extent and distribution. Complementing these data with EELT HARMONI spatially resolved observations of the stellar component of these galaxies (morphology, age, star formation history, kinematics, dynamics) will allow us to answer these key questions: a) what drives SFR on large scales b) what sets the form and constancy of the IMF c) are there multiple SF modes perhaps physically separated?

1.4- Publication agreement: yes

2.1- PI: Dimitra Rigopoulou

2.2- CoIs: Steve Rawlings, Martin Bureau

2.3- Institute: University of Oxford

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: d.rigopoulou1@physics.ox.ac.uk

3.1- Source of targets: GOODS, VISTA, VST, but also Spitzer, SCUBA2, ALMA.

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 18, 22, Vegamag, K

3.4- Target size: extended source, 100, 300

3.5- Number of targets: 50-100

3.6- Density of targets: 1-2

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: 10, 2

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: 10, 1x1arcsec

4.4- Plate scale stability: 2e-5, 7200

5.1- Wavelength range: 1200 - 2500

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: HARMONI

6.2- Desired special mode: N/A

6.3- Desired AO mode: LTAO

7.1- Integration time per target or field and per setup: 1, 4, 0.7" seeing, 1.2 airmass, rest don"t matter.

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 40

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, ALMA will map the gas, and HARMONI the stellar light, both simultaneously observing kinematics

9.2- Critical aspects / limiting factors for the science case:
An EELT IFU spectroscopic capability is key, that can operate in the J,H & K band at close to diffraction limited performance.

9.3- Detailed description or other comments:
N/A

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1.1- Project Title: Galaxy agglomeration by clusters of galaxies

1.2- Project Category: 2

1.3- Abstract:
The dominating gravitational potential of galaxy clusters led to the agglomeration of galaxies AND gas. Depending on the built-up time of the intra-cluster gas, galaxies that fall into the gravitational potential of galaxy clusters experience the existence of hot tenuous intra-cluster gas by ram pressure at different epochs with different strengths. By this ram-pressure stripping, more massive disk galaxies lose their ISM partly but can survive with starvation becoming redder, but without morphological transformation, while low-mass galaxies are easily transformed already in the outermost cluster regions. Here we propose to study the RPS effect on the morphology of infalling galaxies at different epochs of the built-up of cluster gas.

1.4- Publication agreement: yes

2.1- PI: Gerhard Hensler

2.2- CoIs: Werner Zeilinger, Alessandro Boselli, Thorsten Lisker, Pepe Vilchez

2.3- Institute: Institute of Astronomy, University of Vienna

2.4- Country of Employment: AT

2.5- Career Stage: faculty

2.6- E-mail: hensler@astro.univie.ac.at

3.1- Source of targets: NED

3.2- Preparatory work on targets required?: yes, pre-imaging or available surveys

3.3- Target brightness: 16, 24, ABmag, H

3.4- Target size: extended source, 200, 2000

3.5- Number of targets: 300

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy cluster

4.1- Spatial resolution: 10, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 370 - 2500

5.2- Spectral Resolution: 5000-10000

6.1- Instrument: EAGLE

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.5, 2, N/A

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 300

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 30

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

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8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, N/A

9.2- Critical aspects / limiting factors for the science case:
all

9.3- Detailed description or other comments:
The dominating gravitational potential of galaxy clusters lead to the agglomeration of galaxies AND gas. Depending on the built-up time of the intra-cluster gas, galaxies that fall into the gravitational potential of galaxy clusters experience the existence of hot tenuous intra-cluster gas by ram pressure at different epochs with different strengths. By this ram-pressure stripping, more massive disk galaxies lose their ISM partly but can survive with starvation becoming redder, but without morphological transformation, while low-mass galaxies are easily transformed already in the outermost cluster regions. Here we propose to study the RPS effect on the morphology of infalling galaxies at different epochs of the built-up of cluster gas. From this we aim at learning which morpgological galaxy types, like e.g. disk-dominated S0""""s and HI-deficient spirals are accumulating by number with time.

1.1- Project Title: Mid-IR observations of brown dwarfs down to a few Jupiter masses

1.2- Project Category: 3

1.3- Abstract:
We propose to observe ultra-cool brown dwarfs in the mid-IR to study the physical and chemical properties of their atmospheres. Targets will be identified by WISE complemented by VISTA, UKIDSS, PanSTARRS1 and LSST, and as companions to nearby stars. They will have masses down to a few Jupiter masses, and effective temperatures down to 300K. Mid-IR photometry and low-resolution spectroscopy will allow to study the NH3 chemistry and vertical mixing. High-SNR mid-IR spectroscopy and polarisation might help revealing water ice clouds. Mid-IR observations will complement the near-IR to better characterise all brown dwarfs of the Solar neighbourhood and derive the local mass function.

1.4- Publication agreement: yes

2.1- PI: Bertrand Goldman

2.2- CoIs: Víctor Bejar, Roy van Boekel, Thomas Henning

2.3- Institute: MPIA

2.4- Country of Employment: DE

2.5- Career Stage: postdoc

2.6- E-mail: goldman@mpia.de

3.1- Source of targets: WISE, VISTA, UKIDSS, VLT

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 0.10, 1, mJy, M

3.4- Target size: point source

3.5- Number of targets: 70

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: other, Brown dwarfs

4.1- Spatial resolution: 50, 3

4.2- Field-of-view: 30x30arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 3 - 15

5.2- Spectral Resolution: bbimaging, 100-300

6.1- Instrument: METIS

6.2- Desired special mode: precision photometry, polarimetry, N/A

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6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 0.3, 2, LTAO/MCAO, airmass=1.15, default thermal background, 42m, high and dry site, 10mas/pix

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: 0.1

7.4- Total time: 130

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 25

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: yes, inf

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, VLT/VLTI, other, in direct competition with JWST, except for the polarimetry

9.2- Critical aspects / limiting factors for the science case:
Only high-accuracy polarimetry (0.1%) would allow the polarimetric study of water ices. This is however highly tentative.

9.3- Detailed description or other comments:
The generation of wide-field surveys of the 90s: DENIS, 2MASS, SDSS, revealed the population of high-mass brown dwarfs, with effective temperature of 2000-700K, in the Solar vicinity (up to 30pc). The new generation of such surveys: first UKIDSS, soon VISTA and WISE, later possibly Euclid, will reveal the population of low-mass brown dwarfs, as well as the population II brown dwarfs, with effective temperatures from 600K down to the Earth""""s temperature.
The discovery of the warmer brown dwarfs led to the definition of two new spectral classes (L and T) and motivated a broad range of questions regarding the properties and dynamics of their atmosphere. The models made quick progress, although many problems remain. We can safely expect that the future cooler brown dwarfs will also raise questions of their own: NH3 will become a major absorber in the infrared, the optical flux will further decrease, the coolest objects may have water-ice clouds high in the atmosphere (Burrows et al 2003; Marley et al 2001). For a given effective temperature, metallicity and gravity will widely differ between the old, metal-poor brown

dwarfs and the young, planetary-mass objects with Solar metallicity. What role will play the dynamics in the atmosphere and how far out of equilibrium will the atmospheres be? The understanding of the chemistry and the physics of these already complicated atmospheres is a necessary step towards the understanding of
the exoplanets'''''' atmosphere. So far, only T-type atmospheres of close-in, transiting planets have been studied, but new facilities will allow to resolve and study planets that are more distant from their parent star, and therefore much cooler.

Ultimately, we will also want to determine the mass function down to a few Jupiter masses, as is being done in (few) star-forming regions now. This will shed light of the formation processes of the brown dwarfs and the planets. This will require the ability to describe as well as possible each individual object within our (limited) reach.

Models for those low-temperature atmospheres are already available, and allow to make some predictions about what could be discovered in the coming decade and what diagnostic tools will be most efficient (Burrows et al, 2003; Saumon & Marley, 2008). No doubts that these models will require refinements when observational constraints become available. (We already know the line list of NH3, H2 collision-induced absorption and CH4 need improvements, Saumon & Marley 2008.)
In the optical, the flux will mostly disappear. In the near-infrared, H2O, CH4 and CH3 will leave flux escape primarily in the J band, and secondly in the H band. In the mid-infrared, the M band should be the brightest (in Jy), as well as the region around 10µm.

Current observations of the latest brown dwarfs, a few T8-T9s, with effective temperatures between 600 and 500K, give some indications on how to extend the L and T dwarf observations into the "Y" dwarf domain. Leggett et al (2009) IRAC and IRS data of two T9 dwarfs show that while the molecular absorption features in the near-infrared become saturated, and therefore insensitive to the temperature, "the mid-infrared flux level is very sensitive to temperature and can remove this degeneracy". Metallicity and gravity effects are degenerate in the K and M-band fluxes, while M and 10-µm bands are sensitive to vertical mixing in the atmosphere. In particular, CO and N2 are enhanced compared to CH4 and NH3 through a larger mixing, resulting in stronger M-band absorption by CO and weaker 10-µm absorption by NH3 (Stephens et al 2009 and ref. therein). Low- to mid-resolution spectroscopy at 10µm would allow a more detailed study of NH3 absorption.

Below 400-500K, Burrows et al (2003) predict the appearance of water ice clouds. The clouds will deplete the water vapour below them, but with small supersaturation (1%) and 10-µm particle sizes, the authors do not expect a strong influence on the emerging flux.
A difficult, but perhaps unique diagnostic could be polarisation. With a rotationally-induced flattening, or some other symmetry-breaking phenomenon, dust and ices in the photosphere may lead to a non-cancelling polarisation. This may have been seen in the optical flux of dusty L dwarfs, below the 1-% level (Ménard et al 2002; Goldman et al 2009). Obtaining such a precision on the N-band polarisation for the coolest brown dwarfs will be challenging, but may be the only way to confirm water ice in their photosphere.

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If the current atmospheric models and the instrument sensitivity are confirmed, WISE will be the most effective survey for many years, to detect 300-K nearby brown dwarfs. This will set the limiting flux of most follow-up observations at 0.16 mJy in the M band. (It remains to be seen if data from other surveys such as Pan-STARRS, VISTA/UKIDSS or Euclid, will allow to identify cool brown dwarfs from WISE single-band detections.) Additional, possibly fainter, cool brown dwarfs will be found as by-products of imaging searches of exoplanets around nearby stars.
Current estimates of the sigma Orionis initial mass-function (Caballero et al 2007) points to a slightly raising function dN/dM~M^(-0.6±0.2) down to 6 Jupiter masses. These "planetary-mass objects", when they reach the age of a few Gyrs, will become "Y" dwarfs. Burgasser (2004) expects 2-3 times more objects per 100K interval at 300 and 400K than for T dwarfs.
Setting a limit of M=0.16mJy corresponds to an effective temperature of 312K at 10pc and, for instance, a 5-Mjup-mass object at 1 Gyr (Burrows et al 2003). This object would have L=11µJy and N~65µJy. The required exposure time for METIS broad-band imaging would be 267s (L, SNR=100), 40s (M, SNR=100) and 727s (N, SNR=25) (high and dry site, 42m, 0.1-s DIT, MTAO/MCAO, 1.15 airmass, 10mas/pix). The survey volume of WISE will be (at best) 4200pc within 10pc, for which Burgasser (2004) expects two dozen objects per 100-K bin between 800 and 300K. The total integration time is about 30 hours (here we allocate the same integration time even to the closer objects).
In spectroscopy, N-band spectroscopy would be limited to targets with N>0.2mJy (5130s for SNR=10 at a resolving power of 300). This corresponds to the same object sqrt(3) times closer, hence 5 times less objects: about 5 and 10 hours per 100-K bin. It also corresponds to a 10-Mjup object, also 1-Gyr old, with an effective temperature of 447K, at 10 pc. Burgasser (2004) expects 70 such objects between 600 and 450K, for a total integration time of 100 hours.

While the near-infrared follow-up will be more effective to confirm the candidates, or study their binarity properties, mid-infrared photometry and resolution spectroscopy will be required to complete the study of the atmosphere properties, particularly of the NH3 chemistry and dynamics. We would need SNR>50 broad-band detections in the L, M and N bands, low-resolution spectroscopy (R~300) of the coolest targets and medium-resolution (R~3000) of the brightest targets. While JWST-MIRI will be able to perform those observations as well, polarisation (at a very high accuracy and sensitivity) may shed light on the dust and ice particle characteristics and the brown dwarf surface heterogeneities.

1.1- Project Title: The Enigmatic Martian Atmosphere

1.2- Project Category: 4

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1.3- Abstract:
The ongoing debate as to climate change due to antropic activities highlights an equally challenging as enigmatic question: How do planetary atmospheres work and why has Earth""s atmosphere been relatively stable during the last 10E9 years? Answers to this rather fundamental question may be derived from studies of the Martian atmosphere, about the most simple atmosphere reference case conceivable (no liquids, little latent heat, relatively simple composition etc). Recent studies, however, indicate that even this in comparison to Earth extremely simple case is highly enimatic. It is therefore proposed use the ELT for a systemtic analysis of infrared active trace constituents to arrive at an understanding of the most simple system in our solar system: how does it work, and why is it stable.

1.4- Publication agreement: yes

2.1- PI: Hans Ulrich Kaeufl

2.2- CoIs: Paul Hartogh, MPI for Solar System Research

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: hukaufl@eso.org

3.1- Source of targets: na

3.2- Preparatory work on targets required?: yes, studies with VLT-CRIRES and Herschel HIFI

3.3- Target brightness: na, na, Vegamag, U

3.4- Target size: extended source, 7000, 12000

3.5- Number of targets: 1

3.6- Density of targets: 1

3.7- Target coordinates:

3.8- Moving target?: yes, max 60-90"/h

3.9- Variable target?: no

3.10- Target type: solar system body

4.1- Spatial resolution: diffraction, 100

4.2- Field-of-view: longslit

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: na, N/A

5.1- Wavelength range: 3000 - 5000

5.2- Spectral Resolution: >100000

6.1- Instrument: METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: 1, 2, constraint is target rotation

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: 30

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: yes, orbital geometry, Doppler shift

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, N/A

9.2- Critical aspects / limiting factors for the science case:
Cross dispersed spectroscopy in combination with self-referenced AO (using the Mars edge to get diffraction limited performance along the slit is mandatory.

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9.3- Detailed description or other comments:
The question of the overall stability of atmospheres is a fundamental one. Our own, telluric, case appears somwhat hopeless, as it is unreasonably complex due to the presence of liquid water which not only dominates all energy transport and storage but gives also rise to cloud formation which in turn produces a delicate modulation of solar radiation input. The fact that a fair fraction of our atmosphere, at least of the water, is being recirculated in the upper lithosphere due to plate tectonics finally renders all modelling "ambitious". Life on Earth has changed the composition dramatically in changing the original composition to the one of today featuring oxygen. Geological evidence is, that the Earth"s atmosphere has not changed too much during the last 10E9 years and lquid water has allways been present. On the other hand the Solar wind and the UV-radiation induce a constant erosion on the telluric atmosphere which could have removed the precious little amount of gas in the lifetime of the Solar system. But this has not happened, fortunately.

Mars should be a relatively simple to understand case in comparison, but the stability of Mars is even more egnimatic, as Mars has much less gravity and no magnetic field shielding the Solar wind. So the sheer presence of the atmosphere is already hard to explain. Recent detailed IR sudies of the Martian atmosphere have found various unexpected constituents, e.g O3 (Fast et al 2006) or CH4 (Mumma et al 2009) in relatively high concentration. This is a proof that complex photochemical processes take place, which potentially may also be the stabilizers of the atmosphere. The circulation of H2O on Mars is another topic relevant in this context. High resolution infrared spectroscopy could be the key to understand the relevant processes: photochemical networks and circulation.

The preferred wavelength band here would be 3-5000nm, as many constituents have fundamental band transitions in this range.

The observations should take place from a Southern Hemisphere site, as - due to the orientation of its elliptic orbit in space - Mars comes much closer to Earth when it is on the Ecliptic at negative declinations. Under these conditions, the diffraction limited spatial resolution of the 42m E-ELT results in a projected linear resolution of order of 8-10km. This is of order of a scale height of the Martian atmosphere and allows thus for limb scanning observations. As Mars is bright, the complete perimeter could be scanned in a time span short compared to the Martian rotation, thus providing for an extremely sensitive snaphot mode of the chemical composition of the Martian atmosphere in a way that goe ubstantially beyond the capability of any Mars-orbiting spacecraft.

A full understading of the much simpler case of the Martian atmosphere, finally, may be the key to understand how more complex system like our Earth work.

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1.1- Project Title: HARMONI spectroscopic follow-up of exoplanets detected with future planet finding instrument.

1.2- Project Category: 3

1.3- Abstract:
We propose medium contrast, spectroscopic follow-up observations of faint exoplanets detected with future planet finding instruments at 8m telescopes, e.g. SPHERE at the VLT and GPI at Gemini, to characterise their stellar type, and physical properties such as age, mass, and temperature. These exoplanets will be too faint to be characterized with instruments at 8m telescopes. Combining the coronagraph and the high-order AO of HARMONI with “Spectral Deconvolution” we will achieve a contrast ratio of >15 magnitudes at first light of HARMONI, years before EPICS will be available at the E-ELT, making HARMONI the ideal instrument for follow-up spectroscopy.

1.4- Publication agreement: yes

2.1- PI: Matthias Tecza

2.2- CoIs: Niranjan Thatte, Fraser Clarke

2.3- Institute: University of Oxford

2.4- Country of Employment: UK

2.5- Career Stage: faculty

2.6- E-mail: m.tecza1@physics.ox.ac.uk

3.1- Source of targets: NICI/Gemini, SPHERE/VLT, GPI/Gemini

3.2- Preparatory work on targets required?: yes, Exoplanet surveys with eg SPHERE/VLT, GPI/Gemini

3.3- Target brightness: 15, 23, Vegamag, H

3.4- Target size: point source

3.5- Number of targets: 50

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: exoplanet

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 1100 - 2400

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: HARMONI

6.2- Desired special mode: coronography, N/A

6.3- Desired AO mode: SCAO

7.1- Integration time per target or field and per setup: 0.5, 5, Extrapolation of SD to high-order SCAO and coronagraph.

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 250

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 25

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

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8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, other, E-ELT/EPICS

9.2- Critical aspects / limiting factors for the science case:
For successful experiment we need: an integral field spectrograph, a diffraction limited pixel scale, a high order SCAO, a coronagraph, wide wavelength range, high sensitivity, and spectral deconvolution.

9.3- Detailed description or other comments:
Radial velocity (RV) detections of extrasolar planets have been a watershed for observational studies of planet formation, compiling a sample of planets large enough (>300 to date) for statistical studies. However, these discoveries are inherently limited, and since RV studies are confined to the inner regions of other solar systems (< 6AU for a 15-yr survey), we know very little about the planetary constituents in the outer regions of other solar systems. To study planets in the outer regions direct detection methods must be used. Furthermore, only direct imaging and spectroscopy can measure colours, luminosities and spectra of the exoplanets, thereby providing temperatures and compositions. Several instruments are currently being designed and built to achieve this goal within the next few years, e.g. SPHERE at the VLT (Beuzit et al. 2006), and GPI at Gemini (Soummer et al. 2006). Another instrument, the Near-Infrared Coronagraphic Imager (NICI), is already commissioned and
used as facility instrument at Gemini South. To achieve the highest contrast possible all instruments use differential imaging techniques to detect planets.
Ultracool objects with photospheric temperatures < 1400K show distinctive CH_4 absorption in the H-band. At young (10-100Myr) ages, these temperatures correspond to masses of 12Mjup (Burrows et al. 1997). CH_4 absorption is therefore a key signature of a planet around a young star. NACO-SDI, NICI, and SPHERE, with their dual band capability, use the powerful tool of Simultaneous Differential Imaging (SDI) to directly detect such planetary companions around young stars. NICI is also capable of detecting non-methane bearing planets, using the high contrast Angular Differential Imaging (ADI) technique. While the imaging techniques can measure the mass and separation distribution of outer (>5-10AU) massive planets around other stars and how it depends on stellar host mass, it can not address a more fundamental question: What are the physical properties of exoplanets?
One of the early surprises from radial velocity discoveries was the diversity in the orbits of exoplanets. Whether this diversity extends to their spectral types and therefore spectral energy distributions is an outstanding question we want to address with the proposed observation. Only their spectra, which have prominent and distinctive near-IR spectral features, e.g. H_2O, CO, K, and CH_4, can tell us the companion's spectral type and physical properties. Yet, the spectral type alone does not allow us to determine physical parameters such as age and mass, as theoretical models show a degeneracy between mass, luminosity, and temperature of these low-mass objects. However, as our targets are close companions to the primary star, we can use the distances, ages and metallicities determined from the primary stars to break this degeneracy and determine the planets

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mass and other properties. This in turn allows us to test theoretical models of these low-mass objects; models that a
re by no means mature. Spectroscopy with R~500 in the H-band allows us to measure the gravity sensitive metal lines (e.g. McGovern et al. 2007). Low gravity is another indicator that a cool object is young and low mass, rather than old and more massive. Below ~500K, water clouds are expected to form to mark the onset of a new spectral class (a.k.a. "Y dwarfs"). Y dwarfs represent the missing link between the known T-dwarfs and Jupiter. Finally, the coolest/lowest mass objects might not exist as free-floating objects if there is a low-mass cut-off to the star formation process, e.g. from opacity-limited fragmentation of molecular clouds (Mmin~5-10Mjup). Such objects might only form via the planet formation process in disks, and thus could only be found as companions.

A very powerful tool for direct spectroscopic follow-up, confirmation, and characterization of exoplanets is AO-assisted integral field spectroscopy (IFS). It simultaneously yields both imaging and spectroscopy, allowing determination of common proper motion (i.e. physical association) and the characterization of the exoplanet's physical properties. Combined with the Spectral Deconvolution (SD) differential detection technique IFS allows the simultaneous detection and characterisation of exoplanets (Sparks and Ford 2002) with similar contrast as achieved by both SDI and ADI (Thatte et al. 2007). In fact all future planet finding instruments, e.g. SPHERE/VLT, GPI/Gemini, and EPICS/E-ELT, plan to have an IFS, though with low spectral resolution (R<100), as their science instrument. Over the next years NICI, GPI, and SPHERE, all at 8m class telescopes, will directly image exoplanets, however, the number of exoplanets they can detect is limited by the telescope diameter in two
ways: the telescope collecting area limits the sensitivity; and the diffraction point spread function sets a lower limit to the separation between exoplanet and parent star. However, many of the exoplanets detected with SDI , ADI, and SD will be so faint and/or so close to the parent star that they cannot be spectroscopically characterised with current 8m class telescopes.

At the E-ELT, the ideal instrument for spectroscopic follow-up of these direct detections is HARMONI. It can be operated in Single Conjugate Adaptive Optics (SCAO) mode and will achieve Strehl ratios of ~80% for guide stars brighter than 9th magnitude. Also, HARMONI will have a coronagraphic mode that, simply because of the narrower diffraction PSF of the E-ELT, allows a much smaller inner working angle than SPHERE or GPI. Similarly, SD can probe much smaller separations as well. Combining the high order SCAO mode, the coronagraph, and spectral deconvolution, will allow HARMONI to achieve a contrast ratio of ~15 magnitudes, similar to SPHERE and GPI, enabling the detection of faint exoplanets at small separations from the parent star. Additionally, HARMONI has a much higher spectral resolving power (R~4500) compared to SPHERE, GPI, and EPICS (R<~100). This not only improves the efficiency of the SD technique in detecting exoplanets, it also allows a much more detailed charact
erisation of the line profiles and the exoplanet's atmosphere.

Furthermore, HARMONI has this capability at first light, and even though HARMONI achieves only a medium contrast compared to EPICS, HARMONI will be available several years before EPICS can start observations at the E-ELT. Therefore, HARMONI is ideally suited to spectroscopically follow-up and characterise exoplanets detected with SPHERE/VLT and GPI/Gemini.

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1.1- Project Title: From first Light to the earliest galaxies: Approaching the end of reionisation with E-ELT/HARMONI

1.2- Project Category: 2

1.3- Abstract:
By first light of the E-ELT, deep broad- and narrow-band imaging surveys will have detected the earliest galaxies that are emerging from the cosmic dark ages. However, only the E-ELT will have the sensitivity to spectroscopically confirm these galaxies, providing constraints on their physical properties and impact on the high-z IGM. We define a program of ~40 nights to perform integral field spectroscopy using HARMONI of the earliest galaxies known. We will (i) perform spatially resolved spectroscopy of ~40 galaxies on the scales of massive HII regions/complexes (ii) perform a deep blank field survey with HARMONI.

1.4- Publication agreement: yes

2.1- PI: Aprajita Verma

2.2- CoIs: & the HARMONI Science Team

2.3- Institute: University of Oxford

2.4- Country of Employment: UK

2.5- Career Stage: postdoc

2.6- E-mail: averma@astro.ox.ac.uk

3.1- Source of targets: Many including VLT, VISTA, HST (ACS, WFC3), JWST, Gemini, Subaru, Spitzer, ALMA, Herschel, SCUBA-2 ....

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 22, 27-29.5, ABmag, H

3.4- Target size: extended source, 50, 400 (Lya blobs ~10")

3.5- Number of targets: 40 + 30

3.6- Density of targets: N/A

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy, AGN, GRB

4.1- Spatial resolution: 10, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 500 - 2500

5.2- Spectral Resolution: 3000-5000, 10000-20000

6.1- Instrument: HARMONI

6.2- Desired special mode: N/A

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 1, 10, 1hr: minimum exposure time for the very brightest targets (4mas scale), 4hr: average exposure time for fainter targets with (10-20mas scale) and 10hr for faintest targets (4/10mas scale) and the blind survey per field pointing.

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 400

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50% (20 galaxies) / 100% (for Harmoni Deep Field)

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, N/A

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, VLT/VLTI, SKA/SKAPF, other, N/A

9.2- Critical aspects / limiting factors for the science case:
The key instrument requirements and limiting factors are summarised here and refer to a selection of the key first-light science drivers that are outlined in Section 9.3.

IFS capability is essential with multiple pixel scales e.g. 4-40mas to optimise the setup to the spatial extent, distribution and brightness of the target. High sensitivity is necessary and the availability of AO-correction (SCAO, GLAO, LTAO) is preferable to achieve this and obtain high spatial resolution. Reasonably wide wavelength coverage is necessary such that the Lyman-limit, Lyman-alpha, HeII1640 and UV spectral features (e.g. ISM absorption features, photospheric lines, fine structure lines, high ionisation lines for AGN signatures) will be accessible for z>5.6 galaxies. Extension to the blue wavelengths would also be useful to enable the history of the IGM to be probed to lower redshift i.e. larger volumes.

Summary of requirements:

Pixel scales: from diffraction limit to ~40mas

FoV size: Typical z>5 LBGs have half-light radii of >~140 mas, to reasonably sample these pixel scales <40 mas and a FoV >0.5 arcsec are required. Extended Lya halos and Lya blobs at high-z associated to young star-forming (or massive) galaxies require large FoVs e.g. 5 arcsec x 10 arcsec achievable with 40mas pixels. For this and for the HARMONI Deep Field science cases an even larger FoV would be advantageous.

FoV format: to ensure efficient observing in the NIR, a 2x1 aspect ratio rectangular FoV is preferable enabling nodding-on-IFU for efficient sky subtraction.

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AO requirements: GLAO, SCAO or LTAO required to reach the best sensitivities. Cosmic web/IGM history observations and extended Lya-blobs/halo studies can be performed with active optics (seeing limited) only.

Spectral Resolution: minimum R~5000 for sensitivity to resolve OH lines, and for detailed kinematics (dvel~60 km/s) and UV absorption line metallicity work. Narrow Lya and He1II640 for population III signatures require R~>5000. R~15,000 is required for detecting absorption line systems along the line-of-sight for the study of the cosmic web.

Wavelength range: 0.5-2.4um, simultaneous bands would be advantageous.

9.3- Detailed description or other comments:
Measuring light from the first stars and galaxies as they emerge from the "dark ages" is one of the most compelling prospects for the E-ELT and will provide key constraints on models of the early universe and galaxy formation. The revolution in high-z galaxy selection techniques means we can routinely select galaxies at 5<z<7, however detecting and spectroscopically confirming galaxies at still higher redshifts remains challenging for 8-10m-class facilities. The E-ELT will break this barrier allowing the characterisation of high-z galaxies that are likely responsible for the reionisation of the Universe. Moreover, spatially resolved spectroscopic data afforded by an IFS will enable studies of the impact of the first galaxies on the high-redshift intergalactic medium (IGM) probing its early enrichment and the process of reionisation. We will address questions such as: How did the Universe change during the first billion years? What sources were responsible for reionisation and how did reionisation proceed? How did the first stars form and can we detect their signatures? Are the early galaxies progenitors of present-day massive galaxies? How was the IGM enriched with metals? With the rest-frame UV redshifted into the optical-near-IR, the IFS HARMONI is the ideal instrument with which to answer these questions. The plethora of forthcoming broad- and narrow-band surveys (see 9.1) will provide an enormous target pool with which HARMONI can probe the elusive "dark ages".

We propose a comprehensive 35-40 night survey that is divided between targeted observations of ~40 high-z galaxies and a survey, the HARMONI deep field. Summaries of a selection of the key first-light science drivers follows.

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- Lyman-alpha kinematics, escape and impact on the high-z IGM

When present, Lyman alpha (Lya) is by far the most dominant feature in the spectra of UV selected galaxies. However, this resonantly scattered line is notoriously difficult to quantitatively interpret: e.g. it is an unreliable tracer of dynamical mass. Nevertheless, important constraints can be gleaned from analysis of Lya line profiles (both in emission and absorption) and its spatial distribution around early galaxies.

Lya escape is a common feature of star-forming galaxies where the emission is enhanced by stellar winds and outflows and therefore often extended beyond the scales of stellar disks. Radiation pressure due to Lya photons, in even moderately star forming systems residing in modest halos, can unbind gas from the halo producing large-scale outflows and can accelerate expanding dust shells of HI gas (Dijkstra & Loeb, 2008, MNRAS, 391, 457). HARMONI"s 3D capability will measure Lya velocity gradients and line profiles to investigate Lya escape and its spatial distribution in the earliest star-forming galaxies and QSOs. The skewness of the Lya profile has been proposed to be an important tool to constrain reionisation models (Dayal et al. 2008, MNRAS, 389, 1683). HARMONI"s diffraction limited capability provides the first opportunity to observe the spatial distribution of Lya, including (mini-)halos around the first stars and first galaxies, revealing information regarding the complex kinematics of Lya, turbulence and winds on the scales of primordial HII regions, and the morphology of the ionised IGM at high redshift.

- Evolution of Galaxy Metallicity and Metal Enrichment of high-z IGM

Metal lines in the spectra of z>5 LBGs (Ando et al. 2007, PASJ, 59, 717) indicate that the ISM of high-z galaxies are already enriched with metals. Since we find that a large fraction of high-z LBGs are young with short duty cycles (Verma et al. 2007), there has been little time for homogeneous mixing of metals both within the galaxy and to the surrounding IGM. HARMONI"s 3D capability can test this through spatially resolved metallicity analyses using proxy UV metallicity indicators (i.e. the 1370, 1425, 1978 & CIV indices Leitherer et al. 2001, ApJ, 550, 724; Rix et al. 2004, 615, 98; Mehlert et al. 02, A&A, 393, 809; see also de Mello et al. 2004, ApJ, 608, L29). These indices require reasonably high SNR, and medium spectral resolution (R=5000). Observations at or close to the diffraction limit of the E-ELT with HARMONI will trace metal

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enrichment on the scales of HII regions and complexes revealing key insights on metal transport with the ISM of the galaxies and the general IGM.

In addition, the exciting field of tracing the cosmic web via absorption line systems is currently restricted to luminous quasars. However, R~15,000 spectroscopy with HARMONI will permit these studies to be extended to fainter QSOs, high-z galaxies and GRBs. The observations will be sensitive to even low density (n(HI)<1015 cm-2) clouds as well as quiescent or low mass galaxies along the line-of-sight.

- Population III signatures

While extremely challenging, detecting the spectroscopic signatures of the massive and highly ionising population III stars with the E-ELT would be a significant break through. Strong and narrow Lya and HeII1640 lines together with low metallicity and the presence of high ionisation lines (e.g. NIV or CIV) in the spectra of high-z galaxies could indicate the presence of population III or very low metallicity stars (see Schaerer 2008, in IAU, 255, 66). EELT/HARMONI provides a unique opportunity to study and spatially resolve HeII1640 on the scale of HII regions for a wide redshift range (z>2.7, subject to the standard NIR atmospheric windows). Because HeII1640 is optically thin and less sensitive to the UV background it could be as good a tracer of low-metallicity high-z galaxies and early gas accretion of baryonic matter in the dark ages as Lya (Yang et al. 2006, ApJ, 640, 539).

- HARMONI Deep Field

Using gravitational lensing as a tool we can currently detect faint galaxies (m(AB)~28), plausibly at 7>z>10 (Stark et al. 2007, ApJ, 663, 10S), but reliable spectroscopic confirmation has been almost impossible with 8-10m class telescopes. E-ELT/HARMONI (R~5000) will be able to spectroscopically confirm these systems. The sensitivity coupled to an IFS make HARMONI an ideal instrument with which to simultaneously select and spectroscopically confirm high-z galaxies. In a blank field survey we should expect ~30 7<z<10 galaxies with m(AB)<29.5 (or F(Lya)~3e-20 erg/s/cm2, 3-sigma) in 160 hours (Choudhury & Ferrara 2007, MNRAS, 380, L6; assuming 2:1 aspect ratio 40mas pixels, FoV 5"x10", 12 HARMONI pointings, LTAO, and spectral binning in post-processing to R~100). By conducting the survey along critical lines in massive lensing clusters one can expect a 1-4 magnitude gain in sensitivity (Richard et al. 2008, ApJ, 685, 705). HARMONI"s izJ (R~4500) mode will be sensitive to 6<z<10 galaxies, a range much larger than traditional narrow-band/tuneable filter surveys. Naturally these predictions are uncertain, particularly given our lack of knowledge on the process of reionisation and the evolution of the high-z IGM. However, given the sensitivity of EELT/HARMONI, failure to detect any high-redshift galaxies in the survey proposed here, would place strong constraints on theoretical models of the early Universe.

1.1- Project Title: Giant-planet-mass objects in the Large Magellanic Clouds

1.2- Project Category: 3

1.3- Abstract:
The goal of the proposal is to probe the complete substellar mass regime of a young star forming region in the Large Magellanic Cloud (LMC) down to giant planet masses (M<=10MJup). This mass may be below the opacity limit setting the minimum mass of objects formed by fragmentation at the metallicity of the LMC. Therefore, the observations proposed here have the potential of revealing the opacity limit in a low-metallicity environment such as that of the early Milky Way, thus providing a
data point that cannot be obtained from observations in our own Galaxy. The determination of the lowest-mass Initial Mass Function, and eventually of the location of the opacity limit at low metallicity, will be helpful to constrain the volume density of evolved giant-planet-mass objects lurking in our own galactic disk, which have faded into
invisibility since a long time ago.

1.4- Publication agreement: yes

2.1- PI: Fernando Comeron

2.2- CoIs: H. Zinnecker, Annalisa Calamida

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: acalamid@eso.org

3.1- Source of targets: HAWK-I, VISTA

3.2- Preparatory work on targets required?: yes, Wide survey

3.3- Target brightness: 19, 32, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: 5

3.6- Density of targets: N/A

3.7- Target coordinates: RA:05 20 00 - ;Dec:-69 00 00 -

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star cluster

4.1- Spatial resolution: diffraction, 3

4.2- Field-of-view: 2x2arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: J, H, K

5.2- Spectral Resolution: bbimaging

6.1- Instrument: other, NIR diffraction limited imager

6.2- Desired special mode: precision photometry, We need a S/N~10 at J ~ 29.1, H ~ 28.7, K ~ 28.2

6.3- Desired AO mode: LTAO

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7.1- Integration time per target or field and per setup: 10, 25, seeing=0.8", airmass=1.0, 3 days from new moon

7.2- Longest continuous observation time on a target or field: 1

7.3- Shortest integration time on a target or field: 60

7.4- Total time: 60

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 80

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
LTAO

9.3- Detailed description or other comments:
The goal of the proposal is to probe the complete substellar mass regime of a young star forming region in the LMC down to giant planet masses (M <=10~MJup). This mass may be below the opacity limit setting the minimum mass of objects formed by fragmentation at the metallicity of the LMC. Therefore, the observations proposed here have thepotential of revealing the opacity limit in a low-metallicity environment such as that of the early Milky Way, thus providing adata point that cannot be obtained from observations in our own Galaxy. The determination of the lowest-mass Initial Mass Function, and eventually of the location of the opacity limit at low metallicity, will be helpful to constrain the volume density of evolved giant-planet-mass objects lurking in our own galactic disk, which have faded intoinvisibility since a long time ago. Theoretical estimates for the opacity limit (Rees 1976; Bate 2005) lie around 10 MJup, but simulations including realistic environment conditions of cores have shown that the opacity limit can be overcome to form objects of even smaller masses (Boyd & Whitworth 2005). Indeed, observations ofvery young aggregates have revealed members with masses probably in the range of a few Jupiter masses only (Zapatero Osorio et al. 2002).
As wide-field, deep infrared surveys of star forming regions are carried out in the next years, it may be expected that the existence and location of the lower limit to the substellar mass function will be firmly established. Nevertheless, even if the lower limit to the IMF can be observationally derived

soon, it will be so only for the young clusters of the solar neighborhood, all of which have virtually solar metallicity. Since the limit depends on the cooling curve of dense, cold molecular gas and the cloud opacity, metallicity is expected to play a major role in determining it. This has rather far-reaching consequences concerning the evolution of the mass function of galactic disks, since during most of its history the disk our Galaxy has been forming stars at subsolar metallicity. Therefore, knowing the shape of the lower end of the IMF at solar metallicity, and knowing the location of its lower mass cutoff, is of limited value for the purpose of estimating the number of extremely low mass objects that may exist nowadays in the galactic disk, since an extrapolation of their present-day formation rates would not be possible towards the low-metallicity ages of our Galaxy. Can this problem be addressed observationally? It seems unlikely at present. Available models at solar metallicity (Baraffe et al. 2003) indicate that a 5 MJup object (similar to the lowest-mass ones detected in the SOrionis cluster; Caballero et al. 2007) coeval with the Sun would have cooled down to 220K of surface temperature, having MJ = 29.8, MH = 28.8, M_K = 41. These faint absolute magnitudes mean that next-generation surveys reaching down to J ~23 could not detect them beyond 0.4 pc -or about 100,000 AU. Objects of the same mass formed at the beginning of the life of the Galaxy would have faded to MJ = 34, and would not be detected beyond 13,000 AU. Somewhat younger objects (ages less than ~ 3 Gyr) of the same mass could be detectable if present at a distance of a few parsecs, but their metallicities would be practically solar and thus not relevant to the determination of the evolution of the low-mass cutoff with metallicity. Unless we are extremely lucky and one of those objects happens to be in the close vicinity of the Solar System, there is no possibility of detecting a real low-metallicity isolated planetary-mass objects (PMOs) in our Galaxy. Yet these objects might be extremely abundant if the early, low-metallicity Galaxy was at all able to form them. Interestingly enough, the E-ELT will make possible the observation of low metallicity brown dwarfs and may answer the question of whether or not they formed, and in which amounts, in the early Galaxy. In principle, old galactic PMOs may be detectable with the E-ELT by carrying out deep surveys reaching up to a few parsecs from the Sun, but the chances to serendipitously detect one such object would be vanishingly small. However, the Magellanic Clouds are places where low-metallicity brown dwarfs are being formed (today), and are thus many orders of magnitude brighter than their old counterparts of the same metallicity in the disk of our Galaxy. In a 1 Myr old star forming region of the LMC, our 5 MJup planetary-mass object would still have a temperature of 1900 K and magnitudes MJ ~ 10.6, MH ~ 10.2, MK ~ 9.7, with a spectral type probably around mid L. At the distance modulus of the LMC (DM0 = 18.5), this implies J ~ 29.1, H ~ 28.7, K ~ 28.2. The numbers are approximate only for several reasons. First, large uncertainties plague evolutionary models as such early ages (Baraffe et al. 2003), especially in the giant-planet-mass regime (Marley et al. 2007). Secondly, these models are calculated for solar metallicity, whereas the atmosphere characteristics, interior opacities, and evolutionary tracks should be expected to vary sensibly for significantly subsolar metallicity.

1.1- Project Title: Characterizing the lowest mass freely floating objects in star forming regions

1.2- Project Category: 3

1.3- Abstract:
This proposal aims at the spectroscopic characterization of the lowest mass freely-floating objects selected in wide-area imaging surveys of young star forming regions, carried out with either survey telescopes or large format infrared imagers at 8-m telescopes. It is likely that the physical properties of such objects, as little massive as one or a few Jupiters, can be derived only from the comparison of spectra covering diagnostic atomic and molecular lines to the next generation of ultracool atmospheres.
Therefore, the determination of the shape of the lowest-mass end of the substellar initial mass function may be only possible by using relatively high signal-to-noise spectroscopy that can only be provided by ELTs. Besides, spectroscopic monitoring will yield information on the meteorology of these objects, which are expected to display complex weather patterns. The goal of this project is to obtain near-simultaneous spectroscopy of the lowest-mass objects in star forming regions, in the wavelength interval ranging from the red (0.6 um) spectral region dominated by the opacity in alkali lines, to the near-infrared (4 um) dominated by molecular opacities (H2, H2O, CH4, NH3).

1.4- Publication agreement: yes

2.1- PI: F. Comeron

2.2- CoIs: H. Zinnecker, A. Calamida

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: acalamid@eso.org

3.1- Source of targets: VLT, VISTA

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 19, 29, Vegamag, I

3.4- Target size: point source

3.5- Number of targets: 10

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3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: yes, 1 per week

3.10- Target type: other, Lowest mass freely floating objects in star forming regions

4.1- Spatial resolution: 50, 3

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: J, H, K, L

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: HARMONI, METIS

6.2- Desired special mode: N/A

6.3- Desired AO mode: GLAO

7.1- Integration time per target or field and per setup: 2, 10, 0.8", 1.2, Paranal-like site

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 100

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 80

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

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8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: VLT/VLTI, VISTA

9.2- Critical aspects / limiting factors for the science case:
This is a program with weak constrains on seeing, transparency, or adaptive optics performance, which would allow the E-ELT to keep doing unique science under worse-than-average atmosphere conditions.

9.3- Detailed description or other comments:
This proposal was designed to explore the performance of the E-ELT under non-optimal atmosphere conditions. The assumption is that a programme of these characteristics will be executed in a survey-like manner at times when the conditions do not allow observations with the good adaptive optics performance required by most other science cases.

1.1- Project Title: The centers of Massive Dense Young Clusters: deep ELT infrared imaging and 3D spectroscopy

1.2- Project Category: 3

1.3- Abstract:
We propose to use the 42m ELT at 2-5 microns (broad band and narrow-band filters) to probe the number density and brigthness of deeply embedded massive stars and protostars just formed in dense Galactic protocluster clouds (ultracompact HII regions, hot cores, outflows and maser sources), penetrating as much as 200 mag of visual extinction. The combination of astrometric, proper motion (1 mas/yr) and spectroscopic, radial velocity (R~104) data are crcucial to study dynamical processes associated with cluster formation, such as tight binary formation and gravitational interactions followed by stellar ejections. Integrated field spectroscopy is needed for these dense and severly crowded clusters (up to 1000 objects per square atrcsec at K = 25-30).

1.4- Publication agreement: yes

2.1- PI: H. Zinnecker

2.2- CoIs: F. Comeron, M. McCaughrean, A. Calamida

2.3- Institute: AIP Potsdam

2.4- Country of Employment: DE

2.5- Career Stage: faculty

2.6- E-mail: acalamid@eso.org

3.1- Source of targets: IRAS, ISO, MSX, Spitzer

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 23, 34, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: 4

3.6- Density of targets: N/A

3.7- Target coordinates:

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star cluster

4.1- Spatial resolution: diffraction, 3

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: K, L, M

5.2- Spectral Resolution: bbimaging, 10000-20000

6.1- Instrument: METIS

6.2- Desired special mode: N/A

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6.3- Desired AO mode: LTAO

7.1- Integration time per target or field and per setup: 1, 24, seeing <= 0.4", airmass = 1, PHO

7.2- Longest continuous observation time on a target or field: N/A

7.3- Shortest integration time on a target or field: N/A

7.4- Total time: 200

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 80

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: ALMA, JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
LTAO is essential given the expected crowding of these regions, ~1000 targets per arcsec2 at K = 25-30

9.3- Detailed description or other comments:
N/A

1.1- Project Title: Is the low-density IGM at z~2-3 metal enriched?

1.2- Project Category: 2

1.3- Abstract:
At the epoch of peak activity of galaxy and quasar formation (redshift z~2-3) over 90% of the baryons are in the IGM, but only about half of the metals produced by star formation in high-

redshift UV-selected galaxies have been measured (in the galaxies themselves, the IGM and the damped Lya absorbers). The missing metals could reside in regions with temperatures T > 2x104 K and HI column densities N(HI)<1014 cm-2, as suggested by hydrodynamic simulations with galactic superwinds. In these models, underdense regions of the IGM could be metal-enriched with mean abundances of up to 10-2 solar. Our goal is to determine the metallicity level of the low density IGM. This requires detecting CIV column densities at least 10 times smaller than currently achieved, thus selecting as background targets the very brightest quasars and possibly GRBs. This will constrain the occurrence and strength of galactic superwinds at z~2-3 and help solve the problem of missing metals.

1.4- Publication agreement: yes

2.1- PI: Joe Liske

2.2- CoIs: Jacqueline Bergeron

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: postdoc

2.6- E-mail: jliske@eso.org

3.1- Source of targets: existing QSO catalogues (NED, SDSS) + new cats from VST/VISTA + LSST

3.2- Preparatory work on targets required?: yes, Surveys to find more bright high-z QSO candidates + spectroscopic follow-up to confirm candidates

3.3- Target brightness: 15, 17.5, Vegamag, V

3.4- Target size: point source

3.5- Number of targets: 15

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-70 - +70

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: AGN

4.1- Spatial resolution: seeing, 1

4.2- Field-of-view: fiber

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 390 - 620

5.2- Spectral Resolution: 50000-100000

6.1- Instrument: CODEX

6.2- Desired special mode: other, low-R mode with R~50000

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 2, 15, seeing=0.8"", airmass < 1.5

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: 1800

7.4- Total time: 150

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 50

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:

The goals of this programme can be met as log as QSO spectra with R~50,000 and S/N~1000 can be taken.

9.3- Detailed description or other comments:
This is a DRM case.

1.1- Project Title: Colour-magnitude diagrams of resolved stellar populations of elliptical galaxies

1.2- Project Category: 2

1.3- Abstract:
Elliptical galaxies represent the majority of luminous mass in the Universe and all the indirect observational indications, from the discovery of Elliptical galaxies in high redshift surveys, to studies of integrated stellar populations, suggest that they are predominantly very old systems. However, the main theory of galaxy formation
predicts that they assembled their mass relatively recently, and should therefore be dynamically young. It is important to accurately quantify this apparent contradiction. The only way to uniquely resolve this issue is to make CMDs of the resolved stellar populations in a sample of Elliptical galaxies, using the techniques developed for studies of Local Group galaxies. This means we need to reach the Virgo cluster, 17Mpc away. The detailed properties of Ellipticals will also be compared to the properties of a range of other large galaxies in the Local Group, and at distances out to and beyond Virgo to understand the effect of environment.

1.4- Publication agreement: yes

2.1- PI: Joe Liske

2.2- CoIs: Eline Tolstoy

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: postdoc

2.6- E-mail: jliske@eso.org

3.1- Source of targets: Existing catalogues of nearby galaxies and Virgo, VLT, HST

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 25, 32, Vegamag, K

3.4- Target size: point source

3.5- Number of targets: 5

3.6- Density of targets: N/A

3.7- Target coordinates: RA:12.5 - 12.5;Dec:12.75 - 12.75

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star, galaxy

4.1- Spatial resolution: diffraction, 2

4.2- Field-of-view: 10x10arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: I, K

5.2- Spectral Resolution: bbimaging

6.1- Instrument: MICADO

6.2- Desired special mode: N/A

6.3- Desired AO mode: MCAO

7.1- Integration time per target or field and per setup: 10, 100, seeing=0.8""

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: 300

7.4- Total time: 500

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7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, N/A

9.2- Critical aspects / limiting factors for the science case:
This programme requires diffraction-limited imaging over as large a FoV as possible.

9.3- Detailed description or other comments:
This is a DRM case. The assumption here is to observe 5 different fields (either all in the same galaxy or in different galaxies) in Virgo, both in I and K, each field requiring ~100 hours in total.

1.1- Project Title: First Stars relics in the Milky-Way and satellites

1.2- Project Category: 2

1.3- Abstract:
There are two basic ways to probe the very first stellar formation events: look for pop III stars at high redshift, or observe, locally, the nucleosynthetic imprints of these first stars. Searches for the most metal-poor stellar content of the galactic halo are advancing fast and in the coming decade, we expect to have large samples of extremely metal-poor stars identified throughout the Milky-Way halo and the nearby galaxies (Magellanic Clouds and closest dwarf spheroidal galaxies). These stars still display in their atmospheres the imprints of metal-enrichment by pop III stars, and allow to gain insight on the nature and nucleosynthesis of the earliest chemical enrichment processes, provided that the detailed abundance patterns of these stars can be derived (eg Cayrel et al. 2004). This DRM reviews what major steps could be taken by a 42m ELT, examining the wavelength domains needed for various applications.

1.4- Publication agreement: yes

2.1- PI: Joe Liske

2.2- CoIs: Vanessa Hill

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: postdoc

2.6- E-mail: jliske@eso.org

3.1- Source of targets: HES, SEGUE, LAMOST, SSS

3.2- Preparatory work on targets required?: yes, surveys for extremely metal poor stars must be carried out first

3.3- Target brightness: 15, 21, Vegamag, B

3.4- Target size: point source

3.5- Number of targets: 100

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-90 - +90, RA:5.5 - 5.5;Dec:-69.75 - -69.75, RA:1 - 1;Dec:-72.75 - -72.75

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: star

4.1- Spatial resolution: seeing, 1

4.2- Field-of-view: fiber

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 310 - 670

5.2- Spectral Resolution: 20000-50000, 50000-100000

6.1- Instrument: CODEX

6.2- Desired special mode: other, low-R mode with R < 100,000

6.3- Desired AO mode: best

7.1- Integration time per target or field and per setup: 2, 10, seeing=0.8"", airmass < 1.5

7.2- Longest continuous observation time on a target or field: 2

7.3- Shortest integration time on a target or field: 1800

7.4- Total time: 500

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 20

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: N/A

9.2- Critical aspects / limiting factors for the science case:
Part of this programme requires observations in the UV down to the atmospheric cut-off (310 nm). This is only possible if the telescope mirrors are coated with aluminium.

9.3- Detailed description or other comments:
This is the DRM case. The number of targets was pulled from thin air, it''s not specified in the proposal. The total time required is a guesstimate only.

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1.1- Project Title: ELT integrated spectroscopy of early-type galaxies at z>1

1.2- Project Category: 2

1.3- Abstract:
Despite early-type galaxies (ETGs) being crucial probes for cosmological and galaxy formation studies, their observation at high redshifts (e.g. $z > 1.5$) is extremely challenging due to their faintness and lack of emission lines which place them generally beyond the limits of 10m-class telescope spectroscopy. We propose here to obtain ELT spatially integrated spectroscopy of a sample of ≈500 ETGs at $1.5 < z < 5$ selected from future
near-IR imaging surveys. Since these galaxies are very compact ($re \approx 0.1 - 0.3$ arcsec), their spectroscopy does not require "high performance" AO correction. These observations will allow us to derive the redshift, stellar population content, age, metallicity and dynamical masses of these galaxies, and to use them to trace the cosmic history of galaxy mass assembly.

1.4- Publication agreement: yes

2.1- PI: Andrea Cimatti

2.2- CoIs: Piero Rosati, Marijn Franx, Isobel Hook

2.3- Institute: U. Bologna

2.4- Country of Employment: IT

2.5- Career Stage: faculty

2.6- E-mail: a.cimatti@unibo.it

3.1- Source of targets: VISTA. e-ROSITA, SPT

3.2- Preparatory work on targets required?: yes, wide-field imaging survey to select the targets

3.3- Target brightness: 21, 23, Vegamag, K

3.4- Target size: extended source, 100, 500

3.5- Number of targets: 500

3.6- Density of targets: 0.5

3.7- Target coordinates: N/A

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy

4.1- Spatial resolution: 250, 2

4.2- Field-of-view: 10x10arcmin

4.3- Multiplexity and pick-off FoV: 50, 1x1arcsec

4.4- Plate scale stability: N/A

5.1- Wavelength range: 600 - 2500

5.2- Spectral Resolution: 3000-5000

6.1- Instrument: EAGLE, OPTIMOS

6.2- Desired special mode: N/A

6.3- Desired AO mode: GLAO

7.1- Integration time per target or field and per setup: 10, 20, ELT ETC v2.5. K=23, GLAO, 100mas scale, R=5000 rh=200 and 300mas

7.2- Longest continuous observation time on a target or field: 8

7.3- Shortest integration time on a target or field: 3600

7.4- Total time: 300

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 100

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: yes, quicklook reduction tools to assess data quality

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8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, JWST will provide rest-frame optical imaging

9.2- Critical aspects / limiting factors for the science case:
Field of view and multiplex are crucial. Optical spectroscopy (to 0.6um) allows us to observe rest-frame UV.

9.3- Detailed description or other comments:
Ideally we would like the full wavelength coverage from 0.6 to 2.5 microns. We have therefore selected both OPTIMOS and EAGLE instruments above.

High-order AO correction is not critical - the targets are of order 0.3" size so seeing-improvement such as GLAO would help.

Detailed science case: (see DRM proposal for full detailsand description of target selection, exposure times etc)

Early-type galaxies (ETGs) play a crucial role in cosmology. They are the most massive galaxies in the local Universe, contain most of the stellar mass and are the primary probes to investigate the cosmic history of galaxy mass assembly. As ETGs are the most clustered galaxies, they are also fundamental in tracing the evolution of the large scale structures as well as the evolution of galaxy clusters.
Finally, due to the correlation between the black hole and bulge masses, ETGs must play a key role in the co- evolution of spheroids and their central supermassive black holes. Although ETGs in the nearby Universe are rather simple and homogeneous systems in terms of morphology, colors, stellar population content and scaling relations (Renzini 2006 and references therein), their formation and evolution is still a debated question.
The most recent surveys suggest the most massive ETGs (stellar mass > 1011 M ⊙) were already in place at z ≈0.8, with a number density consistent with the one at z=0 (e.g. Yamada et al. 2005; Bundy et al. 2006; Scarlata et al. 2007; Cimatti, Daddi & Renzini 2006; Bundy, Treu & Ellis 2007), whereas the evolution is more pronounced for the lower mass ETGs which may increase their mass from z ≈0.8 to z=0 through the merging of disk and/or early-type galaxies (e.g. Bell et al. 2004). This mass–dependent evolution is known as ”downsizing” (Cowie et al. 1996), i.e. with massive galaxies forming their stars earlier and faster than the low mass ones. It is unclear whether the downsizing can be extended to the stellar mass assembly evolution itself (e.g. Cimatti, Daddi & Renzini 2006; Bundy, Treu & Ellis 2007), and whether this may represent a significant problem for galaxy formation models where massive galaxies are expected to assemble their mass gradually through hierarchical merging of CDM halos (e.g. De Lucia et al. 2006).

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The uncharted territory beyond $z \approx 1$:

Beyond $z \approx 1$ the picture is even more controversial because the spectroscopic identification and study of ETGs at these redshifts is usually beyond the capabilites of 10m-class telescopes. Due to the strong k-correction, ETGs become rapidly very faint in the optical (e.g. I > 25 Vega) and extremely difficult to observe with optical spectroscopy. In addition, ETGs have spectra without strong emission lines, and the most prominent spectral features (e.g. the D4000 continuum break and CaII H&K absorption lines) are redshifted at $\lambda > 1\mu m$ for $z > 1.5$, where ground-based spectroscopy is increasingly difficult due to the strong OH sky lines.
Pushing the 10m-class telescopes to their limits, it has been possible to unveil ETGs up to $z \approx 2$ with spectroscopy done either in the optical (Cimatti et al. 2004; McCarthy et al. 2004, Daddi et al. 2005) or in the near-IR (Saracco et al. 2005; Kriek et al. 2006). However, despite the very long integration times, spectroscopy was limited only to the very few brightest ob jects (K < 19, Vega) and to rather low spectral resolution (typically R<1000), and it was impossible to derive the dynamical masses through the velocity dispersion of the absorption lines.

The few distant ETGs spectroscopically identified at $1.5 < z < 2.5$ are very red ($R - K > 5 - 6$), compact (re $\approx 0.1 - 0.2$ arcsec), dominated by passively evolving old stars with ages of 1-4 Gyr, and have stellar masses typically > 1011 M $\odot$, implying a star formation history characterized by strong (> 100 M$\odot$/yr) and short-lived (0.1-0.3 Gyr) starbursts occurring at $z > 2 - 3$, then followed by passive evolution.
It has been recently found that ETG photometric candidates continue to be present in substantial number also at higher redshifts (3 < zphot < 6) (Mobasher et al. 2005; Dunlop et al. 2006; Brammer & van Dokkum 2007; Rodighiero et al. 2007), but it is unknown if they are really old/passive systems or starbursts with extremely red colors due to strong dust obscuration. Also in this case, their faintness (e.g. KAB $\approx 24 - -25$) makes the spectroscopic identification and study currently impossible.
The existence of old, massive, passive ETGs $z > 1.5$ was unexpected in the galaxy formation models available in 2004-2005, and opened the question on how it was possible to assemble such systems when the Universe was so young. A better agreement with the observations seems possible by ”quenching” the star formation at high redshifts with some ”feedback” mechanisms (e.g. AGN), but the question is still completely open (e.g. Menci et al. 2006), and more observations are required to clarify the picture.

1.1- Project Title: A Survey of Black Holes in Different Environments

1.2- Project Category: 2

1.3- Abstract:
We propose to carry out a spatially resolved spectroscopic survey of the centers of elliptical and early type galaxies with very low and very high central velocity dispersions. The goal of the survey is to resolve the Sphere of Influence (SoI) of the suspected black holes (BHs) in those galaxies and thereby investigate the low and hi-mass end of the M_BH-σ relation. Our sample includes galaxies in a broad range of clusters as well as field galaxies. The centers of all galaxies in our sample have previously been imaged by HST and/or JWST, and expected BH masses have been estimated based on the cusp brightness and velocity dispersion. The survey will for the first time resolve the SoI of BH with masses M_BH of around 106 outside the local Universe, and at the same time yield spectroscopic data of a significant sample of the most massive BHs currently known. The survey also might discover supermassive BHs with masses of up to about 10e10 M_solar.

1.4- Publication agreement: yes

2.1- PI: Wolfram Freudling

2.2- CoIs: Eric Emsellem (ESO), Alessandro Marconi (Arcetri), Aybüke Küpcü Yoldaş (ESO)

2.3- Institute: ESO

2.4- Country of Employment: ESO

2.5- Career Stage: faculty

2.6- E-mail: ayoldas@eso.org

3.1- Source of targets: SDSS, HST

3.2- Preparatory work on targets required?: no

3.3- Target brightness: 17, 25, Vegamag, R

3.4- Target size: extended source, 500, 5000

3.5- Number of targets: 70

3.6- Density of targets: N/A

3.7- Target coordinates: RA:0 - 24;Dec:-61 - +19

3.8- Moving target?: no

3.9- Variable target?: no

3.10- Target type: galaxy, AGN

4.1- Spatial resolution: 5, 1

4.2- Field-of-view: 1x1arcsec

4.3- Multiplexity and pick-off FoV: N/A

4.4- Plate scale stability: N/A

5.1- Wavelength range: 800 - 2400

5.2- Spectral Resolution: 3000-5000, 10000-20000

6.1- Instrument: HARMONI, other, Single field IFU

6.2- Desired special mode: N/A

6.3- Desired AO mode: LTAO

7.1- Integration time per target or field and per setup: 2, 20, 0.8 arcsec seeing, 1.0 airmass, dark time, based on simulations

7.2- Longest continuous observation time on a target or field: 20

7.3- Shortest integration time on a target or field: 600

7.4- Total time: 500

7.5- Percentage of the total time sufficient to obtain scientifically useful results: 75

7.6- Are the observations time critical?: no

8.1- Does the execution of observations require real-time decisions?: no

8.2- Would you welcome remote observing capabilities?: no

8.3- Does the programme require the use of two or more different E-ELT instruments?: no

8.4- Is it Target-of-Opportunity like?: no

9.1- Synergy with other programmes: JWST, N/A

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9.2- Critical aspects / limiting factors for the science case:
high spatial resolution IFU capabilities is essential to resolve the sphere of influence of the SMBH.

9.3- Detailed description or other comments:
The relationship between host galaxy bulge mass and black hole (BH) mass is well established for both active and currently inactive galaxies (McLure & Dunlop, 2002, MNRAS, 311, 795). Wyithe (2006, MNRAS 365, 1082) and Greene & Ho (2006, ApJ 641, L21) have recently argued that the linear M_BH-σ relation steepens at high black hole masses and flattens at low black hole masses. Lauer et al. (2006, ApJ, astro-ph/0606739) argue that cusp brightness might in fact be a better estimator of the black hole masses than σ for the most massive BHs with M_BH> 10e9 Msun. If confirmed, this might explain why it has been so difficult to find the supermassive black holes in the local Universe, which are expected to exist as the counter parts of the high-z QSOs. It is currently not known whether the M_BH-σ relation depends on environment or if and how it evolves.
To study the MBH-σ relation at its extreme ends, it is necessary to directly determine the BH masses for statistical significant samples. To confidently detect and measure the mass of a nuclear BH, we need to probe the volume within which the BH dominated the galactic dynamics. Called the 'Sphere of Influence', this region has a radius defined as:

r = G*M_BH /σ^2 = 4.3pc(M_BH /10e7 Msun)/(σ/100km/s)2 (1)

where σ is the stellar velocity dispersion. A typical scale for BH masses of ~ 10e7 Msun is about 7 pc.
Unfortunately, it is quite difficult to probe the SoI in galaxies at the extreme ends of the M_BH-σ relation.
There are currently only two cases where this region has been probed directly to show that a massive BH is the only physical possibility: our Galaxy and NGC4258. The projected diameter of the SoI for a BH with masses of ~ 10e7 Msun is significantly smaller than 100mas at the distance of the Virgo cluster. Because of the low volume density of high-mass BHs, studying the high-mass end of the M_BH-σ relation requires samples at moderately high redshifts out to z ~ 0.4. At such distance, the SoI is again smaller than 100mas. In addition, the onset of significant surface brightness dimming at such redshifts makes it impossible to obtain spatially resolved spectroscopy of the cores of such galaxies with 8m class telescopes. Therefore, progress in this field will be moderate before the arrival of the E-ELT.
However, the high angular resolution and sensitivity of the E-ELT will allow:
1. to resolve nuclear sub-structures down to a few pc at distances of tens of Mpc (depending on aperture and PSF). This will allow mass determination of BHs with masses similar to the one in the center of the Milky Way out to the distance of Virgo.
2. resolve the sphere of influence for the most massive BHs with masses of greater than 10e9 Msun at cosmological redshifts. Mass determination of black holes will be limited by the available light only. Mass determination for 10e9 Msun BHs will be possible out to a redshift of about 0.4, allowing the collection of statistical samples of such objects.

Such measurements are fundamental to the understanding of the relationship between the evolution of the BH and the host galaxy, including the possible connection between AGN and starburst activity.
A rough estimate of the maximum redshift at which BHs can be spectroscopically resolved is shown in Fig. 1.
For each BH mass, the size of the SoI was computed. Subsequently, the maximum distance at which the projected diameter of the SoI is more than 10 mas was determined. An additional complication is that the most massive BHs tend to be in galaxies with relatively low surface brightness in the center. This effect was taken into account by assuming that the central surface brightness is related to the BH mass as given in Eq. 10 of Lauer et al. (2006). It can be seen that accurate mass determination will be limited to redshifts less than z ~ 0.6 even for the most massive BHs.

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