THE UV BRIGHT STAR ZNG 1 IN M 5

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ABSTRACT: We report the results of H\(\alpha\) imaging and UV spectroscopy with the Hubble Space Telescope of the hot post-AGB star ZNG 1 in M 5 and its suspected planetary nebula.

1 UV bright stars

Post asymptotic giant branch (PAGB) stars of population II are rare objects but are Rosetta stones for testing the theory of stellar evolution. Bona fide members of this class are the rare nuclei of halo planetary nebulae (PN) and PAGB stars in globular clusters. The cluster PAGB stars have to evolve from low initial progenitor masses (\(\approx\) turn-off mass of the cluster < 1\(M_\odot\)). Thus these PAGB objects and their PNe provide us with important tests of the evolution of low mass stars.

Most cluster PAGB stars were detected because of their brightness in the UV region. In their pioneering work Zinn et al. (1971; ZNG) selected hot luminous objects in a number of globular clusters by looking for stars of exceptional brightness in the Johnson U band and termed these objects UV bright stars. Zinn et al. listed seven UV-bright stars for the globular cluster M 5 (NGC 5904), ZNG 1 is located very close to the cluster center.

A low resolution IUE spectrum of ZNG 1 obtained by Bohlin et al. (1983) showed strong resonance lines of N V (1240 Å) and C IV (1550 Å) and an emission of the semiforbidden NIV\] 1487 Å line. Bohlin et al. (1983) estimated an effective temperature of \(\approx 35000 \text{ K}\). A comparison with an IUE spectrum of the main sequence O star \(\mu\) Col revealed that the N V 1240 Å resonance lines are much stronger in the low metallicity star ZNG 1 than in the pop. I star \(\mu\) Col. Bohlin et al. explained this finding by means of the dredge-up of CNO processed material in ZNG 1. The NIV\] emission was interpreted as evidence for a possible PNe around this hot post-AGB object.
2 Imaging and UV spectroscopy

Optical imaging of ZNG1 with the ESO-NTT in the UBV bands demonstrated that ZNG1 is double with a G-type companion being only 0″.5 apart, which makes further investigation of ZNG1 by ground based observations virtually impossible. Hence we obtained HST observations with the GHRS spectrograph and the WPFC2 camera to improve our understanding of this object.

Since up to now only four PNe in globular cluster are known any new object is of importance. Thus we obtained a WFPC2 Hα image of ZNG1 (F656N filter) to check the PN hypothesis of Bohlin et al. (1983). The central region of the PC image is displayed in Fig. 1. Due to the superior angular separation of HST both components of the binary are easily resolved.

Figure 1: Enlarged area of the PC F656N image of M 5, showing ZNG1 and its companion. The UV bright star is marked with an arrow.

Ultraviolet spectra of ZNG1 were obtained with the Goddard high resolution spectrograph onboard of the Hubble Space Telescope using the grating G140L. Two spectra were taken through the large science aperture which covered the wavelength range 1150 Å to 1430 Å and 1470 Å and 1750 Å, respectively. The achieved spectral resolution is 0.7 Å.
The UV spectra of ZNG1 are compared in Fig. 2 to the IUE spectra of the well known sdO star HD 128220 B (superposition of 30 IUE high resolution spectra, degraded to 0.7Å resolution). There are striking similarities: The NV resonance doublet is a P-Cygni profile in both stars indicating that it is formed in a stellar wind. The CIV line is shifted bluewards by 900 km/s in ZNG1 but unshifted in HD 128220 B, indicating that it is formed in a stellar wind in case of ZNG1 but is of atmospheric origin in HD 128220 B (note that the CIV resonance lines of HD 128220 B displays time variable wind features, i.e. narrow components. Only spectra without CIV wind features were coadded, see Rauch, 1993). Photospheric lines of CIII,CIV,NIII, NIV, OIV, O V and SV can be identified in both spectra with line strengths remarkably similar (see Fig. 2).

The atmospheric UV line spectrum of HD 128220 B has been analysed extensively.
by Rauch (1993), who derived the atmospheric parameters $T_{\text{eff}} = 40600 \pm 0.4 \, \text{K}$, $\log g = 4.5 \pm 0.1$. The atmosphere is enriched in helium (He/H=0.3) and nitrogen (1.0 dex) with respect to solar abundance, whereas oxygen is depleted (by 0.64 dex) and carbon is almost solar. The N V P-Cygni profile was analysed by Hamann et al. (1981) and a mass loss rate in the range $10^{-10.9} - 10^{-8.5} \, \text{M}_\odot/\text{yr}$ was derived.

3 Conclusions

ZNG 1 and its cool companion are easily resolved in our PC image. Their separation is $0\farcs5$. Adopting a distance for M 5 of 7600 pc (Harris & Racine 1979) we derive a projected physical distance of 3700 A.U. between ZNG 1 and the bright companion. Since it is very likely that such a wide pair would be disrupted in the dense environment of a globular cluster, we conclude that these stars don’t form a binary but are a chance alignment. No nebula was detected on our H$\alpha$ image of ZNG 1 (see Fig. 1). Since the stellar image of ZNG 1 looks like any other star we conclude that we can rule out any PN more extended than, say, $0\farcs2$ ($7 \cdot 10^{-3}$ pc). Neither could the presence of the semiforbidden NIV] 1487 Å line be confirmed.

The richness and strength of the C, N and O line spectrum of ZNG 1 is surprising since the star resides in metal poor environment (Fe/H=-1.4, Djorgovski 1993). From its spectral similarities with the well studied sdO star HD 128220 it is tempting to conjecture that C, N and O have been enriched by nuclear burning and subsequently mixed to the stellar surface. A similar case is reported for K648, the central star of a planetary nebula in the globular cluster M 15, which is enriched in carbon by more than a factor of 100 with respect to the cluster metallicity (Heber et al., 1993). The results of a quantitative spectral analysis must be awaited to prove or disproof our conjecture.

Acknowledgments. The help of M. Rosa in preparing our HST observations is gratefully acknowledged. R.N. is supported by the DARA under grant 50 OR 9309. Attendance of U.H. at the FBS meeting was made possible by a DFG travel grant.

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