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IMPLICATIONS OF DUST FOR THE RADIATION SPECTRUM OF SHELL-TYPE PN MODELS

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We have modeled the dust in extended PNe and found that the traditional methods used to derive dust temperature and dust-to-gas ratio from IRAS 25 and 60 μm fluxes can be subject to large errors.

Despite the great importance of dust in shells of planetary nebulae (PNe), the effects of dust have been controversial in the literature (Pottasch et al. 1984; Stasińska & Szczerba 1999). The IRAS data are commonly interpreted by means of the following simplifying assumptions:

1. The emissivity of the grains in the IR is approximated by a λ^{-n} law (often n is fixed to -1).
2. The dust is identified by a canonical mean size.
3. The physical conditions are described by a mean temperature derived from an emissivity law λ^{-1} from the IRAS 25 and 60 μm fluxes only (hereinafter $T_{25/60}$).

In the present work we employ a more sophisticated physical model to test the basis of these assumptions.

We used the shell model of Armsdorfer et al. (2002) and examined the effect on the emitted spectrum of independently varying the stellar luminosity L_*, dust-to-gas ratio d/g, and maximum grain size $a_{\rm max}$ in the gas+dust-shell model described by Koller & Kimeswenger (2000) (see Fig. 1). As theoretical calculations show, the grain size distribution is nearly always a power law with an index just below -3, but $a_{\rm max}$ varies strongly with the speed/duration of the formation zone. A variation of $a_{\rm max}$ with constant d/g ratio and L_* leads to almost no variation of $T_{25/60}$ (61 to 69 K). The 60 μm flux, and therefore the derived d/g, varies by a factor of 4. A change in L_* leads to the same result ($61 < T_{25/60} < 68$) as the variation of 4 in the d/g ratio This is remarkable because the real physical temperature of grains undergo the strongest variations here. Finally a true change of d/g leads to a strong modification of $T_{25/60}$ (55 to 90 K) even if the physical temperature is stable in this regime. For a real d/g < 0.002 the gas emission dominates completely and fakes the determination of d/g. Applying our "close to reality" model, we derived for, e.g., NGC 2438 an authentic d/g of 0.0075 and a L_* of $400 L_\odot$ from all IRAS fluxes together. Our results clearly show that $T_{25/60}$ and d/g, if derived "classically", do not provide pure physical parameters but a mixture of ambient condition parameters. We have also investigated the effects of dust on the optical line ratios/structures. We found that the small filling factors of such old evolved PNe allow the ionizing photons to penetrate almost unaffected. The implications for the optical PNe are marginal but this may no longer be the case for young compact objects.

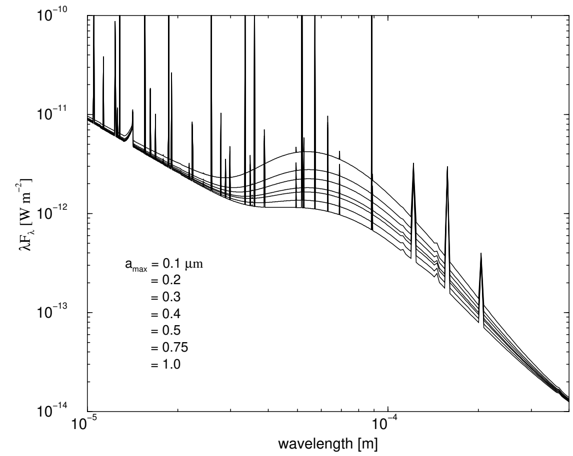

Fig. 1. IR models for different $a_{\rm max}$ at constant d/g.

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