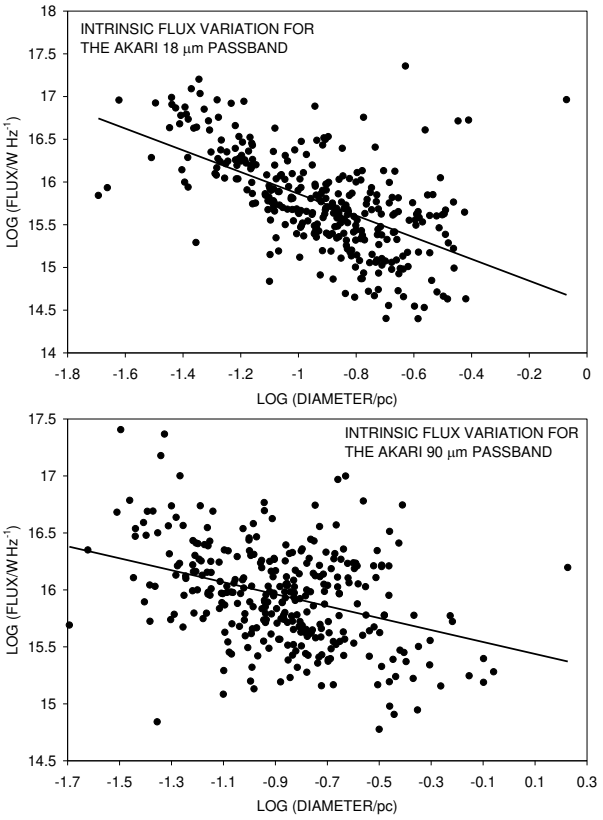

Fig. 7. The variation of the intrinsic 18 and 90 μm fluxes with nebular diameter. In both cases, there is a decrease of flux with increasing diameter, most clearly seen in the 18 μm trends. It is likely that most of this arises from systematic cooling of the IR continua.

these sources may be being only partially detected, we have excluded such nebulae from the present analyses. By contrast, the 18 μm beam sizes are very much smaller, and this may lead to a quite considerable short-fall in certain of the fluxes. This, where it is the case, would counteract the effects of line and band "contamination" noted in § 3.1. We note however that PNe having warmer dust continua tend to be smaller and unresolved (see Figure 6), and their fluxes and temperatures are therefore relatively secure. Similarly, sources having lower values of $T_{\rm GR}$ tend to be angularly large, and their shorter wave fluxes may be significantly too low. However, estimates of $T_{\rm GR}$ for such (lower) grain temperatures are relatively insensitive to uncertainties in the flux, and errors in the trends are likely to be modest. This is consistent with the variations noted in Figure 6, where we see little inconsistency between the estimated temperatures for large and smaller PNe (Figure 6).

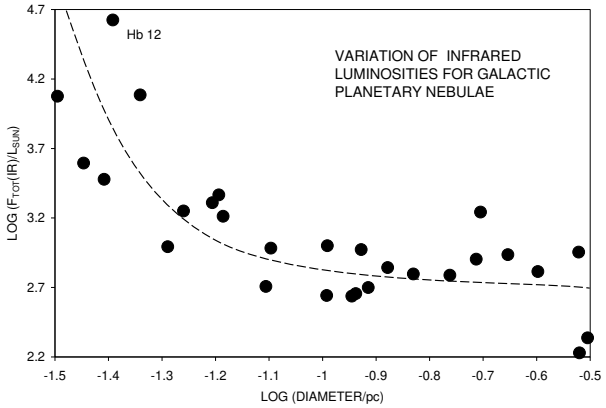

Fig. 8. Variation of total IR luminosity with nebular diameter. It is apparent that luminosities decline with expansion of the PNe, and have maximum values comparable to the luminosities of the central stars. This higher luminosity for the more compact sources suggests appreciable levels of dust opacity. The dashed curve represents an eye-fitting to the results.

3.3. *Variation of Nebular Fluxes and Luminosities with Nebular Evolution*

The emission characteristics of dust in PNe are expected to vary as the nebular envelopes evolve. Thus, expansion of the envelopes would be expected to lead to a reduction in stellar radiative flux densities, and decreases in the levels of direct grain heating. Similarly, the roles of changing stellar temperatures; absorption of Lyα radiation; and the transfer of grains from neutral to ionized regimes, will all be important in determining the energy budgets of the grains and, by extension, the temperature of the dust.

A trivial consequence of such evolution is noted in Figure 7, where we show the variation of intrinsic 18 and 90 μm fluxes as a function of source diameter. It would seem that both of the trends indicate a decrease of flux with D; a variation which may arise through a cooling of the dust continua, such as is noted in Figure 4.

An even more interesting trend is illustrated in Figure 8, where we have estimated total fluxes $F_{\rm TOT}$(IR) for sources within the dust emission regime of Figure 5 (lower panel). For this case, $F_{\rm TOT}$(IR) is determined using the values of γ and $T_{\rm GR}$ obtained from Figure 5; observed 90 μm fluxes; and the distances quoted in Table 1. It is again clear that luminosities decline with increasing nebular dimensions, and have values approaching $\approx 1.5 \times 10^4\ L_\odot$ where $D < 0.05$ pc – perhaps even larger ($\sim 4{\times}10^4\ L_\odot$) for Hb 12. Since this brightness