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Broad Hα wings in Young Planetary Nebulae

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Abstract. In a sample of 30 young planetary nebulae, proto-PNe and other emission line objects we have found 11 young PNe and 2 symbiotic stars that show very broad wings of the emission Hα line (from 800 km s^{-1} and up to 5100 km s^{-1}). For 7 objects, their first report was in Arrieta & Torres-Peimbert (2002).

Very wide Hα emission lines have been reported previously in other objects in the early stages of planetary nebulae phase; these include seven post-AGB, five young PNe and one symbiotic star (Van de Steene et al. 2000; Lee & Hyung 2000; Miranda et al. 1997; Balick 1989; López & Meaburn 1983; Wallerstein 1978).

From observations carried out at the Observatorio Astronómico Nacional in San Pedro Mártir, Baja California with the 2.1-m telescope and the REOSC echelle spectrograph (R $\sim$ 18,000 at 5,000 Å) and a 1024$\times$1024 Tektronix detector that yielded a spectral resolution of 10.6 km s^{-1} pix^{-1} we were able to determine extreme broadening for 11 objects among those with strong emission lines and faint stellar continuum.

We have explored the following possible wing broadening mechanisms:

(a) Emission from circumstellar disks. The width of the lines cannot be explained with this mechanism.

(b) Electron scattering. For this process it is required (i) an ionized dense region where the bulk of Hα is produced (ii) a high temperature region where scattering takes place and (iii) a lower density region where the relatively narrow forbidden lines are produced.

(c) Stellar winds. Only IRAS 20463+3416 shows evidence of P Cyg profiles both in our optical spectra and in the UV, with a terminal velocity in the resonant lines of $\sim$ 2000 km s^{-1}. We can adjust a mass loss rate of 10^{-5} M$_{\odot}$ y^{-1} for the Hα wing in this object.

(d) Rayleigh-Raman Scattering. Lee & Hyung (2000) have suggested this process as the mechanism to widen Hα in IC 4997. They propose that hydrogen Lyβ photons with a velocity width of a few 10^2 km s^{-1} are converted to optical photons and fill the Hα broad wing region.

An inner compact core of high density, $n_e \sim 10^9 - 10^{10}$ cm^{-3}, and a scattering region with H I column density, $N_H \sim 10^{20}$ cm^{-2}, with a substantial covering factor are required. These conditions could correspond to those prevailing in symbiotic stars and bipolar planetary nebulae.

This mechanism produces a $1/(\Delta\lambda)^2$ profile. In 9 objects we can adjust this profile to the Hα wings.

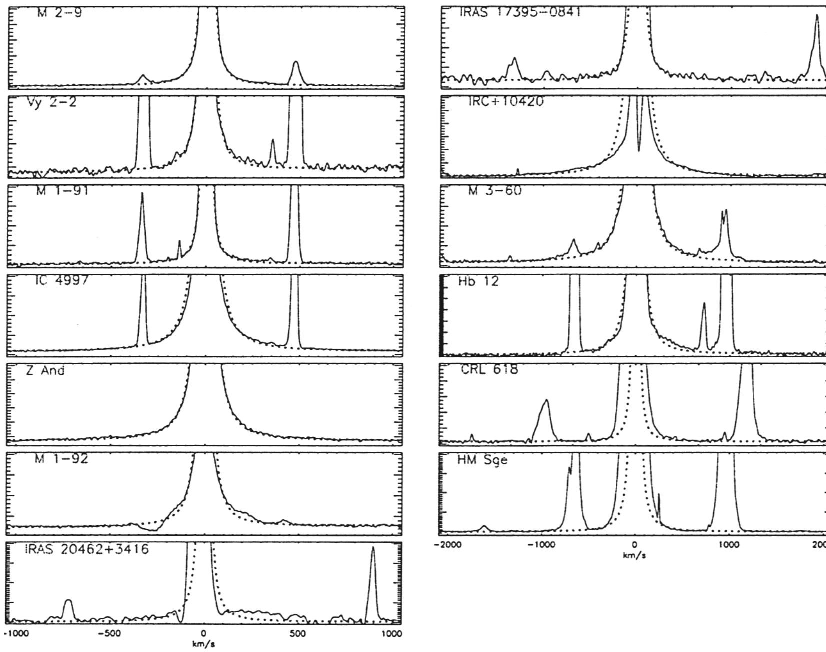

Figure 1. Spectra centered at Hα. The abscissa is radial velocity in km s^{-1}. In each frame, we plot the $1/(\Delta\lambda)^2$ fit.

Raman scattering is possibly the mechanism responsible for the line broadening. Most of the objects with broad lines seem to have common characteristics, namely: bipolar morphology, composite emission line profiles, and compact objects in the process of forming a planetary nebulae. Very probably they are sites of wind interaction.

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