

Atmospheric abundances of CP SB2 star components of equal masses. II. 66 Eridani

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Abstract. We report the results of abundance determination for the components of the SB2 star 66 Eri ($M_A/M_B=0.97$) from high resolution CCD echelle spectra with $S/N \geq 100$ taken with the 1-m telescope of Special Astrophysical Observatory (Zelenchuck, Russia). The atmospheric parameters of the components were determined using all available photometric, spectrophotometric and spectral data. The abundances of 27 elements were found. The abundances of components are different. The B component, previously classified as an Hg-Mn star, does not show anomalies typical of this group such as deficit of He, Al and excess of P, Ga but shows overabundances of heavy elements which amount up to 4-5 dex. The A component also shows moderate Mn and Ba excess. Lines of other heavy elements were not detected. Estimates of upper limits to their abundances do not permit to exclude completely the presence of fainter anomalies in the A component either.

Key words: Stars: abundances – Stars: spectroscopic binaries – Stars: chemically peculiar

This work is part of our programme to investigate atmospheric abundances of SB2 system components of equal masses. The spectroscopic orbit of 66 Eri (HD 32964) was published by Young (1976). The mass ratio of the B9V+B9V components, $M_A/M_B = 0.97$ is the closest to unity among the systems which are investigated in this programme. The orbital period of this binary is 5.522731^d. 66 Eri is designated as a mercury star in Yale Bright Star Catalogue, but as a variable star (EN Eri) of the α^2 CVn type in the Catalogue of Variable stars with a lightcurve amplitude of 0.005^m and a photometric period of 7.86^d (Schneider, 1987).

We analyzed two spectra of 66 Eri obtained with the échelle spectrograph of the 1-m telescope (Musaev, 1996) of the Special Astrophysical Observatory at Zelenchuk (Russia) in the wavelength region 4385-6695 Å, with a signal-to-noise ratio $S/N \geq 100$ and a spectral resolution of 36000. The reduction of the spectra

was done with the DECH code (Galazutdinov, 1992) and URAN package written in Odessa observatory.

As the components of 66 Eri are very similar, we can use photometric calibrations for single stars to determine mean characteristics of the system. We made flux calculations with an abundance pattern typical of CP stars and Kurucz' (1993) line list (>31 millions lines). The result obtained from photometric calibrations and from comparison of observed and calculated fluxes gave us $T_{\text{eff}} = 11000$ K, $\log g = 4.25$ as mean atmospheric parameters.

We tried to find T_{eff} , v_{urb} and correction factor of equivalent widths WCF for each component using unblended lines of Fe II in both spectra. We took the grid of values of T_{eff} , v_{urb} , WCF , fixed $\log g$ and determined the Fe abundance of each component for each point of the grid and then selected parameters, which met three conditions simultaneously: zero correlation between equivalent widths and calculated abundances; zero correlation between energies of the lower levels and calculated abundances; minimal r.m.s. error for iron abundance. This has permitted us to select the parameters: $T_{\text{effA}} = 11100$ K, $v_{\text{urbA}} = 0.9$ km s⁻¹, $WCF_A = 1.95$; $T_{\text{effB}} = 10900$ K, $v_{\text{urbB}} = 0.7$ km s⁻¹, $WCF_B = 2.05$.

The projected rotational velocity of the components was found to be $v \sin i = 17$ km s⁻¹. The parallax of 66 Eri, measured by the Hipparcos satellite, is $\pi = 11.65 \pm 0.73$ mas (Perryman et al., 1997). Combining this value with the visual magnitude and flux ratio of the system, and with bolometric corrections and effective temperatures of the components, we found the radii of the components $R_A = 1.75$, $R_B = 1.86$, and the rotational periods: $P_A = 5.21 \sin i$ and $P_B = 5.53 \sin i$ days. These values are close to the orbital period $P = 5.5227^d$, so the rotation is synchronized if $\sin i$ is close to 1.

For the identification of lines we used Tsymbal's (1995) spectrum synthesis programme and Kurucz' (1993) line data from CD-ROMs 18, 23.

We made several iterations with different abundance patterns to achieve the best fit of the computed spectrum to the observed one in the whole spectral region. Only lines free of blending by lines of the other component were taken into account. Abundances of the elements with $Z \geq 16$, except barium, were obtained with the technique of equivalent widths using the WIDTH9 code. Abundances of He, C, N, Ne, Mg, Al, Si, Ba were determined with the method of spectrum synthesis using Kurucz' (1993) SYNTH program. The abundance of barium was obtained with the inclusion of hyperfine structure according to Francois (1996). Results are given in Table 1, where n is the full number of measured lines of an element in two spectra, $\log N$ is the abundance of an element in the scale $\log N(H) = 12.0$, σ is the mean square error of one measurement, $A, B - \odot$ is the abundance relative to the Sun.

No correlation was found between the elemental abundance and the Landé factor for lines of Fe, Ti, Mn and Cr. We attempted to identify lines of P, Ga and Xe, but no detectable line was found in the spectra. To our knowledge 66 Eri is the first SB2 system studied so far which contains chemically peculiar, but non-HgMn type components.

Table 1. Atmospheric abundances for both components of 66 Eri

| Ident. | n_A | $\log N_A$ | σ_A | n_B | $\log N_B$ | σ_B | $A - \odot$ | $B - \odot$ |
|--------|-------|------------|------------|-------|------------|------------|-------------|-------------|
| He I | 6 | 10.98 | .09 | 5 | 10.98 | .03 | -.01 | -.01 |
| C I | 1 | 8.40 | | 1 | 8.37 | | -.16 | -.19 |
| O I | 9 | 8.79 | .03 | 7 | 8.68 | .01 | -.14 | -.25 |
| Ne I | 1 | 8.15 | | | | | .06 | |
| Mg I | 6 | 7.49 | .07 | 5 | 7.15 | .07 | -.09 | -.43 |
| Mg II | 6 | 7.49 | .17 | 5 | 7.28 | .13 | -.09 | -.30 |
| Al II | 4 | 6.64 | .09 | 2 | 6.32 | .11 | .17 | -.15 |
| Si II | 7 | 6.97 | .19 | 5 | 6.87 | .07 | -.58 | -.68 |
| S II | 2 | 7.34 | .13 | 1 | 7.26 | | .13 | .05 |
| Ca II | 2 | 6.62 | .15 | 2 | 6.36 | .12 | .26 | |
| Sc II | 1 | 3.35 | | 1 | 3.14 | | .25 | .04 |
| Ti II | 22 | 5.24 | .21 | 27 | 5.90 | .16 | .25 | .91 |
| Cr I | | | | 1 | 6.09 | | | .41 |
| Cr II | 20 | 5.92 | .18 | 18 | 6.42 | .16 | .25 | .75 |
| Mn II | 2 | 6.00 | .18 | 3 | 6.39 | .20 | .61 | 1.01 |
| Fe I | 7 | 7.88 | .20 | 8 | 7.71 | .30 | .24 | .07 |
| Fe II | 62 | 7.72 | .13 | 60 | 7.66 | .10 | .08 | .02 |
| Ni I | | | | 1 | 6.62 | | | .37 |
| Zn I | | | | 1 | 5.89 | | | 1.29 |
| Y II | | | | 14 | 5.21 | .31 | | 2.97 |
| Zr II | | | | 3 | 4.19 | .17 | | 1.59 |
| Ba II | 4 | 3.41 | .06 | 6 | 3.82 | .13 | 1.28 | 1.69 |
| La II | | | | 2 | 4.05 | | | 2.83 |
| Ce II | | | | 1 | 3.95 | | | 2.40 |
| Yb II | | | | 4 | 4.32 | .15 | | 3.24 |
| Hf II | | | | 1 | 4.37 | | | 3.49 |
| W II | | | | 4 | 4.34 | .24 | | 3.23 |
| Pt I | | | | 5 | 6.75 | .31 | | 4.95 |
| Au I | | | | 1 | 6.66 | | | 5.65 |
| Hg I | | | | 2 | 5.88 | .10 | | 4.79 |
| Hg II | | | | 1 | 6.40 | | | 5.31 |

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