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UBV PHOTOMETRY OF THE SYMBIOTIC BINARY BF CYGNI

The light-curve (LC) of the symbiotic star BF Cygni has been studied since 1890 photographically (e.g. Jacchia, 1941). It is characterized by several outbursts of 2-3 mag amplitude accompanied by a gradual decrease of the star's brightness, from $m_{pg} \sim 10$ to $m_{pg} \sim 11$, and by long period variations, $\Delta m_{pg} \sim 1$, corresponding to an eclipse-like effect. Recent observations were collected by Hric et al. (1991) and Skopal et al. (1992).

The last increase of the brightness became at the middle of 1987 ($m_v \sim 10.6$). After a gradual decrease up to $m_v \sim 12.2$ at the beginning of 1989, the star's brightness grew abruptly to $m_v \sim 9.8$ at the end of 1989. Our photometric observations of BF Cyg have been made during this recent outburst phase, from November 1989. The measuring were carried out in the standard UBV system using a one-channel photoelectric photometer installed in the Cassegrain focus of the 0.6/7.5 m reflector of the Skalnaté Pleso and Stará Lesná (near Tatranská Lomnica) Observatories, operating on the principle of the method of pulse counting. The stars HD 183 650 (SAO 68384), $V = 6.96$, $B - V = 0.71$, $U - B = 0.34$, Sp G5 and BD+30° 3594, $V = 9.54$, $B - V = 1.20$, $U - B = 1.70$ were used as comparisons. Several observations were obtained within the framework of an international campaign of long-term observations of symbiotic stars (Hric et al. 1991; Skopal et al. 1992).

Figure 1 shows the UBV photometry of BF Cyg. During the whole observational period BF Cyg was brightest in the U filter. This fact reflects a strong interaction in the binary. In October 1990 the star's brightness reached the maximum 9.35 in the U filter, but during the period June – August, 1991 the brightness faded by about 1.8 mag in all filters (U $\sim$ 11.2, B $\sim$ 12.0, V $\sim$ 11.5) and in September 1991 sudden brightening by about 0.9 mag was observed. Such behaviour of the LC reflects an eclipse-like effect. Compiling our V measurements with the visual magnitude estimations, the middle of this primary minimum can be derived at JD 2 448 444 $\pm$ 1.1 days by the second degree polynomial least squares fit. Behaviour of the UBV light curves around JD 2 448 130 shows a possible existence of a secondary eclipse (hot component between the cool component and observer). Their middle at JD 2 448 129.4 $\pm$ 3.4 was determined by the same method as for the primary minimum. According to Heintz (1978), the position of the secondary, t_s, and the primary, t_p, minima gives the condition which must be satisfied by the orbital eccentricity e, periastron angle ω and orbital period P of binary as

$$\pi(t_s - t_p - P/2)/P = 2\,e\cos\omega \qquad (1)$$

Orbital period $P = 757$ days (e.g. Pučinskas 1970), $t_s = 2\,448\,886.4$ and $t_p =$ JD 2 448 444 imply

$$e\,\cos\omega = 0.133 \qquad (2)$$

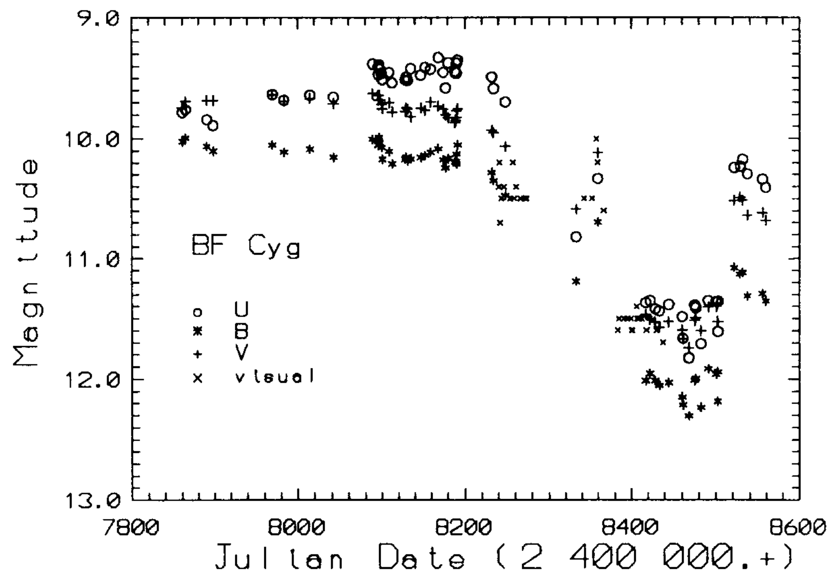

Figure 1: Light curves for BF Cygni according to the data published by Hric et al. (1991) and Skopal et al. (1992)

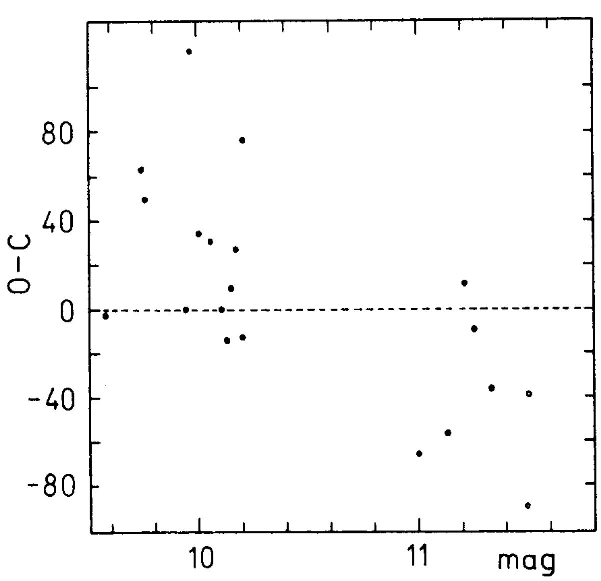

Figure 2: Relationship between the O-C values and the star's brightness (see text in detail). The minima were taken from Jacchia (1941) - full circles, and determined from the data published by Kudashkina (1988) - open circles

This value agrees with the orbit geometry derived by Mikolajewska et al. (1989) from radial velocities of the emission HeI lines (e = 0.23 ± 0.10, $\omega = 60^\circ \pm 27^\circ$). Position of our last primary minimum indicates new average value of the orbital period of 759 days. Jacchia (1941) and Pučinskas (1970) showed considerable real differences, up to 100 days, between observed and computed minima positions. From this point of view it is very problematical to determine a more accurate orbital period (if such one exists at all) of this binary system. Generally, this irregularity results from interaction in the system. For example, if we take the maximum of the star's brightness before and after the minimum observed as a parameter characterising interaction in the system, we can obtain the relationship between this parameter and the $O - C$ value (Fig. 2). The times of the primary minima were taken from Jacchia (1941) and the $O - C$ values were determined according to the ephemeris

$$JD_{\mathrm{Min}} = 2415\,035.7 + 759.3\,E \tag{3}$$

derived from the first well defined minimum, at JD 2415 795 in Jacchia (1941) and average value of the orbital period derived from this and recent minimum. This fact means that during the maxima of the activity the period is larger than during the quiescence. Analogical problem of the orbital period determination is known, for example, in the symbiotic star AG Peg, and/or the symbiotic star V 1329 Cyg exhibited eclipses with 950 day separation (Grygar et al. 1979) during the quiescent phase ($m_{\mathrm{pg}} \sim 15$), but during the outburst phase ($m_{\mathrm{pg}}^{\mathrm{max}} \sim 12$ to 14) the orbital period became longer, about 964 days (Nussbaumer et al. 1986). Detailed analysis of BF Cyg LC can lead us to solving this crucial problem.

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