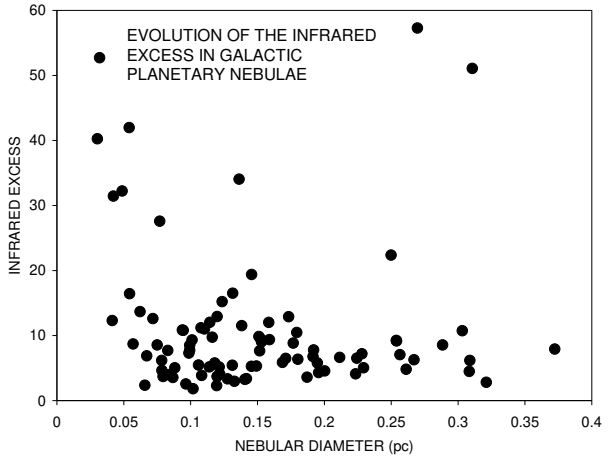


Fig. 10. Variation of the Infrared Excess in Galactic PNe. Notice the evolution in the IRE as nebular dimensions increase.

though the qualitative trend appears consistent with the analysis above, it is interesting to note that the IRE is still relatively large (≈5) even where nebulae are evolved – and that the minimum values are larger than found by Pottasch et al. (1984).

### 3.4. *Radio Infrared Flux Correlation*

It has been noted that the ratio of infrared to radio fluxes in extragalactic systems is reasonably constant, and invariable with redshift $z$. Appleton et al. (2004) have noted that the parameter $q_{70} = \log[S_\nu(70\ \mu\mathrm{m})/S_\nu(20\mathrm{cm})]$ is of order ∼2, whilst $q_{24} = \log[S_\nu(24\mu\mathrm{m})/S_\nu(20\mathrm{cm})]$ is ∼1. Cohen & Green (2001) have made a similar analysis for 21 Acker et al. (1992) PNe, using 8.3 $\mu$m fluxes taken from the Midcourse Science Experiment (MSX; Price et al. 2001). They derived MIR/radio ratios in the region of 12. However, a later analysis for ten MASH PNe (Parker et al. 2006; Miszalski et al. 2008) yielded a ratio of the order of ∼5 (Cohen et al. 2007). This difference between the less evolved Acker PNe, and more evolved MASH nebulae was attributed to an evolution in the properties of the sources – perhaps a reduction in PAH emission as fluorescent excitation decreased. This mechanism is only applicable, however, where C/O is greater than or close to unity.

A further investigation of this issue has also been undertaken by Zhang & Kwok (2009), using 8 and 24 $\mu$m photometry deriving from the GLIMPSE and MIPSGAL surveys. In this case, the authors note a linear relation between MIR and 1.4 GHz fluxes; a trend they interpret as indicating a constancy in the ratios $q_{24}$ and $q_8$. It is also suggested that the scatter

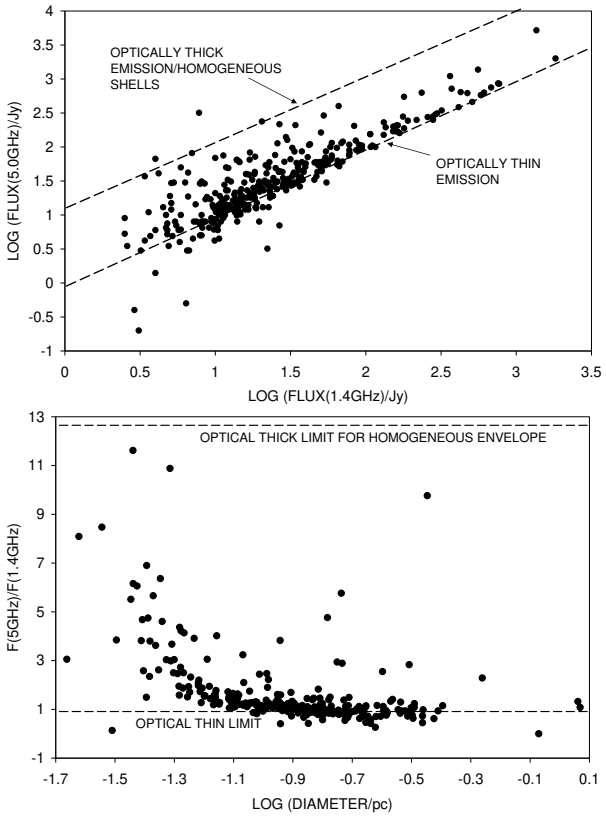


Fig. 11. The 1.4 and 5.0 GHz emission of the AKARI PNe, where we show a comparison between the fluxes (upper panel), and the evolution of the 5.0 GHz/1.4 GHz flux ratios (lower panel). The lower dashed line indicates the limit for optically thin sources, whilst the upper dashed line is for high opacity homogenous PNe. It is clear that most of the nebulae follow the locus for optically thin emission (upper panel), and that only a minority of sources are partially or totally optically thick. The evolution of the ratios (lower panel) indicates higher opacities where $D < 0.07$ pc.

in their figure is attributable to optical thickness at 1.4 GHz – a hypothesis which we will suggest, below, is unlikely to be the case.

We have investigated this question using the present AKARI photometric results, and 1.4 GHz measures deriving from Condon et al. (1998). It should be emphasized that whilst most PNe are likely to be optically thin at 5 GHz, a small proportion may have higher opacities. Thus, we have made a comparison between 5 and 1.4 GHz fluxes in Figure 11 based upon the data summarized in Tables 1 and 2. It is clear that the vast majority of sources follow the trend for optically thin emission (lower dashed line), although ∼20% fall between the optically thick and thin regimes (the former indicated