Why Galaxies Care About AGB Stars:
A Continuing Challenge through Cosmic Time
Proceedings IAU Symposium No. 343, 2019
F. Kerschbaum, M. Groenewegen & H. Olofsson, eds.

doi:10.1017/S1743921318006361

Modelling dust around Nearby Evolved Stars Survey (NESS) Targets

Sundar Srinivasan†, T. Dharmawardena, F. Kemper, P. Scicluna and The NESS Collaboration

Academia Sinica Institute of Astronomy & Astrophysics (ASIAA)
11F Astronomy-Mathematics Building, No. 1, Sec. 4, Roosevelt Road, Taipei 10617, Taiwan
email: s.srinivasan@irya.unam.mx

Abstract. We present radiative transfer modelling of the dust around U Ant, a well-studied detached-shell source. U Ant is among the >400 sources targeted by the Nearby Evolved Stars Survey (NESS; PI: P. Scicluna), and the procedure used to model this source will be applied to the rest of the AGB sample in NESS.

Keywords. stars: AGB and post-AGB, stars: mass loss, (stars:) circumstellar matter, radiative transfer

1. Background

The Nearby Evolved Stars Survey (NESS; Scicluna *et al. in prep.*) is a large collaboration targeting a volume-limited ($d < 2$ kpc) sample of evolved stars in both CO line emission as well as continuum using multiple sub-mm facilities. The large sample size (over 400 objects) will allow NESS to derive robust estimates of the stellar gas and dust return to the Galactic interstellar medium. A pilot study for NESS imaged 14 AGB stars and one RSG with the SCUBA-2 instrument on the James Clerk Maxwell Telescope (JCMT) at 450 and 850 μm. Dust density profiles derived from these data showed a non-constant mass loss in all cases (Dharmawardena *et al.* 2018). In addition, multiple sources showed detached shells and asymmetric dust distributions. A systematic analysis of the NESS data requires us to develop a general framework for the radiative transfer (RT) modelling. We begin by modelling dust around the C-rich AGB star U Ant, a well-known detached shell source (*e.g.*, González Delgado *et al.* 2003; Kerschbaum *et al.* 2010; Maercker *et al.* 2010; Arimatsu *et al.* 2011; Maercker *et al.* 2018).

2. Analysis

The U Ant observations analysed here were obtained as part of the NESS project (see Dharmawardena *et al. in prep.* for details). Surface brightness profiles were derived using the methods described in Dharmawardena *et al.* (2018). The PSF-subtracted 850 μm residual profile is dominated by a broad peak in the $20'' - 40''$ range. We fit these data with synthetic intensity profiles generated from radiative transfer models for the U Ant detached shell. Following a procedure similar to that of Kerschbaum *et al.* (2010) and Maercker *et al.* (2018), we first constrain the properties of the central star and the recent mass loss (the "attached" shell). For this purpose, we fit the spectral energy distribution (SED) with models from the GRAMS carbon-star grid (Srinivasan *et al.* 2011). We then

† Present address: Instituto de Radioastronomía y Astrofísica, Universidad Nacional Autonóma de México, Antigua Carretera a Pátzcuaro #8701, Ex-Hda. San José de La Huerta, Morelia, Michoacán, 58089, México.

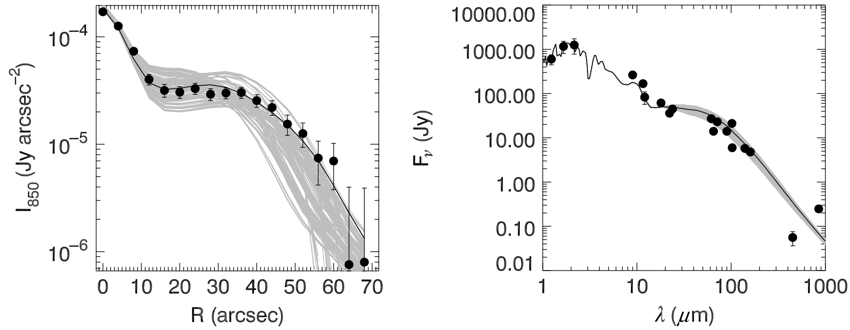

Figure 1. *Left*: best-fit models (black and grey curves) to the observed U Ant intensity profile (circles) at 850 μm. *Right*: the same models overlaid on the observed SED (circles).

construct a grid of models for the detached shell, exploring three parameters – the inner and outer radii $R_{\rm in}$ and $R_{\rm out}$ of the detached shell, and the density enhancement at $R_{\rm in}$ compared to the attached shell.

3. Results and discussion

Figure 1 shows the best-fit model along with the top 100 acceptable fits, which are used to estimate the parameter errors. These models also fit the overall SED (Figure 1). We find a dust-production rate of $(3.6 \pm 0.5) \times 10^{-9}$ $M_\odot$ yr^{-1} for the detached shell, corresponding to a dust mass of $(1.5 \pm 0.2) \times 10^{-5}$ $M_\odot$. Assuming a gas:dust ratio of 200, we obtain a gas mass-loss rate of $(7.2 \pm 1.1) \times 10^{-7}$ $M_\odot$ yr^{-1}. These estimates are consistent with those of Kerschbaum *et al.* (2010) and Maercker *et al.* (2018). While the modelled intensity profile and SED show good overall agreement with those derived from the data, our models seem to predict a lower 850 μm flux than observed (Figure 1). This could be due to the fact that we have ignored the complex geometry of the dust shell in our model, or possibly due to a variation in the dust properties in the shell. We will explore more free parameters in future modelling to address these issues, by combining our data with interferometric observations to constrain the properties in the inner ($R < 12''$) regions of the shell.

References

Arimatsu, K. Izumiura, H., Ueta, T., *et al.* 2011, *ApJ*, 729, 19

Dharmawardena, T., Kemper, F., Scicluna, P., *et al.* 2018, *MNRAS*, 479, 536

González Delgado, D., Olofsson, H., Schwarz, H. E., *et al.* 2001, *A&A*, 372, 885

González Delgado, D., Olofsson, H., Schwarz, H. E., *et al.* 2003, *A&A*, 399, 1021

Kerschbaum, F., Ladjal, D., Ottensamer, R., *et al.* 2010, *A&A* 518, 140

Maercker, M., Olofsson, H., Eriksson, K., *et al.* 2010, *A&A*, 511A, 37

Maercker, M., Khouri Silva, T., De Beck, E., *et al.* 2018, *A&A*, https://arxiv.org/abs/1807.11305

https://doi.org/10.1017/S1743921318006361 Published online by Cambridge University Press