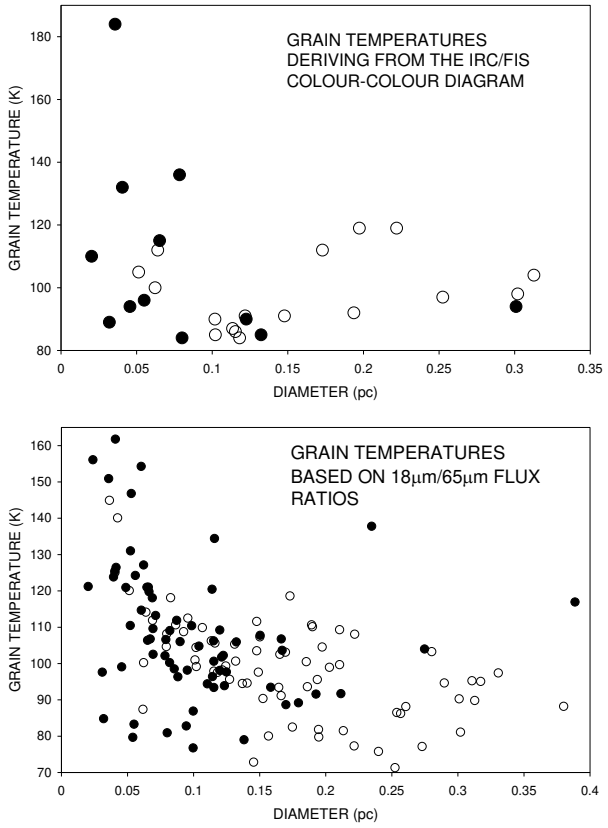

Fig. 6. The variation of grain temperatures as a function of nebular diameter, where we have evaluated $T_{\rm GR}$ using results in the lower panel of Figure 5 (upper panel). Notice how temperatures are larger for diameters < 0.05 pc, and fall within the range $T_{\rm GR} \sim 85-120$ K for larger shell diameters. Sources with angular sizes $\theta < 7$ arcsec are indicated by filled circles, and those having $\theta \geq 7$ arcsec are flagged using open circles. We also show temperatures calculated using 18 and 65 μm fluxes, and assuming an emissivity exponent $\gamma = 1$ (lower panel).

the FIS colour plane (upper panel), and a significant narrowing of the dust regime in the IRC/FIS colour plane (lower panel, where we show examples of the corrected and uncorrected loci).

Where the emission in PNe is dominated by grain continua, then the positions of the sources in Figure 5 will depend upon $T_{\rm GR}$ and γ. However, it is clear that the majority of nebulae in the upper panel fall well away from the dust emission trends. Some of this scatter is likely to be due to errors in the results, although it is interesting to note the bias in the ratios to larger values of 90 μm/140 μm. This is rather larger than would be expected from the *ISO* analysis described in § 3.1. Thus, whilst the shift could be explained in terms of an increase of 20% in the 90 μm flux, this would not be consistent with the smaller mean enhancements expected for ionic transitions in this regime (∼7%; see § 3.1). It would also fail to account for the higher levels of line contamination noted for the 65 μm band, which tend to push PNe to higher positions within this plane.

Similar problems occur for the 18–140 μm trends in the panel below, although in this case, many of the sources lie within the limits of the dust emission loci. We here assume that emission for these sources is dominated by dust continua, and use the positions of the nebulae to determine values for γ and $T_{\rm GR}$. The enhancement in 18 μm/65 μm ratios due to line emission (see § 3.1) may lead to increases in $T_{\rm GR}$ by ∼10–20 K – although see also our comments below concerning the partial detection of 18 μm fluxes.

The corresponding variation of $T_{\rm GR}$ with source diameter is illustrated in Figure 6 (upper panel), where filled circles correspond to sources having $\theta <$ 7 arcsec, and open circles are for nebulae which are larger. It is clear that dust temperatures are significantly higher where the sources have smaller physical dimensions, with $T_{\rm GR}$ approaching ∼180 K where D is less than ∼0.08 pc. By contrast, PNe having larger physical dimensions tend to have smaller values of $T_{\rm GR}$, and fall within a narrower range of values $T_{\rm GR} \sim 85 - 120$ K.

Stasinska & Szczerba (1999) have represented the variation of dust temperatures against Hβ surface brightnesses S(Hβ). The value of $T_{\rm GR}$ is determined using IRAS 25 and 60 μm fluxes, and by assuming that the emissivity exponents γ are uniformly equal to unity. This leads to qualitatively similar trends to those illustrated in the upper panel of Figure 6, although the nature of their procedure permits them to measure many more PNe. The authors find that temperatures are ∼60–100 K where $\log(S(H\beta)/\mathrm{erg\ cm^{-2}\ s^{-1}\ sr^{-1}}) < -2$, and increase rapidly to higher S(Hβ).

A comparable analysis can be achieved using AKARI photometry at 18 and 65 μm, and where one adopts similar simplifying assumptions. The results are illustrated in Figure 6 (lower panel). It is again clear that there is a marked increase in temperatures for diameters < 0.07 pc; that temperatures are of order ∼70–110 K for larger nebulae; and that there is a significant overlap of values for angularly small and larger PNe. There is little evidence for the linear fall-off of temperatures noted by Pottasch et al. (1984).

Finally, we note that the FIS beams are relatively large, varying from 37 to 61 arcsec. Nevertheless, a small proportion of nebulae have diameters which are larger than these values. Given that the fluxes for