Magnetic Stars, 2011, pp. 259 – 263

On the Dynamics of Circumstellar Gaseous Structures and Magnetic Field of β Lyrae

Skulsky M. Yu.[1], **Kos E. S.**[2]

[1] Lviv Polytechnic National University, Ukraine
[2] Astronomical Observatory of Ivan Franko National University of Lviv, Ukraine

Abstract. During 2008 – 2010 the observations of the β Lyrae system were carried out on the echelle spectrograph of the Peak Terskol observatory 2–m telescope. Based on this spectral material we investigated the magnetic field effect on the behavior of lines, formed in the circumstellar gas structures to clarify the presence of magnetosphere in a close interacting binary system β Lyrae.

Key words: close binary β Lyrae – the circumstellar gas structures – the magnetosphere

1 The Study of the Circumstellar Structures with the Help of Lines He I 3888, 3964, 5015 Å, Ca II 3933 Å, Na I 5890, 5896 Å

To study the circumstellar structures during 2008 – 2010 with the 2–m telescope of the Peak Terskol observatory we obtained 100 echelle spectrograms of a close interacting system β Lyrae with a resolution of about 45 000. Processing of these spectra was carried out using the software package DECH. Based on this spectral material we have studied the influence of magnetic field on the behavior of lines, formed in the circumstellar gas structures to clarify the presence of the magnetosphere of the close interacting system β Lyrae. Below we list the preliminary results of a study of spectral lines He I 3888 Å (having a lower metastable level), He I 3964, 5015 Å, Ca II 3933 Å, Na I 5890, 5896 Å, which are formed in the near and more distant circumstellar gas structures.

Having studied the narrow shell components of the He I 3964 Å and He I 5015 Å lines we noticed that the variations of radial velocities and intensities with the phase of the orbital period are practically correlated (Fig. 1 and 2). Evidently, these lines are formed at about the same distance from the center of the system and participate in the same processes: orbital rotation of the system and changing with the phase of the donor's magnetic field. If we assume as extreme the phases $0.355P$ and $0.855P$ for the poles of the donor's magnetic field (Skulsky, 1985, 1993), then the characteristic bending is close to these phases. It can indicate the influence of this field on the course of the curve variations with the phase of the orbital period. For example, a depression is visible in the intensities of these lines in the phase of $0.855P$ in the region of donor's magnetic field maximum (Fig. 1), as well as the maximum of negative radial velocity near the phase of $0.355P$ (Fig. 2). However, the abrupt changes are clearly seen in these parameters with the phase that testify a more complicated nature of the processes in the circumstellar structures of the whole system. While the intensity of these lines more smoothly fits into the overall quasi-sinusoidal curve of variations with phase, then the changes of radial velocity are more sensitive to other processes which are present in the system, as well as a sudden change twice of the difference in the radial velocities that stands out in the phases of $0.6P – 1.0P$. There is also some shift in phase between the changes of line intensities

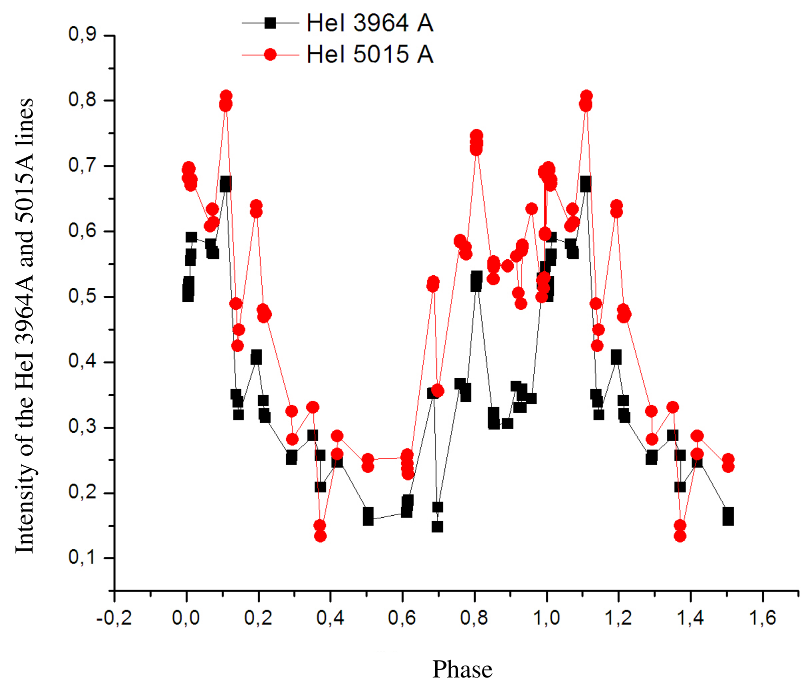

Figure 1: Variations of the He I 3964 Å and He I 5015 Å line intensities with the period

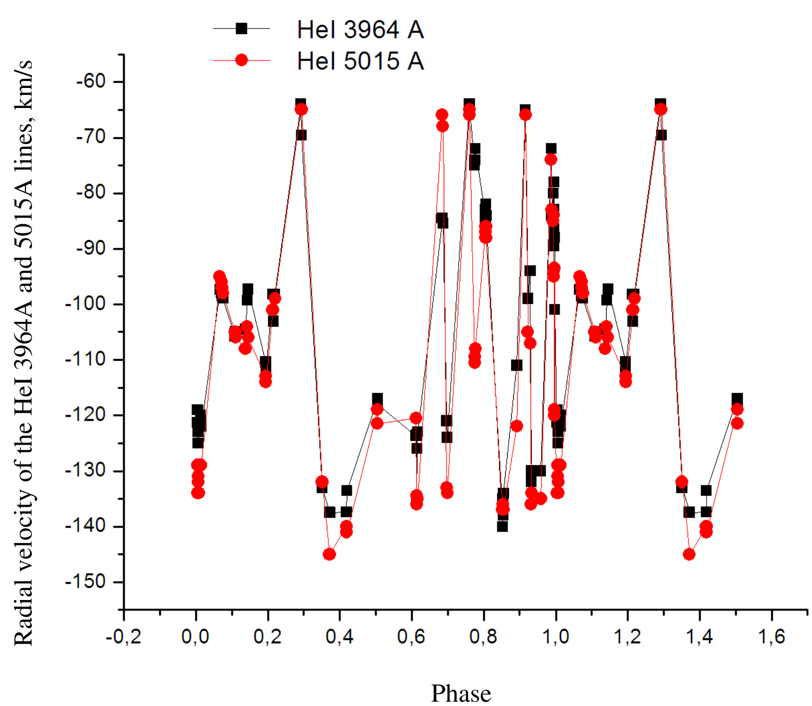

Figure 2: Variations of radial velocity of the He I 3964 Å and He I 5015 Å lines with the period

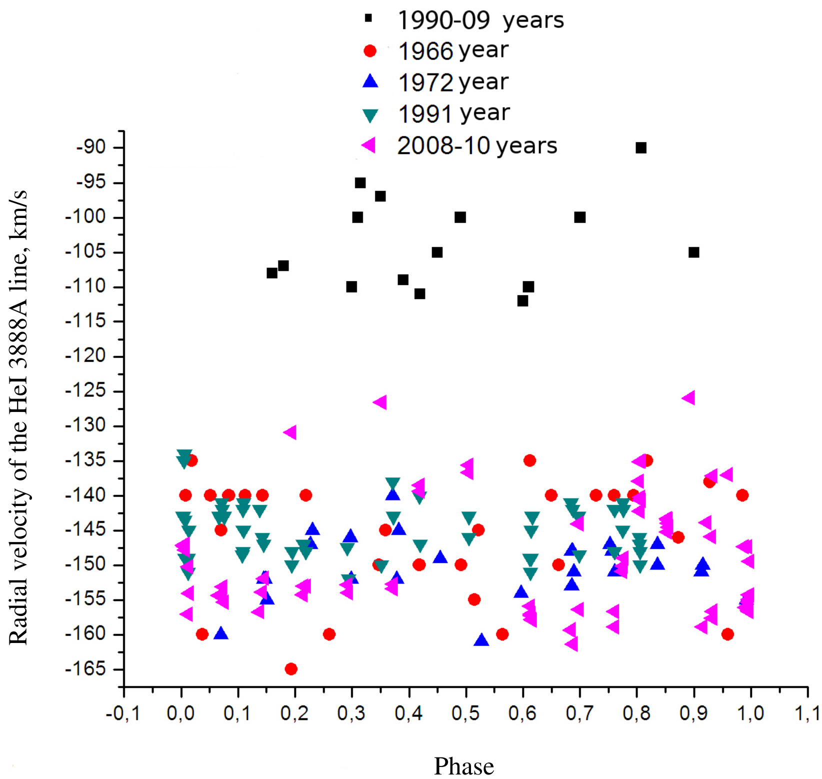

Figure 3: The radial velocity of the line He I 3888 Å in 1900 – 2010

and their radial velocities. Such a picture gives evidence not only of the complex processes in the system, including eruptive, but it may be, unfortunately, a consequence of the off–duty factor of observations, which is important to the time processes of different durations.

2 The Question of Secular Variations of Gas Expansion Shell of β Lyrae system

The measurements of radial velocity in the lines of He I 3888 Å are available for the years 1900 – 2009 (Curtiss, 1912), 1966 – 68, 1972 (our observations), 1991 (Harmanec et al.). We combined these measurements of radial velocities of these lines with our measurements for 2008 – 2010 (Fig. 3). The line He I 3888 Å, having an inferior metastable level, is formed in the gas structure of the binary, in general, but close and expanding from the system shell, where its narrow component appears (Skulsky, 1992, 1993). The He I 3888 Å line has a smaller range of variations in radial velocity with phase relative to the center of mass of this binary, than in the He I 3964 Å and He I 5015 Å lines. This suggests that its formation is more external in the system shell relative to the He I 3964 Å and He I 5015 Å lines. Figures 3 and 4 show the measured radial velocity of the narrow component of the He I 3888 Å line during the past century. We approximate the measurements of radial velocity in Figure 3 with straight lines, it gives the following negative values: 1900 – 09 — 107 km/s, 1966 – 68 — 145 km/s, 1972 — 150 km/s, 1991 — 144 km/s, 2008 – 10 — 150 km/sec. If the 1900 – 2009 observations correspond to reality, then we can conclude that the shell expands at a speed of 10 km/s in 20 years. However, the observations of 1968 – 2010 do not show an explicit increase. Moreover, the data for 2008 – 10 show that the radial velocity of this component of the He I 3888 Å line can reveal an

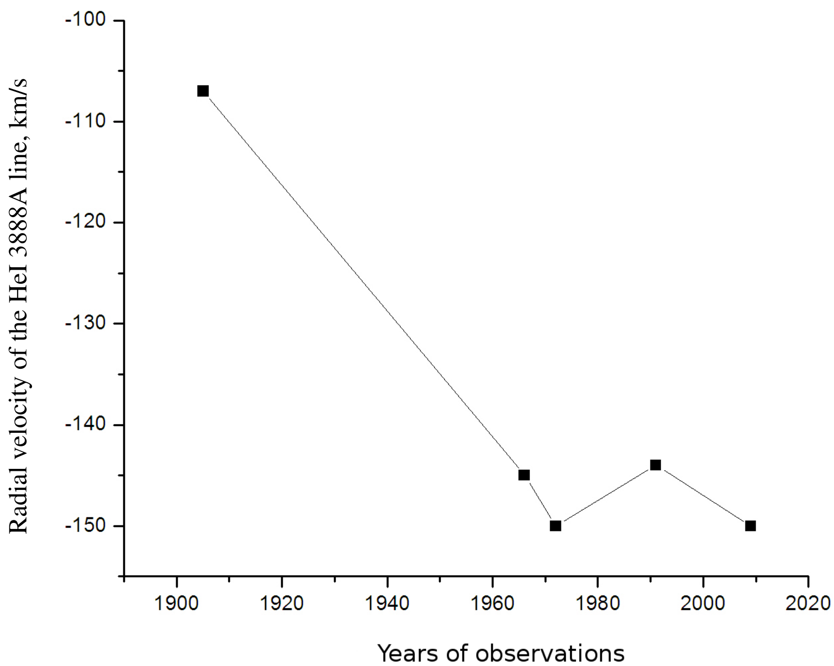

Figure 4: Average radial velocity of the line He I 3888 Å in 1900 – 2010

accretion disk rotation, but this is a question for further research. In addition, for all the years of observations, on the average the curve of radial line He I 3888 Å velocities, as well as in the lines of sodium and calcium rise above the maximum phases of the donor's magnetic field stand out.

3 Circumstellar Structures in Lines of Na I 5890 Å, Na I 5896 Å and Ca II 3933 Å

Very distant gas structures of β Lyrae can be studied on the lines of sodium and calcium that appear in densities, almost close to the density of the interstellar medium. These lines are suitable because they are very narrow and practically not blended. From the radial velocity variations, we can conclude that there are some variations in these lines with the phase — the visible overshoots are superimposed on the general trend (Fig. 5). Although the lines somehow change their amplitude of radial velocity with phase, with the small amplitude (to our surprise!) they "feel" the magnetic field (e.g., near the phase $0.355P$ a minimum is seen in the curve of the calcium line radial velocity with the phase, and a maximum is observed in the lines of sodium). This may indicate the presence of the magnetosphere in the distant neighborhoods of the binary system. Since the distance from the center of the system is large, these bendings have a small amplitude, but at the same time it is possible that due to the off-duty ratio of observations some of the values of radial velocity in these lines trace the eruptive processes of the binary system. It also requires further consideration in more complete observations.

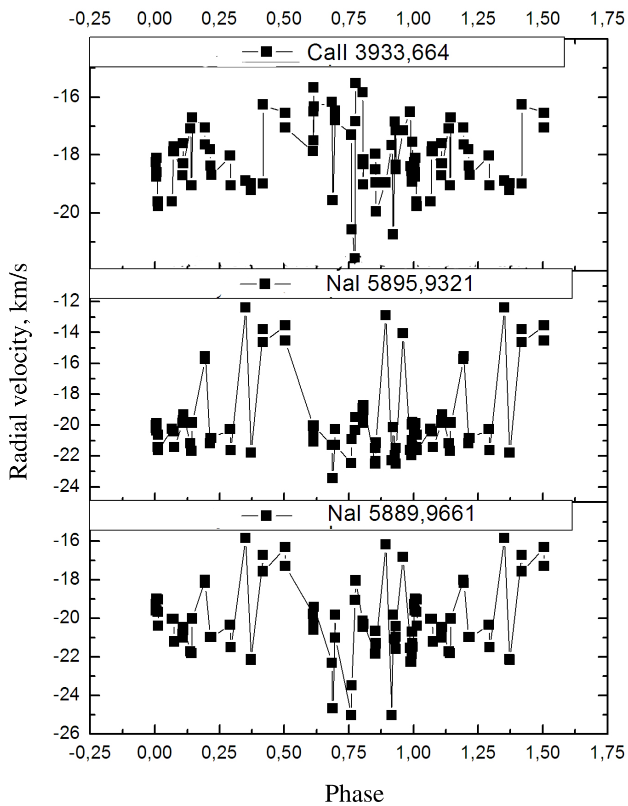

Figure 5: Variations of the radial velocity of Ca II and Na I lines

4 Conclusion

It can be concluded that all the lines formed in the outer gas structures of the β Lyrae system can in one way or another feel the magnetic field, which is revealed by its time at the donor, but, apparently, the external magnetosphere of this interacting binary system may indicate a more complex structure of its general magnetic field (possibly, a magnetic field at the accretor). If the measurements of the He I 3888 Å radial velocity made in 1990 – 2009 are true, then a gas shell has considerably increased its radial velocity in the second half of last century. This may indicate powerful eruptive processes in the system. To examine these data further observations are required.

References

Curtiss M. R., 1912, Publ. of the Allegheny Observatory of the University of Pittsburgh, v. 2, No. 11, 73

Harmanec P., Morand F., Bonneau D., Jiang Y., Yang S., Guinan E. F., Hall D. S., Mourard D., Hadrava P., Bozic H., Sterken C., Tallon–Bosc I., Walker G. A. H., McCook G. P., Vakili F., Stee P., Le Contel J. M., 1996, A&A, 312, 879

Skulsky M. Yu., 1985, Soviet Astron. Lett., 11, 21

Skulsky M. Yu., 1990, Mittelungen KSO Tautenburg, 125, 146

Skulsky M. Yu., 1992, Astron. Zhurnal, 69, 803

Skulsky M. Yu., 1993, Astron. Lett., 19, 45