an extremely helium-rich "subdwarf" with a cool companion

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Abstract

BI Lyn = PG 0900+400 has been erroneously classified as an evolved binary system containing either a hot subdwarf or white dwarf and a thick accretion disk. New intermediate dispersion spectra are presented which demonstrate that the hot component is a luminous low-mass helium star and the cool companion is a rapidly rotating G-type giant. Techniques of spectrum synthesis have been used to establish the dimensions of both components. Although the orbital period of the system remains unknown, other phenomena are entirely consistent with these observed dimensions. The established $\sim 0.34d$ periodic photometric variation could be explained by pulsations in the B-type primary and, by analogy with other H-deficient binaries, it is suggested that the variable absorption in Hα may be due to a gas stream flowing through the inner Lagrangian point.

BI Lyn: the story so far

- Identified in the PG survey as an sdB star with an infrared excess (Ferguson et al. 1984).
- Photometric monitorring identified a 0.34d period. (Lipunova & Shugarov 1990, 1991).
- Hα has a P Cygni profile with variable absorption (Wade & Potter 1995).
- Suspected velocity variable (Orosz et al. 1997).
- sdB+K3V spectral decomposition (Ferguson et al. 1984, Orosz et al. 1997, Liu & Hu 2000)
- Reports of strong He I lines (Orosz et al. 1997, Liu & Hu 2000)
- SIMBAD gives "V* BI Lyn – Nova-like Star"

We present here:

- A reanalysis of the UV and optical flux distribution to measure the effective temperatures and angular diameters of both stars (Fig. 1). For this we used the automatic flux fitting package FFIT and a combination of hydrogen-deficient model atmospheres for hot stars and Kurucz models atmospheres for cool stars.

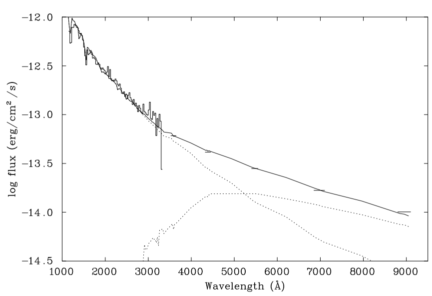

Figure 1. Ultraviolet and visual spectrophotometry of BI Lyn (histogram) together with the best fitting theoretical flux distribution (polyline and horizontal bars). The latter represents the sum of two model atmospheres (dashed lines) with $T_{\rm eff:1} = 28\,600$ K, $\theta_1 = 0.55 \times 10^{-11}$ rad, $T_{\rm eff:2} = 5\,840$ K and $\theta_2 = 4.09 \times 10^{-11}$ rad. Interstellar reddening is negligible.

- New INT and WHT intermediate resolution spectra of BI Lyn in the blue and around Hα and the infrared calcium triplet (Figs. 2 – 4). The new spectra demonstrate the relative strnegth of the neutral helium lines relative to the hydrogen Balmer lines.

- A simultaneous spectral analysis of both stars using the automatic fitting package SFIT and a combination of synthetic spectra for hydrogen-deficient hot stars and normal composition cool stars.

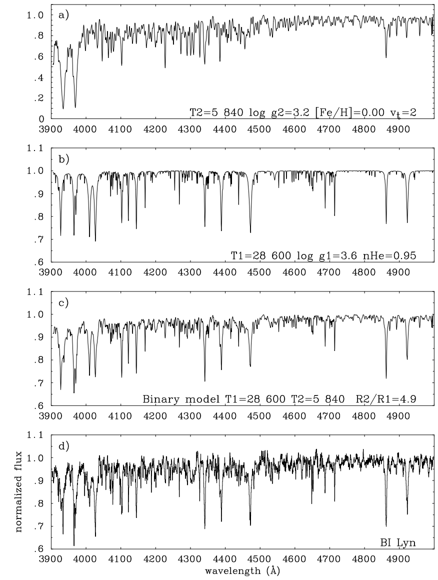

Figure 2. Normalized blue spectrum of BI Lyn (bottom: d) together with a best fit composite model spectrum (c) formed by adding models with a) $T_{\rm eff:2} = 5\,840$ K, $\log g_2 = 3.2$, $[{\rm Fe/H}]_2 = 0.00$ (top) and b) $T_{\rm eff:1} = 28\,600$ K, $\log g_1 = 3.64$, $n_{\rm He\,1} = 0.95$ assuming that the relative radii $R_2/R_1 = 4.9$. The model spectra have been velocity shifted and degraded to match the observed spectral resolution (1Å).

- The analysis of the hot star based on the WHT blue spectrum (Fig. 2) yields a hydrogen abundance $\sim 1\%$ by number, $T_{\rm eff} \sim 28\,000$ K and $\log g \sim 3.6$, making the primary a helium giant.

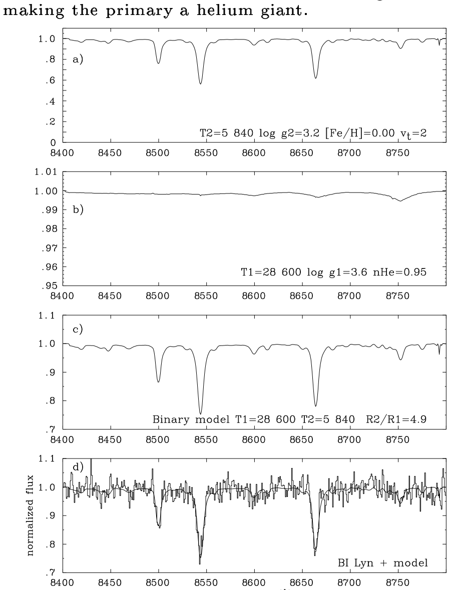

Figure 3. As Fig. 2 in the region of the infared calcium triplet.

- Assuming a solar composition for the cool star, its surface gravity is estimated from the CaT lines (Fig. 3) to be $\log g \sim 3.2$ and hence also a giant.
- The two methods (FFIT and SFIT) give a radius ratio for the two stars R_2/R_1 between 7.4 and 4.9.

- Simply estimating $M_1 = 0.5\,{\rm M}_\odot$ enables all remaining system dimensions to be evaluated.

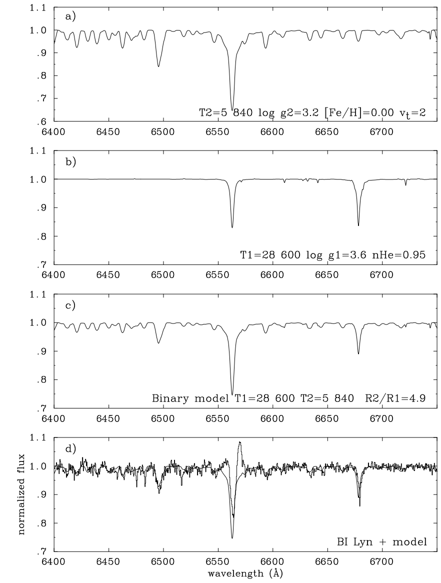

Figure 4. As Fig. 2 in the region of Hα.

Conclusions

- Contrary to previous assumptions, BI Lyn does not contain a hot subdwarf or white dwarf, nor is it a nova-like variable.
- The hot star is a luminous hot hydrogen-deficient star with a probable mass around $0.5\,{\rm M}_\odot$.
- The cool star is a cool giant with a mass $> 1\,{\rm M}_\odot$.
- The hydrogen-deficiency of the hot star is probably the result of a comon-envelope phase during which the outer envelope was entirely removed or transferred to the cool companion.
- The hot star luminosity suggests that it lies on a post-AGB evolution track.
- Previously established 0.34d light variations are likely to be due to pulsations in the helium star.
- By analogy with hydrogen-deficient binary υ Sgr, previously established Hα P-Cygni profile variations may be due to the orbital motion of a supersonic jet between the components.
- Further observations are required to determine the orbital period and mass ratio, to verify the pulsation hypothesis and to correlate the Hα behaviour with orbital phase.

References

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