New Findings Supporting The Presence Of Various Structures Of The Circumstellar Matter In The Beta Lyr System

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Introduction: Beta Lyr is a very complicated and one of the most intensively studied interacting binary (for details and further references see review by Harmanec (2002)). Our study of this eclipsing binary was based on two sets of spectra - 651 "red" electronical spectra and 52 "blue" digitized photographic spectra. They were processed in two different ways. First, we disentangled four appropriate spectral regions into the spectra of both binary components. Next, we made spectrophotometric measurements and subsequent processing of the 15 pronounced absorption lines belonging to the primary star.

Disentangling the spectra

Disentangling the spectra was carried out using the program KOREL (Hadrava 2004). Our results are presented in Fig.1. For electronic spectra, it was necessary to include telluric lines which appear in the given spectral region.
One can see that the disentangling led to the discovery of a number of weak absorption lines originating in the pseudophotosphere of the accretion disc. In other words, we obtained a rich line spectrum of the disc, not limited to previously known two silicon lines seen in the fourth panel. Emission lines seen in the disc spectra originate actually in the jet-like structures but we were not successful in separating them from these spectra.
Primary spectrum corresponds quite well to the synthetic spectrum with T=13000K, log g=2.5[cgs] and v.sin$i$=55km/s which agrees with the values currently adopted for this star. Such a comparison for disc spectrum is complicated since there are still no synthetic spectra for accretion discs. However, radial velocities for the accretion disc spectra define well a sinusoidal RV curve in antiphase to that for the primary.

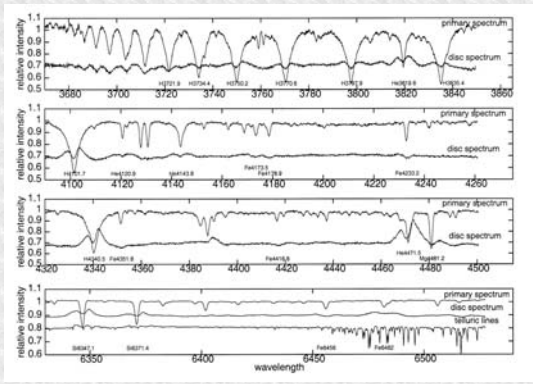

Fig.1. Decomposition of four selected spectral regions into spectra of both binary components.

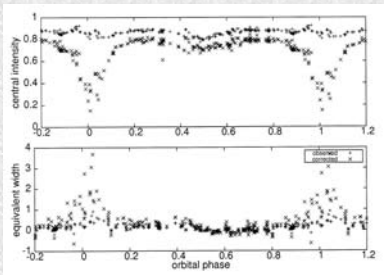

Fig.2. On-phase dependency of central intensity and equivalent width of Si II 6371 absorption line.

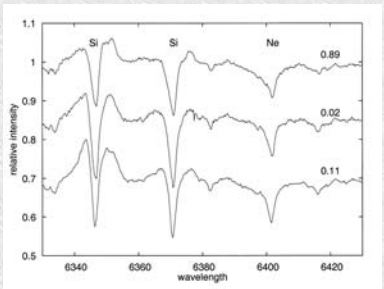

Fig.3. Three spectra round primary eclipse. Orbital phase is signed on the right side of each spectrum.

Spectrophotometry of absorption lines

Central intensity (CI) and equivalent width (EW) of 15 pronounced absorption lines was measured on the source spectra. A problem is that these lines originate in the primary but their quantities are measured with respect to the continuum of both the primary and the accretion disc. It is obvious that the measured quantities must be corrected to the continuum of the primary star only.
To do such a correction, one needs to have a synthetic light curve of the whole binary and of the primary only (due to eclipses by the accretion disc) since this correction depends on the ratio of these two quantities in given orbital phase. For such a modeling, we used program Binsyn, developed by A.P.Linnell (2000).
In Fig.2, there are phase plots of observed and corrected CI and EW of Si II 6371 line. One can see very pronounced line strengthening in the phases round primary eclipse. The same phase dependence was found also for all other investigated lines. These changes are too large to be caused by physical or geometrical properties of the primary. This effect can be also demonstrated in Fig.3. Note that absorption lines in the phase of primary mid-eclipse (second spectrum) are deeper which is in the contradiction with the fact that most of the primary surface is hidden from view in this phase.
It seems that the only plausible explanation is this one: During the eclipse, there is always a certain part of the primary which remains uneclipsed by the disc and the light from this uneclipsed part goes though both, one of the jets and the gas envelope toward an observer. These circumstellar structures may cause an additional absorption. If correct, this interpretation means that there is another absorption line spectrum observable only in the phases of the primary eclipse.

Conclusion: Both analyses led to the discovery of a new set of spectral lines – accretion disc spectrum and „eclipsing“ spectrum. Presence of these spectra supports the current model of beta Lyr with the accretion disc, the jet-like structures and the scattering envelope above the disc. Further analysis of these spectra could bring new pieces of information about this enigmatic binary.

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