# EVOLUTION OF PLANETARY NEBULAE: A COMPARISON WITH OBSERVED CENTRAL STARS

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ABSTRACT. The relation between nebular excitation E(He II λ4686/Hβ-ratio) and absolute visual magnitude of the central star (CS) is compared with hydrodynamical models of planetary nebulae (PNe) from Schmidt-Voigt and Köppen (*Astron. Astrophys.*, 174, 211 and 223) (see figure below, data from D. Schönberner, *Astron. Astrophys.*, 169, 189). Models marked by drawn lines have a 0.644 $M_\odot$ CS following a Schönberner track, an initially expelled PN of 0.1 $M_\odot$, and different mass loss rates of the precursor star on the AGB, described by the Reimers parameter η; η = 1 corresponds to a mass loss rate of $1.55 \times 10^{-6} M_\odot\ a^{-1}$. The dashed line model has a higher initially expelled mass (0.3 $M_\odot$), the dash-dotted line model a CS of 0.6 $M_\odot$ which evolves more slowly. Model numbers refer to the above cited studies. Since M_V increases with evolutionary time, the M_V axis represents a (highly) nonlinear time axis: for $M_V < 4$ the CS heats up towards its temperature maximum and the PN is optically thin. Differences for high excitation nebulae are most probably due to different helium abundances. When the rate of ionizing photons decreases as the nuclear energy sources extinguish ($M_V > 4$), the excitation may decline, depending on the density in the nebula. For the so called "accreting models" ($\dot{m} > 10^{-6} M_\odot\ a^{-1}$) the mass accretion from the AGB wind determines the density hence nebular excitation. For an AGB mass loss rate $\dot{m} < 10^{-5} M_\odot\ a^{-1}$ the numerical results approximately fit an exponential law $E = E_0 exp\ (-\dot{m}/\dot{m}_0)$ with $E_0 \cong 1.1$ and $\dot{m}_0 \cong 6.1 \times 10^{-6} M_\odot\ a^{-1}$. From the spread of the observed $E(M_V = 4)$ we conclude a mean AGB mass loss rate of $6.7^{+3.3}_{-2.3}$ $10^{-6} M_\odot\ a^{-1}$ within 1σ error bars. Obviously the model 11 reproduces the data best since most of the observed objects are found in the dark shadowed regions of the histogram. This is totally consistent with our previous results (cited above). The colliding-wind models, having no initially PN, behave quite similar as model 11.
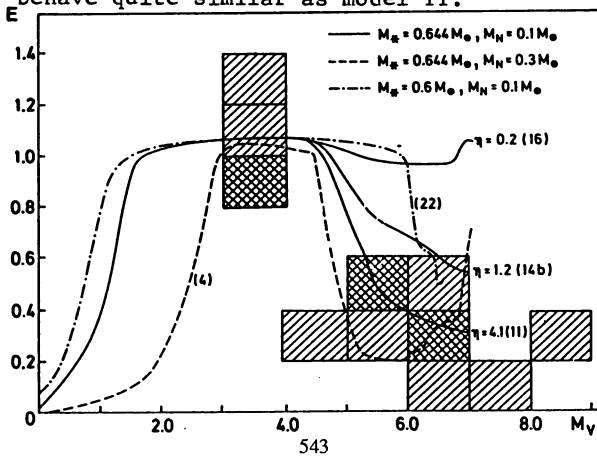
Escuela Nacional Preparatoria, main patio.