PHYSICAL PARAMETERS AND CHEMICAL COMPOSITION
OF COMPONENTS OF THE Am-TYPE BINARY SYSTEM
RR LYNCIS

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Duplicity is a very widespread phenomenon among Am-stars. For instance, Abt (1961) investigating 25 such stars found out that 22 of them are spectroscopic binaries. However this important phenomenon is ignored usually in chemical composition investigations of Am-stars. Consequently some "mean" element abundances are determined, which can noticeably differ from real abundances in atmospheres of components. Moreover false chemical anomalies can appear, as shown by the theoretical modelling of spectra of binary stars (Lyubimkov, 1989, 1992). Meanwhile accurate data on chemical composition of Am-stars must be considered as observational test for any hypothesis suggested for explanation of these objects.

Taking into account a significance of discussed problem we analyse a composite spectrum of the eclipsing binary RR Lyn (its period $P = 9^d.945$), which was classified earlier as Am-star. Kondo (1976) studied its orbital elements and determined masses M, radii R and surface gravities g for both components. Moreover Kondo tried to analyse individual chemical composition of the components. As can be seen from his data, the secondary component B shows a tendency to underabundance of chemical elements relatively to the primary component A. At the same time there is a great scatter (about 3 dex) in values $log\ \varepsilon_B - log\ \varepsilon_A$, abundance difference between B and A. Our aim was a more accurate determination of chemical composition of the components. For solution of this task we made additional observations of RR Lyn and used more accurate technique of analysis (Lyubimkov and Samedov, 1987).

Spectroscopic observations of RR Lyn have been carried out at the Crimean Astrophysical Observatory with the 2.6 m telescope equipped with the CCD-camera. The usual S/N ratio was about 100, and dispersion was equal to 3 Å/mm. Equivalent widths of spectral lines of both components have been measured, and these data were used in abundance analysis as well as the measurements of Kondo (1976). Observed equivalent widths were corrected in order to obtain intrinsic widths of the components A and B. It is interesting that both our CCD-spectra and the data of Kondo led to compatible abundances.

The values $log\ g_A$=3.91±0.01 and $log\ g_B$=4.07±0.08 were adopted as surface gravities of the components A and B according to Kondo (1976). Effective

temperatures T_{eff} of the components were found by us on the basis of the following characteristics: observed equivalent widths of Balmer lines H_α and H_γ, photometric index $[c_1]$ and ratio of luminosities L_B/L_A. We must note that observations give not individual equivalent widths of Balmer lines and index $[c_1]$ for the components, but only common characteristics. In Fig.1 we have plotted a diagram for $T_{eff}(A)$ and $T_{eff}(B)$ determination. For H_α and H_γ the average curve is drawn. For the ratio L_B/L_A two cases are shown: line I corresponds to L_B/L_A value of Kondo (1976), line II represents data of other authors. On the basis of this diagram we found that $T_{eff}(A)=8020\pm200$ K and $T_{eff}(B)=7150\pm300$ K.
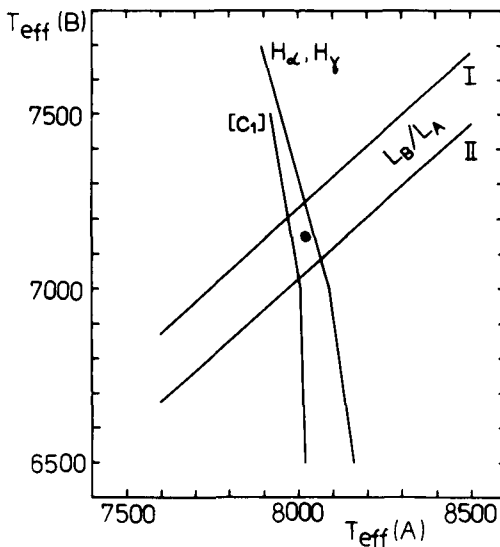

Fig. 1. Diagram for the determination of effective temperature of the components A and B. Filled circle corresponds to the adopted temperatures.

A comparison of T_{eff} and $log\ g$ values with evolutionary calculations allows us to evaluate the masses of components M_A and M_B. Using evolutionary tracks of different authors we infer the values $M_A=1.95\pm0.06\ M_\odot$ and $M_B=1.57\pm0.07\ M_\odot$, which are in good accordance with masses $M_A=1.89\pm0.07$ $M_\odot$ and $M_B=1.50\pm0.05\ M_\odot$ found by Kondo (1976) from an analysis of orbital elements. We conclude that both components correspond obviously to the main sequence evolutionary phase and are of the age $t = (1.1 \pm 0.3) * 10^9$ years.

Knowing parameters T_{eff} and $log\ g$ and also masses M_A and M_B we can evaluate a difference Δm_v between A and B in its visual magnitudes (Lyubimkov and Samedov, 1987). We found that $\Delta m_v =-1.2$.

In order to determine a chemical composition of the components A and
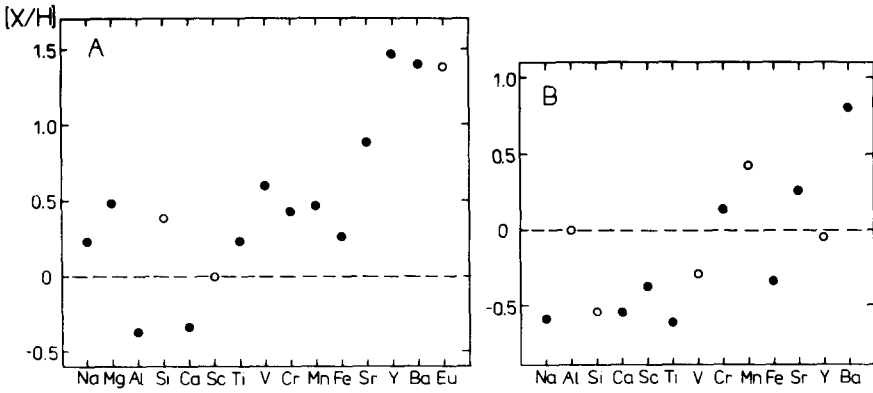
Fig. 2. Chemical composition of the components A and B with reference to
the Sun. Open circles correspond to less confident abundances determined
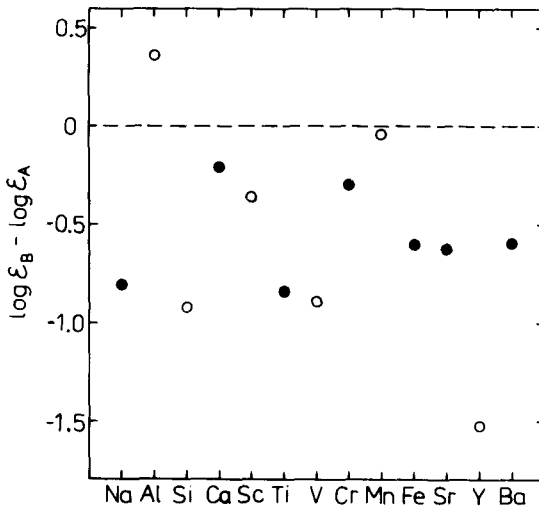from one spectral line.

Fig. 3. Difference in chemical composition of components.

B, we must know its microturbulent velocities ξ_t. Using FeI lines we obtained ξ_t=6.3±0.5 km/s for the component A. In the case of the component B this method is not successful because of insufficient number of FeI lines and considerable scatter in corresponding values of Fe abundance. Here we used the relation between ξ_t and parameters T_{eff} and $log\ g$, which has been found by Nissen (1981) for yellow dwarfs. According to this relation ξ_t=2.1 km/s for the component B.

Model atmospheres were constructed for stars A and B in accordance with its T_{eff} and $log\ g$ values (by interpolation of models of Kurucz, 1979). Then the chemical composition is analysed on a basis of corrected equivalent widths. In Fig.2 determined abundances are plotted in logarithmic scale with reference to the Sun. All solar abundances with the exception of iron are taken from the compilation of Anders and Grevesse (1989). The solar iron abundance $log\ \varepsilon_\odot(\text{Fe})$=7.55 was adopted.

As can be seen from Fig.2, the component A has a chemical composition, which is typical for Am-stars. Many chemical elements show overabundance, which has a tendency to increase with atomic number Z. The greatest excess (about 1.4-1.5 dex) is found for the heaviest of considered elements – Y, Ba and Eu. For the component B on the contrary most of elements is in deficiency, but in this case analogous trend with Z is observed, too.

So the components of the binary system RR Lyn have different chemical composition. This conclusion becomes more obvious if we calculate the abundance difference $log\ \varepsilon_B - log\ \varepsilon_A$. As can be seen from Fig.3, there is a systematic discrepancy in abundances between components B and A. If uncertain points for Al and Y are excluded (its abundances $log\ \varepsilon_B$ determined from one spectral line), we can see that all remaining values $log\ \varepsilon_B - log\ \varepsilon_A$ vary from 0.0 to -0.9. On the average this difference equals -0.56. Our analysis shows that such steady underabundance of elements in component B relatively component A evidently cannot be explained by probable errors in equivalent widths or in adopted parameters T_{eff} and $log\ g$.

Components of the binary system have formed simultaneously and had the same primary chemical composition. We have pointed out above that at present both stars are still on the main sequence. The following questions arise: 1) what process led to the appearance of chemical peculiarities in atmospheres of stars A and B? 2) why the character of these peculiarities is different? Special interest is excited by the systematic deficiency of elements in component B relatively component A (Fig.3). As known, analogous underabundance (but relatively the Sun) was found for A-stars of λ Boo type. One of the potential mechanisms suggested for explanation both Am and λ Boo stars is the diffusion in the presence of mass loss. It was shown that a mass loss rate of $10^{-15}\ M_\odot/yr$ is required for appearance of Am-star, and a rate of $10^{-13}\ M_\odot/yr$ is required for appearance of λ Boo star (Michaud, 1988).

We intend to continue the investigations of binary Am-stars to obtain more complete data on differences in chemical composition of its components.

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