β LYRAE: ON THE MAGNETIC FIELD

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β Lyrae shows a complicated and intricate time-dependent behaviour of the magnetic field.

INTRODUCTION

A system of periodicities is observed for the eclipsing binary β Lyrae. The more important and main period is the orbital period $P_{orb} \cong 12.94^d$, which is being increased to the value of 18.9 s yr^{-1} [3] because the brightest B8 II star ($\sim 3M_\odot$) losing mass due to a more massive ($\sim 13M_\odot$) and invisible in the spectrum component, which surrounded by an accretion disc. A more shorter transient period of 1.85^d was observed in the absolute radiative flux of the H_α emission [1]. $P \cong 4.74^d$ was derived from the radial velocities behaviour of strong emission lines [2]. There are present the considerably longer periods as well: $P = 283^d \pm 1^d$, which was evaluated from the analysis of light curves in [12] and [2], and P $\approx 340^d$ that was evaluated in [6].

OBSERVATIONS

The first extensive study of the magnetic field of the eclipsing binary system β Lyrae was carried out in 1980–1988 using the 6-m telescope of the Special Astrophysical Observatory [8–10]. The Zeeman splitting was measured in the atmospheric lines of the brightest B8 giant. These photographic observations showed the negative mean value of the magnetic field equal to -1240 G. An amplitude of the variance versus the orbital period was $\sim \pm 450$ G. Measurements of Zeeman splitting in the Si II 6347, 6371 Å lines were made in 1991–1992 with the Stokesmeter and CCD detector, mounted in front of the coude spectrograph of the 2.6-m Shajn telescope at the Crimean Astrophysical Observatory [11]. The presence of the magnetic field on the primary component was confirmed. The amplitude of the variability against the orbital period was $\sim \pm 100$ G and the mean value was 0. Since 1993, we have continued the observations studying some lines of metals. Results of photographic measurements as well as our magnetic field measurements during 1993–1995 and 2000 using a total sample of spectral lines and results of magnetic field measurements at the Catania Astrophysical Observatory in the summer of 1999 are presented in [4]. The mean value of the measured effective magnetic field in 1999 was +1290 G. Therefore, the change of the magnetic field on β Lyrae for the long-time-scale variability is 2.5 kG.

All the Crimean observations since 1993 have been reprocessed using the Monte Carlo method of numerical simulation of standard deviations [7]. Spectral lines which have huge errors of magnetic field measurements have been eliminated from the sample. Results of the processing of the Crimean observations since 1993 to 2004, of the photographic measurements from 1980 to 1988, and of the Catania observations in 1999 are shown in Fig. 1. The Crimean observations do not show any periodicity with the orbital period. This period is not clearly present in the Catania observations of 1999 even by taking into account the 1980s observations.

The multi-periodicity and resonances are observed in the cataclysmic variable stars with the accretion disc (SU UMa-type dwarf novae). As it is showed in [5] for SU UMa stars, the interconnection between the external critical radius of the disc ($\sim 0.46A$, where A is the distance between the centers of stars), the relation of the masses ($q \leq 0.3$), the orbital period P_{orb}, and the disc precession period $T = P_{pr}$ are as follows:

$$P_{pr} = \frac{4}{3} P_{orb} (R_{ext}/A)^{-3/2} (q+1)^{1/2} q^{-1}. \tag{1}$$

The mass ratio in the β Lyrae system is $q \cong 0.22$. The external critical R_{ex} and internal R_{in} radii of the disc were obtained from radial velocities of the disc satellite lines, and from the light curve at 6488 Å [1]:

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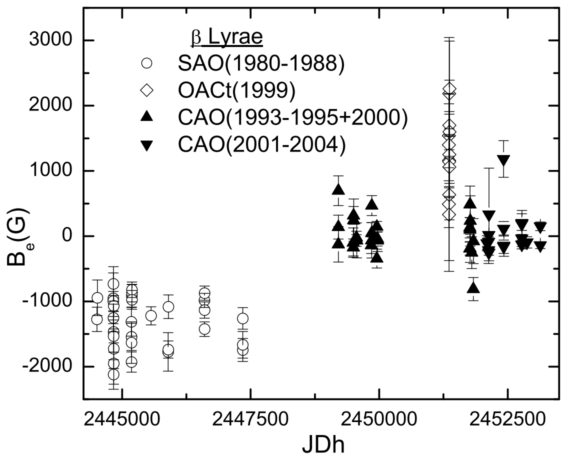

Figure 1. Magnetic field of β Lyrae

$R_{ex} \cong 0.45A$ and $R_{inq} \cong 0.295A$. The precession periods determined from the formula (1) are then equal to 282.4^d and 564.8^d, respectively. Thus, the external edge of the accretion disc is rotating round the accretor during 282.4^d. This period is equal to the period of the tidal wave on the surface of donor that is in the resonance with it. Moreover, the accretion disc is arranged so that his internal edge is turning twice slower and its time is equal to the fundamental period of $T_f = 564.8^d$. The rotation period of the disc matter on the Keplerian orbits of the disc's internal edge is 0.25^P (P is the orbital period) at the linear velocity of 266 km s^{-1}, and it is 0.5^P on the disc's external part with the linear velocity of 208 km s^{-1}. It coincides with the observable frames of the radial velocity of the satellite lines which are formed in the disc. Thus, the matter in the accretion disc is revolving strictly differentially.

We phased the data of an uniform sample of the Crimean observations with periods of 282^d and 338^d. The significant periodicity in both cases is absent as well as the periodicity with the orbital period.

[1] *Burnashev V. I., Skulsky M. Yu.* H-alpha photometry and magnetic field of β Lyrae // Bull. Crimean Astrophys. Obs.–1991.–**83**.–P. 95.

[2] *Harmanec P., Morand F., et al.* Results of optical interferometry, spectroscopy and photometry // Astron. and Astrophys.–1996.–**312**.–P. 879.

[3] *Harmanec P., Scholz G.* Orbital elements of β Lyrae after the first 100 years of investigation // Astron. and Astrophys.–1993.–**279**.–P. 131.

[4] *Leone F., Plachinda S. I., Umana G., et al.* The magnetic field of the β Lyrae system: Orbital and longer time-scale variability // Astron. and Astrophys.–2003.–**405**.–P. 223.

[5] *Osaki Y.* Irradiation-induced mass-overflow instability as a possible cause of superoutbursts in SU UMa stars // Astron. and Astrophys.–1985.–**144**.–P. 369.

[6] *Peel M.* The 340-d period in β Lyrae // Mon. Notic. Roy. Astron. Soc.–1997.–**284**.–P. 148.

[7] *Plachinda S.* Measurements of general magnetic fields on stars with vigorous convective zones using high-accuracy spectropolarimetry // Photopolarimetry in Remote Sensing / Eds G. Videen, Ya. S. Yatskiv, M. I. Mishchenko.– Kluwer Acad. Publ., 2004.–P. 351–368.

[8] *Skulsky M. Yu.* β Lyrae as a magnetic binary star // Pis'ma Astron. Zh.–1982.–**8**.–P. 238.

[9] *Skulsky M. Yu.* The magnetic of the Lyrae system // Sov. Astron. Lett.–1985.–**11**.–P. 21.

[10] *Skulsky M. Yu.* The magnetic field and tidal resonant phenomena in β Lyrae // Mittelungen KSO Tautenburg.– 1990.–**125**.–P. 146.

[11] *Skulsky M. Yu., Plachinda S. I.* A study of the magnetic field of the bright component of β Lyr in the Si II 6347, 6371 lines // Sov. Astron. Lett.–1993.–**19**.–P. 203.

[12] *Van Hamme W., Wilson R. E., Guinan E. F.* Periodic Light Changes for β Lyrae // Astron. J.–1995–**110**.–P. 1350.