Spectroscopic observations of Be/X-ray binary star LSI+$61^0$303

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Abstract. We report our first results based on Hα spectroscopy of the microquasar LSI+$61^0$303. We find that (1) the 26.5 d and 1600 d radio periodicities reflect on the Hα emission. (2) the rotation of the mass donor is almost pseudosynchronized with the orbital motion of the black hole.
Key words: binary stars

Спекроскопични наблюдения на Ве рентгеновата двойна звезда LSI +$61^0$303

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Ние докладваме нашите първи резултати на базата на Hα спекроскопия на микроквазара LSI +$61^0$303. Намерихме, че (1) 26.5 и 1600 радио периодичности влияят на Hα емисията. (2) въртенето на донора на маса е почти псевдосинхронизирано с орбиталното движение на черната дупка

1 Introduction

The remarkable system LSI +$61^0$303 (V615 Cas, GT0236+610) is a Be/X-ray binary star at a distance of 2.3 kpc (Steele et al. 1998) with radio outbursts every 26.496 d (Gregory 2002, and references therein). The variable radio counterpart of the system was resolved at milliarcsecond scales as a rapidly processing relativistic compact jet (Massi et al. 2004), so LSI+$61^0$303 joined the group of Galactic microquasars. The morphology typical of a microquasars, is the observational evidence of the occurrence of accretion/ejection processes in the system. The compact object is probably a black hole orbiting around Be star in a highly eccentric orbit ($e \sim 0.8$, Casares et al. 2005). The spectral observations displayed that the Hα emission is variable on time scales days-years (see Grundstrom et al. 2007 and references therein).

2 Hα emission line variability

Two periodicities have been detected in the radio monitorings of LSI+$61^0$303 – 26.496 d (the orbital period) and a long term 4 yr modulation. We are searching for signs of these two periodicities in the parameters of the Hα emission with aim to understand the connection between the mass loss of the mass donor and jets launched by the black hole.

We have secured more than 110 spectra with the Coude spectrograph of the 2-m RCC telescope at the Bulgarian National Astronomical Observatory Rozhen and Photometrics AT200 CCD 1024x1024 pixels. The wavelength coverage is from 6500 Å to about 6700 Å at resolution of 0.2 Å px^{-1}. An example of our spectrum is plotted in Fig.1. On this figure we also plot a theoretical

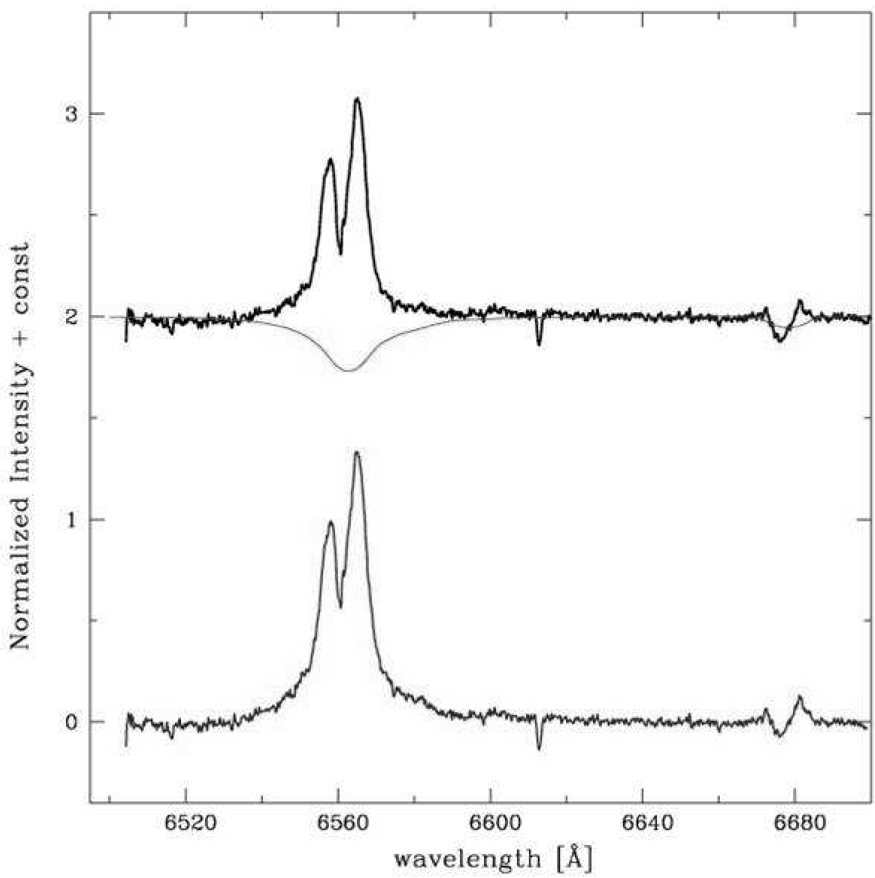

Fig. 1. Synthetic spectrum of the photosphere of B0V star set on an original LSI+61^{0}303 spectrum (up). The spectrum of the circumstellar disk, obtained after subtraction of the photospheric spectrum from the observed (down). The synthetic spectrum represents star photosphere with $v\ \sin i$=360 km s^{-1}, T$_{eff}$=30 000 K, and *log* g= 3.45.

spectrum of the B0V star. The emission lines in Be stars are formed in a circumstellar disk, from which the compact object accretes material.

On each spectrum, we have measured the spectral parameters of Hα line: the ratio of the equivalent widths of B and R peaks of Hα line, the equivalent width of Hα line, the full width at half maximum (FWHM) of B and R peaks, the radial velocity of the two peaks and the dip between the peaks, the ratio of the intensity of the peaks.

Our results are plotted in Fig 2. On these figures we see that EW(B)/EW(R), EW(Hα), and RV(dip) are modulated with the orbital motion of the black hole. The 4-year modulation is visible in EW(B)/EW(R) and EW (Hα). For Fig 2 we also use data from Grundstrom et al. (2007) and Liu & Yan (2005).

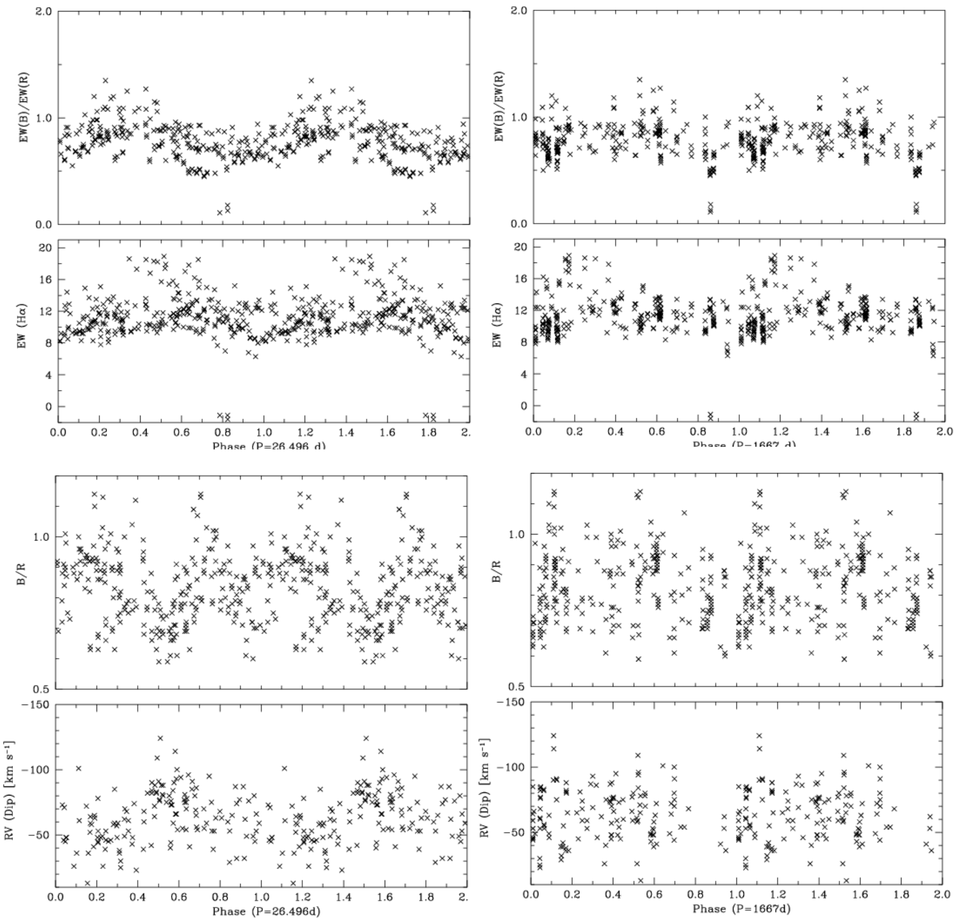

Fig. 2. Right: Variability of Hα line parameters folded with P = 1667 day. From up to down are plotted EW (B)/EW (R), EW (Hα), B/R and RV (Dip).

3 Pseudosynchronization

For a B0V star, we adopt radius R= 8 $R_\odot$ and mass M= 20 $M_\odot$ (Vacca et al 1996). It is known that all Be stars rotate fast, typically at about 0.7v_{crit} (Porter 1996), which means that B0V star in LSI+61^{0}303 has to rotate at equatorial velocity about $v_{eq} = 375 \pm 20$ km s^{-1}.

Casares et al. (2005) have calculated v sin i=115 km s^{-1} and inclination $i = 30 \pm 20^0$, which corresponds to v$_{eq}$ = 400 ± 200 km s^{-1}. Hutchings & Crampton (1981) give v sin i=360 km s^{-1} and $i = 70-80^0$, which corresponds to v$_{eq} = 370 \pm 50$ km s^{-1}.

In the case of LSI+61^{0}303, we expect that the rotation of the B0V star will be synchronized with the orbital motion of the compact object at periastron (so named pseudosynchronization). For the pseudosynchronization period (P$_{ps}$) Hut (1981) gives the expression:

$$P_{ps} = \frac{(1+3e^2+\frac{3}{8}e^4)(1-e^2)^{\frac{3}{2}}}{1+\frac{15}{2}e^2+\frac{45}{8}e^4+\frac{5}{16}e^6} P_{orb} \tag{1}$$

We calculate the period of pseudosynchronization for the mass donor P$_{ps}$ = $2-4$ d, and rotation period P$_{rot}$=0.98 d (assuming v sin i=360 km s^{-1}, $i = 75^0$) and P$_{rot}$=1.03 d (v sin i=115 km s^{-1}, $i = 30^0$), which means P$_{rot} \leq P_{ps}$. The system appears to be close to pseudosynchronization and the tidal force seems to slow (decelerate) the rotation of the mass donor.

4 Conclusions

On the base of spectroscopic observations of the Hα emission line we find that

(i) The Hα parameters influenced by the orbital period are EW(B)/EW(R), EW(Hα), FWHM(B), FWHM(R) and RV(dip).

(ii) The 4-year period modulates the parameters EW(B)/EW(R) and EW (Hα).

We also find that the rotation of the B0V primary is close to pseudosynchronization with the orbital motion of the black hole.

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$E = h\nu = \frac{hc}{\lambda}$
$N = \frac{4\pi\Delta^2 F}{q}$