RADIATIVE TRANSFER MODELING OF PERIODIC MASS-LOSS ENHANCEMENT DURING THE AGB PHASE

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1. Introduction

Thermally pulsing asymptotic giant branch (AGB) stars suffer mass loss which leads to the formation of a circumstellar shell of gas and dust. At the end of the AGB phase, mass-loss stops and the circumstellar shell begins to drift away from the star. Assuming the velocity of the AGB wind has been relatively constant, the history of mass loss during the AGB phase is imprinted on the dust shell of the post-AGB envelope. By studying the distribution of matter in these circumstellar shells we can gain a better understanding of the mass-loss processes involved in the evolution of these stars. Using far-infrared (IR) ISOPHOT images of the circumstellar shells of the Egg nebula and AFGL 618, we showed that dust shells can be imaged out to a radius of 2-3 pc, and that these dust shells show evidence for episodic enhancements in the mass loss with a period of $\sim 10^4$ years[1]. Here, we present radiative transfer (RT) models of the dust shell around the Egg nebula using the 1-d RT code DUSTY[6] which has been modified to include heating by the ISRF.

2. The models

The observed surface brightness distributions at 120 and 180μm show two well-defined features (bumps) on a slope that gradually flattens out. We have used various density profiles together with heating from the ISRF to try to match the intensity distributions. Our only variables are the dust density distribution and the normalization factor of the ISRF. The external heating from the ISRF is *always* necessary.

In order to get bumps in the dust shell we have included spikes of increased dust density in the density profiles. The bumps must be separated by sufficient space so that they are resolved.

The best fits so far are shown in Fig. 1, which includes the input density profiles.

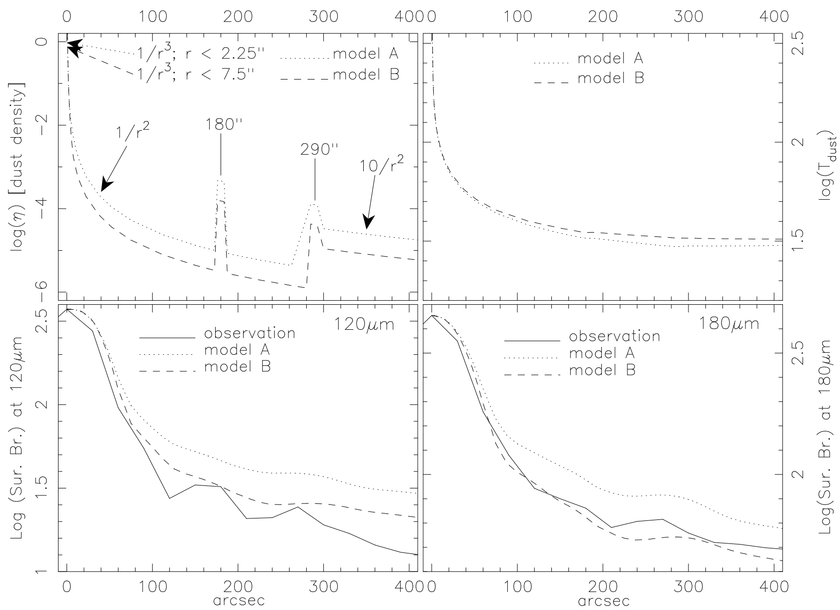

Figure 1. Best fit.

3. Interpretation

The modeled density distribution implies that the mass-loss rate was higher earlier in the progenitor AGB star's evolution and that its mass-loss rate decreased $\sim 7.5 \times 10^5$ years ago, possibly after a thermal pulse. However, the increased density in the outer shell may be the result of the outflowing matter piling up as it reaches the interface with the ISM. The need for a $1/r^3$ fall-off in the innermost part of the shell is indicative of the superwind region where the density reflects the dramatically increasing mass-loss rate at the end of the AGB phase. The spikes in the density distribution correlate with the timescales for thermal pulses during the AGB phase.

References

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