FURTHER MODELS OF PLANETARY NEBULA SPECTRAL EVOLUTION

K. VOLK

Department of Physics and Astronomy, University of Calgary, 2500 University Drive N.W., Calgary, Alberta, Canada T2N 1N4

Abstract. Four new calculations of planetary nebulae spectral evolution are presented, as in Volk (1992). These models use the 0.64 $M_\odot$ central star evolution track of Schönberner (1983) but with the rate of evolution accelerated by a factor of 2, as the original models evolve to the planetary nebula phase too slowly to match the observations. Models were calculated for mass-loss rates of 2.1×10^{-5} and 5.2×10^{-6} $M_\odot$ yr^{-1} using solar composition and silicate dust, and using the average observed planetary nebula composition and graphite dust. An interacting winds shell was assumed to form. The model results were combined with an assumed Galactic distribution of 25000 planetary nebula to simulate a variety of observables including V magnitudes, Hβ fluxes, the IRAS colours, the 5 GHz radio flux densities, and the nebular radii.

The models show that even for the higher mass-loss rate the nebulae are matter-bounded during most of the high luminosity phase of the evolution. For the nebulae to stay ionization-bounded mass-loss rates of order 4×10^{-5} are required for steady mass-loss. If there is no interacting winds shell or if the mass-loss rate is increasing with time this limit will be higher. The low mass-loss rate models do not produce typical planetary nebulae optical spectra because of extreme matter-bounded conditions. The carbon-rich nebulae are found to be considerably brighter in the infrared than the solar composition nebulae, which explains the observed preponderance of carbon-rich planetary nebulae and proto-planetary nebulae with IRAS low resolution spectra.

A 50%/50% mixture of carbon-rich and oxygen-rich planetary nebulae from the higher $\dot{M}$ model runs is able to reasonably match the IRAS photometry of planetary nebulae at 12, 60, and 100 μm but fails for 25 μm at low flux densities. Among other things, this implies that the rapid post-AGB luminosity decline for PPN and PN deduced by Knapp (1986) from CO observations is incorrect.

References

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