THE DUST CONTENT OF PLANETARY NEBULAE WITH NEUTRAL HALOS

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ABSTRACT. Young planetary nebulae (PN) which are still optically thick in the Lyman continuum can have a large fraction of material in neutral halos surrounding the ionized zone. The cool dust in the neutral region can make a significant contribution to the far infrared flux, reducing the derived dust-to-gas ratio. This is important when attempting to understand the apparent decrease in dust-to-gas ratio with nebular radius (age) suggested by Pottasch *et al.* (1984).

Comprehensive models of dusty PN with neutral regions have been developed to investigate the dust in these objects in detail. A distribution of grain sizes is used which are heated by stellar and diffuse continuum, as well as by UV resonance line radiation. The grain temperatures are calculated at each point in the nebula. Dust absorption is fully taken into account when constructing the photo-ionization model, so the predicted emission line strengths and radio flux are self-consistent with the dust emission.

Of particular interest is IC 418, in which neutral hydrogen emission was detected by Taylor and Pottasch (1987), and a faint halo seen by Monk *et al.* (1987). Thermal emission from dust, including the neutral region, is shown to agree with IR observations, using graphite with a dust-to-gas ratio of 7.9×10^{-4}. Amorphous carbon could not match the observations.

A model is also shown for DDDM-1 which is the only PN in the galactic halo detected by IRAS. An abundance analysis by Clegg *et al.* (1987) found the object to be very carbon-poor, with Mg and Fe also depleted, probably into dust. A model incorporating silicate dust with a dust-to-gas ratio of 8.5×10^{-4} fits the IRAS observations, and is consistent with the mass available from refractory elements.

S. Torres-Peimbert (ed.), Planetary Nebulae, 202.