NLTE Analysis of Keck HIRES Spectra of K648: Central Star of the Planetary Nebula Ps1 in M15

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Küstner (1921) catalogued K648 in his photographic survey of M15, but it was not recognized as a PN central star until Pease (1928) discovered the nebula, denoted Ps1. As one of very few PN known in globular clusters — it was the *only* known until Gillet *et al.* (1989) reported the discovery of a second in M22 and Jacoby *et al.* (this meeting) announced two new but very faint objects — K648 offers one of the better opportunities to study the post-AGB evolution of extreme Pop. II stars. Previous investigations of the nebula and star (Adams *et al.* 1984; Peña, Torres-Peimbert, & Ruiz 1992; Heber, Dreizler, & Werner 1993) all concluded that the stellar temperature is slightly less than 40000 K. Heber *et al.* also concluded the photospheric He and C abundances were $3\times$ and $5\times$ higher than solar.

We have conducted a NLTE model atmosphere analysis of K648 based on optical spectra obtained with the 10 m Keck HIRES echelle spectrograph. The high resolution ($R = \lambda/\Delta\lambda = 35,000$ [4 pixels]), high S/N (140 at Hγ) Keck spectra of K648 revealed HI Balmer, HeI, HeII, CIII, and CIV absorption lines, among others. Also evident in the HIRES spectra were weak narrow lines indicating contamination by a metal poor red giant spectrum; by comparing the equivalent widths of the contaminating features to a reference red giant spectrum (metallicity similar to M15), we successfully removed the red giant light (contributing 15% to 25% of the observed continuum) from the K648 spectrum.

Lines of HeI (*e.g.*, λ4471 Å) present in the HIRES spectra were particularly significant, enabling use of the HeI/HeII ionization equilibrium to determine T_{eff} more reliably than possible previously. We derive $T_{eff} = 43000$ K, $\log g = 3.9$, and helium abundance $y = 0.08$ (nearly solar) for K648; nor does our analysis of the CIII and CIV lines in the HIRES spectra support the high C abundance derived by Heber *et al.* Comparison to evolutionary tracks in the $\log(g) - \log(T_{eff})$ plane yields distance-independent estimates of the stellar mass ($0.60\,M_\odot$) and post-AGB evolutionary age (2000 y). Finally, we derive a spectroscopic distance to K648, $d = 11.8 \pm 1.5$ kpc, which compares favorably to the 10.4 ± 0.8 kpc accepted distance to M15 (Durrell & Harris 1993) to within the quoted errors. This result strongly supports the reliability of central star spectroscopic distances to PN generally.

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