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The Circumstellar Envelopes of Post-AGB Stars

Kim L. Clube and Tim M. Gledhill

Centre for Astrophysics Research, University of Hertfordshire, College Lane, Hatfield, Herts, AL10 9AB, UK email: kclube@star.herts.ac.uk

Abstract. Mid-IR images of a small sample of post-AGB stars have been obtained with the mid-IR camera, OSCIR, mounted on the 8-m Gemini North Telescope. Model calculations, using a 2-D dust RT code, have been performed in order to constrain the physical and chemical properties of the dust in the envelopes, for each object. Studies of individual objects in this transitional phase can be used to investigate the final period of AGB mass loss and improve our current understanding of the evolution of PN. Mid-IR images and modelling results for IRAS 22223+4327 are presented here. The observed mid-IR structure, which shows two emission peaks, is interpreted as the detection of two limb brightened edges of a dust torus. The position of the dust torus is in agreement with the position of the outflows observed in the archived HST optical images. This object deviates from axisymmetry, in the same way as several other post-AGB stars, where one of these peaks is brighter than the other. From the modelling of the SED of this object, estimates for the mass of the dust in the envelope and the mass-loss rate are derived.

Keywords. radiative transfer, stars: AGB and post-AGB, stars: individual (IRAS 22223+4327), stars: mass loss, infrared: stars

1. IRAS 22223+4327

IRAS 22223+4327 is a C-rich (Likkel *et al.* 1991) post-AGB star and displays both the 21 and 30μm features. So far measurements of the radial velocities show no evidence of a binary companion (Decin *et al.* 1998; Van Winckel & Reyniers 2000). The observed mid-IR morphology (Fig. 1) indicates an equatorially enhanced density distribution with two peaks aligned on an E-W axis which we suggest are the limb brightened peaks of a dust torus. The bipolar outflows observed in the HST optical image (Fig. 2) are perpendicular to the orientation of this dust torus. The western peak is brighter than the eastern peak and as this asymmetry is also observed in the J-band polarized flux images (Gledhill *et al.* 2001) this implies that there is more dust present on this side (as opposed to the western peak being hotter).

2. Modelling

The dust code (see Clube & Gledhill 2004; Clube & Gledhill 2006) uses a dust density distribution for an axisymmetric shell based on that of Kahn & West (1985). A uniformly expanding shell, generated by a mass loss rate which is constant over time, is assumed. The model spectrum (Fig. 3) is plotted against the OSCIR data and other observational data for IRAS 22223+4327 taken from the literature (full details in Clube & Gledhill 2006). From the modelling of the SED, estimates for the mass of the dust in the envelope and the mass-loss rate are derived. All modelling results are available in a complete version of this work which is in preparation and will be submitted to MNRAS.

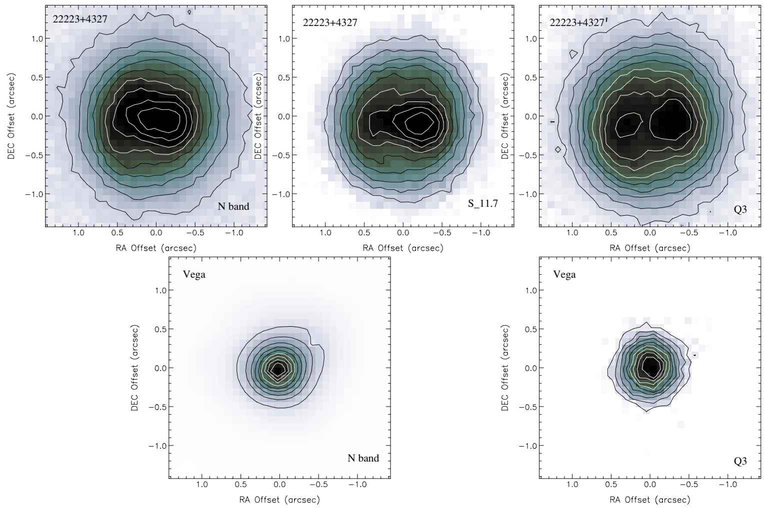

Figure 1. Images of IRAS 22223+4327 from the OSCIR camera on Gemini North using N (10 μm), S11.7 and Q3 (20 μm) filters. The N and Q3 images of the standard star, Vega, observed immediately before and after, are also shown. Innermost contours are 90% of the peak values and spaced linearly at intervals of 10%.

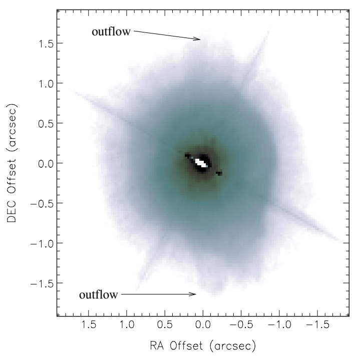

Figure 2. HST/ACS/HRC image of IRAS 22223+4327 with F435W filter from the HST data archive (program 9463)

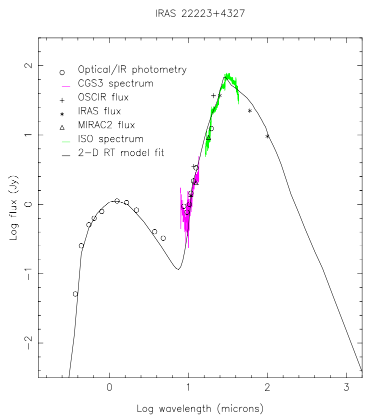

Figure 3. SED and model fit for IRAS 22223+4327

From estimating the flux at the Earth by integrating the energy under the SED and using Schönberner's lower limit for the luminosity of central stars of PNe (2500 $L_\odot$, Schönberner 1983), we suggest that IRAS 22223+4327 is at least 2.8 kpc away.

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