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Properties of the Circumstellar Envelope of the Dual Chemistry Post-AGB Star Roberts 22

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Abstract. A major discovery by the ISO satellite was the presence, in the spectra of many evolved stars, of an array of narrow emission features that could be attributed to crystalline silicate grains in their envelopes (Molster et al. 2002). As the circumstellar envelope is formed from the continuous mass loss of the object during the AGB stage, it is natural to suppose that the central star would share its chemical properties. Thus, one would expect a star surrounded by silicate-rich material to be oxygen-rich. However, crystalline silicates are frequently associated with carbon-rich central objects. These dual chemistry objects present an opportunity to investigate the mechanisms of mass ejection that forms the circumstellar envelope during and after the AGB stage and that also contribute to the enrichment of the interstellar medium. We are modeling the dust envelope of Roberts 22, a post-AGB star with dual chemistry, using a Monte Carlo simulation method to describe the radiative transfer in its circumstellar dust envelope.

1. Introduction

Roberts 22 is an OH maser-line and infrared source, initially catalogued as a Wolf-Rayet star (Roberts 1962) but now believed to be a post-AGB star with an envelope of gas and dust. Sahai et al. (1999) presented a detailed study of its optical morphology, using HST–WFPC2 images and polarimetry. They identified a bipolar SW–NE envelope component of dust and hot gas, and a dense equatorial (perpendicular to the first) disk of dust. From the equatorial component there is also a dust clump protruding to the NE direction, presumably made of material detached from the disk in an early outflow. We are modeling the dust envelope of Roberts 22 using MOCASSIN, a 3D Monte Carlo radiative transport code able to deal with dust and/or gas envelopes of arbitrary geometry and density distribution (for details, see Ercolano et al. 2003; Ercolano, Barlow & Storey 2005). We assume radiative decoupling between dust and gas, and consider dust-only models.

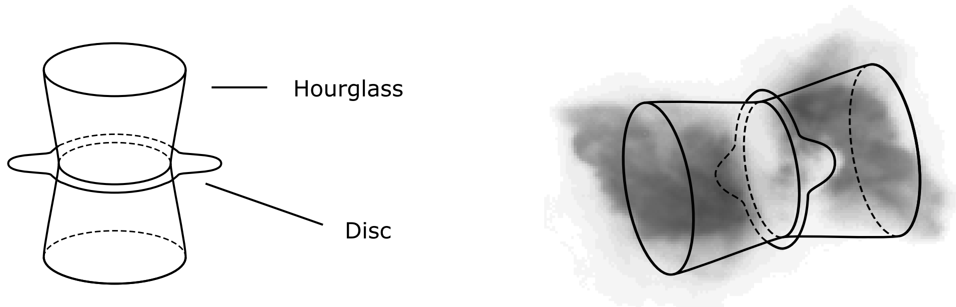

Figure 1. *Left*: the two geometrical components of our dust distribution model for Roberts 22. *Right*: the model oriented to match the data observed by Sahai et al. (underlying image obtained from HST archive).

2. Model and Results

At this stage, we have modeled the circumstellar dust density as the sum of two constant-density components: an hourglass-shaped distribution, to account for the dust on the bipolar complex, and an equatorial disk with two opposite protruding clumps (assuming that the visible clump was generated by a point-symmetric outflow), as shown in Figure 1. We used three grain species: amorphous carbon (AC), amorphous silicate (AS) and crystalline silicate (CS). The relative densities of the species, as well as the grain size, are free parameters; for now, these are assumed to be the same for both components.

These initial simulations could not reproduce the complete spectra observed by the ISO satellite. A fit to the peak of the energy distribution led to some tentative values: a central star temperature $T_\star = 10,000\,\mathrm{K}$ (compatible with the usual description as an A-type star), a dust density of 10^{-8} (hourglass) and 10^{-6} (disk) particles/cm^3, grain species ratios AC/AS = 0.67 and CS/AS = 2×10^{-3}, and a grain size of 50 nm. The next steps are the introduction of density functions decaying with distance from the star, and the use of Gemini/TReCs observations (images and spectra) of Roberts 22 in combination with models with different compositions for each component.

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