Euclid

Mapping the geometry of the dark Universe

NASA**facts**

Overview

Euclid is a European Space Agency (ESA) M-class mission designed to accurately measure the expansion history of the Universe and the growth of cosmic structures over the past 10 billion years. Euclid will constrain dark energy models, test general relativity, measure dark matter, and refine constraints on the initial conditions of the Universe with unprecedented accuracy, which only a space-based experiment can deliver.

The mission will carry out an imaging survey in the optical and near-infrared, as well as a spectroscopic survey in the near-infrared. The Euclid instruments are provided by the ESA member states, with NASA contributing to the spectrometer and imaging photometer in the near-infrared. The Euclid mission has been optimized for the measurement of two probes sensitive to dark energy:

(1) Weak Lensing (WL) — Observing the distortion of the images of galaxies caused by gravitational light deflection from invisible foreground mass concentrations of predominantly dark matter. The spatial and redshift distribution of dark matter can be derived if the redshifts of the distorted background galaxies are known. Euclid will perform this cosmic tomography of dark matter out to redshifts equal or larger than 2, enabling the investigation of the growth of dark matter structures and the effects caused by dark energy.

(2) Galaxy Clustering — Observing the large-scale distribution of galaxies by measuring the positions and redshifts of tens of millions of galaxies. The distribution carries the imprint of sound waves from the epoch of recombination, the scale of which is known from measurements of the cosmic microwave background. As a standard ruler, these baryon acoustic oscillations (BAO) provide Euclid with accurate measurements of the Hubble parameter and distance, allowing precision constraints on the accelerated expansion of the Universe. The same data set contains the effect of redshift space distortions (RSD), the signature of the anisotropic distribution of galaxies in redshift space due to galaxy clustering dynamics. The RSD give an additional, independent measure of the growth of structure in the Universe, probing the validity of general relativity on cosmic scales.

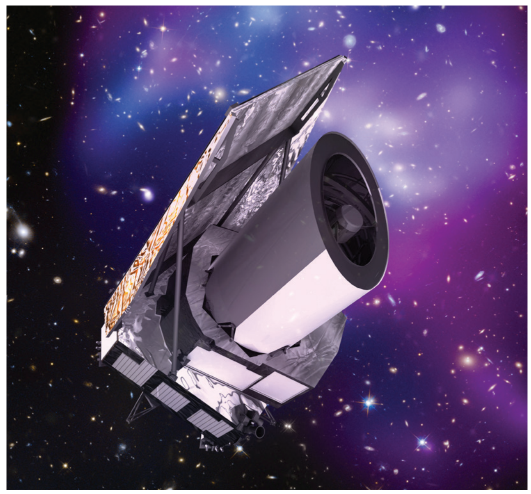

Image Credit: ESA/C. Carreau

Artist's impression of Euclid. Euclid will make unprecedented measurements of the properties of dark energy with visible and near-infrared instruments using a 1.2-m telescope, operating at the Earth–Sun L2 point.

Although Euclid is optimized for Dark Energy surveys, the data it gathers will enable unprecedented advances across a range of astrophysics topics. Euclid delivers high-quality morphologies, masses, and star-formation rates for billions of galaxies out to z~2, over the extragalactic sky. In addition, the data provide vital information on objects in our own Solar System, probe the history of the Milky Way halo, and determine the contribution of the light of the first stars to the infrared background.

Euclid Science Objectives

Euclid incorporates four main science objectives:

1. Dark Energy Properties. Measure the dark energy equation of state parameters, w_p and w_a, to a precision of 2% and 10%, respectively, using Euclid's expansion history and structure growth constraints alone. When combined with additional probes and results from Planck, the constraints on w_p and w_a improve to 0.7% and 3.5% precision, respectively.
2. Beyond Einstein's Gravity. Distinguish general relativity from modified-gravity theories by

measuring the galaxy clustering growth factor exponent, γ, with a precision of 2%.

3. Dark Matter. Test the cold dark matter paradigm for structure formation, and measure the sum of the neutrino masses to a precision better than 0.02 eV when combined with results from the Planck mission.
4. Seeds of Cosmic Structure. Improve the determination of the initial condition parameters compared to Planck alone. These parameters include the index of primordial power spectrum fluctuations, n, the running of the spectral index α_s, and the non-gaussianity parameter, f_{NL}.

Payload

The Euclid payload consists of a 1.2-m Korsch telescope feeding two instruments via a dichroic beam splitter. The visible-band imager (VIS) has one pass band of 550–900 nm. The VIS focal plane consists of 36 4kx4k CCDs, covering more than a 0.5 deg^2 field of view with 100 milliarcsecond pixels.

The near-infrared spectrometer and imaging photometer (NISP) provides both slitless spectroscopy and imaging, with mode selection via a filter wheel. The NISP focal plane consists of 16 2kx2k infrared detectors, covering more than a 0.5 deg^2 field of view with 300 milliarcsecond pixels. The imaging photometer mode contains 3 filters: Y, J, H in the 0.9–2 micron wavelength range. The slitless spectrometer mode contains one blue bandpass grism (0.92-1.3 microns) and three red bandpass grisms (1.25-1.85 microns). This mode provides a spectral resolution $\lambda/\Delta\lambda \sim 380$ for an object of 0.5 arcsec.

Euclid Surveys

Euclid's Wide Survey will cover > 1/3 of the sky at high galactic latitude. The Wide Survey enables galaxy shear measurements for 30–40 galaxies/arcmin^2, and spectroscopic measurements for 1700 galaxies/deg^2 with a redshift accuracy of $\Delta z < 0.001(1+z)$. Euclid's Deep Survey will be 2 magnitudes deeper than the Wide Survey, obtained by repeated wide survey observations, and covers an area of approximately 40 deg^2 in patches of greater than 10 deg^2.

Operations

The science data are downlinked in the K-band (26 GHz) during 4 hours ground station contact. The science data rate is 850 Gbits/day. Communications in the X-band are used for commanding and housekeeping data transfer. Mission operations will be conducted from the European Science Operations Center (ESOC) in Darmstadt (Germany); science operations will be conducted from the European Space Astronomy Center (ESAC) in Madrid (Spain).

Project Management

ESA has established a project structure for Euclid, with Giuseppe Racca as the Project Manager and René Laureijs as the Project Scientist. The Euclid Consortium, led by Yannick Mellier, is a collaboration of over 100 universities and laboratories across Europe and the U.S., and is tasked with building VIS and NISP for Euclid, as well as contributing to the Science Ground Segment.

NASA Participation

NASA has negotiated a Memorandum of Understanding with ESA for a role in Euclid. For its contribution administered through the Physics of the Cosmos Program Office, a NASA project office has been established at the Jet Propulsion Laboratory, with Ulf Israelsson as the Project Manager and Michael Seiffert as the Project Scientist. NASA's contribution includes the NISP detectors, along with cryogenic cables and cold readout electronics. Goddard Space Flight Center's Detector Characterization Lab (DCL) will characterize the flight detectors.

In addition to the hardware contribution, NASA has selected three PI-led teams to participate in the Euclid consortium. They are:

- "Exploring Dark Energy and Modified Gravity With Euclid," PI Jason Rhodes.
- "Looking at Infrared Background Radiation Anisotropies with Euclid," PI Alexander Kashlinsky.
- "Precision Studies of Galaxy Growth and Cosmology Enabled Through a Physical Model for Nebular Emission," PI Ranga-Ram Chary.

These NASA-sponsored investigators and their teams have integrated into the Euclid Consortium and will conduct their investigations in the context of the Science Working Groups organized by the consortium. In addition, Jason Rhodes has been selected as the NASA representative to the Euclid Science Team and Euclid Consortium Board.

NASA has also established the Euclid NASA Science Center at IPAC (ENSCI) in order to support US-based investigations using Euclid data. ENSCI will participate in the Euclid Consortium's Science Ground Segment, providing algorithm and software development, participating in data quality assurance, and performing data processing. In addition, ENSCI will support the US research community by providing expert insight into the Euclid surveys, data processes, calibration, and products.

For more information:

Euclid Definition Study Report	**arxiv.org/abs/1110.3193**
ESA project website	**sci.esa.int/euclid/**
NASA project website	**euclid.jpl.nasa.gov**
Euclid Consortium website	**www.euclid-ec.org**

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JPL 400-1515 Rev. 2 2/15