On the Formation of the Broad H Wings in the Planetary Nebula IC 4997

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The young and compact planetary nebula IC 4997 is known to exhibit very broad wings with a width exceeding 5000 km s^{-1} around Hα. We propose that the broad wings are formed through Rayleigh-Raman scattering involving atomic hydrogen, by which Lyβ photons with a velocity width of a few 102 km s-1 are converted to optical photons and fill the Hα broad wing region. We find that the conversion efficiency reaches 0.6 near the line center where the scattering optical depth is much larger than 1 and rapidly decreases in the far wings. From the existence of N III line in the spectrum of IC 4997, it is inferred that there exists an unresolved inner compact core of high density, $n_H \sim 10^{9-10}\,cm^{-3}$ close to the central star, where sufficient Lyβ photons for scattering are produced. which was shown by using the photoionization code 'CLOUDY'. Assuming a top-hat incident profile for the Lyβ flux and a scattering region with a H I column density $N_{HI} = 2 \times 10^{20}\,cm^{-2}$ and a substantial covering factor, we perform a profile fitting analysis to obtain a satisfactory fit to the observed flux. This result is consistent with the H I 21 cm absorption observation by Altschuler et al. (1986), who reported the H I absorbing column $\sim 4 \times 10^{20}\,cm^{-2}$. We briefly discuss the astrophysical implications of the Rayleigh-Raman processes in planetary nebulae, symbiotic stars, post-AGB stars, active galactic nuclei and premain sequence stars.