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ACTIVITY OF T CORONAE BOREALIS IN 1996

T CrB is one of best studied recurrent novae having undergone major eruptions in 1866 and 1946. At quiescence it is classified as a symbiotic binary with an M3 giant cool component (Kenyon 1986 and references therein). The most uncertain parameters of the system are the masses of both components. Most of the published orbital solutions (e.g. Kraft 1958; Kenyon & Garcia 1986) prefer the hot component less massive than the M3 giant but larger than the Chandrasekhar limit. This leads to models with rapidly increasing mass transfer onto a main sequence star as the reason of the nova-like outbursts (e.g. Webbink 1976; Cannizzo & Kenyon 1992). However, the UV data (e.g. Selvelli et al. 1992) and occasionally demonstrated flickering activity in the optical (see Dobrzycka et al. 1996 and references therein) are more easily interpreted if the giant has a white dwarf companion. Recently, Mikołajewski et al. (1996) suggested that T CrB may belong to the subclass (*propellers*) of symbiotic binaries in which a massive, magnetic and rapidly rotating white dwarf accretes matter from the M giant's wind.

Photoelectric observations were carried out using the one-channel UBVRI photometer with the 60cm telescope at Toruń observatory. The stars HD 143313 ($V = 8\overset{m}{.}33; U - B = 0\overset{m}{.}72; B - V = 1\overset{m}{.}00; V - R = 0\overset{m}{.}81; V - I = 1\overset{m}{.}26$) and HD 142929 ($V = 8\overset{m}{.}41; U - B = 0\overset{m}{.}03; B - V = 0\overset{m}{.}51; V - R = 0\overset{m}{.}54; V - I = 0\overset{m}{.}81$) were used as the comparison and the check, respectively. However, the first one seems to be a low-amplitude (less than $0\overset{m}{.}05$) variable. UBVRI light curves covering more than one orbital period ($P = 227^d$) are shown in Figure 1. The occasional, one to three hours searches for rapid variability are marked in Figure 1 as filled triangles for positive detection or open ones for negative detection. During three nights we observed a flickering with amplitude $\sim 0\overset{m}{.}4$ and $\sim 0\overset{m}{.}2 - 0\overset{m}{.}15$ in U and B, respectively. During the two remaining runs a possible amplitude was less than $0\overset{m}{.}2$ in both filters. No flickering with an amplitude larger than $0\overset{m}{.}1$ was observed in the VRI bands.

Spectral observations of the Hα region were carried out with a CCD-camera mounted in the coudé-spectrograph of the 2m telescope at NAO Rozhen. The resolution is 0.35 Å and the S/N ratio ~ 100 in the continuum around Hα. The epochs of observations are marked in Figure 1 and the profiles are shown in Figure 2.

Iijima (1990) noted that between dramatic nova-like outbursts T CrB exhibits two states: a "high" one when the emission lines (H I, He I) and the hot continuum are relatively strong, and a "low" one when they almost disappear. The last increase of Balmer emission lines as well as the He II 4686 appearance was noted by Iijima in April–July 1990 and over the five last years T CrB seems to remain in a low state. The Slovak photometric campaign (see Skopal et al. 1995 and references therein for previous reports) shows a very low level of U and B brightness and it excludes the presence of a blue continuum during this period. Anupama and Prabhu (1991) reported measurements of Hα equivalent widths that remain below 5-7Å after the "high" state in 1986-87, when they were larger than 20-30Å. Hα is also very weak in June 1989 (Ivison et al. 1994).

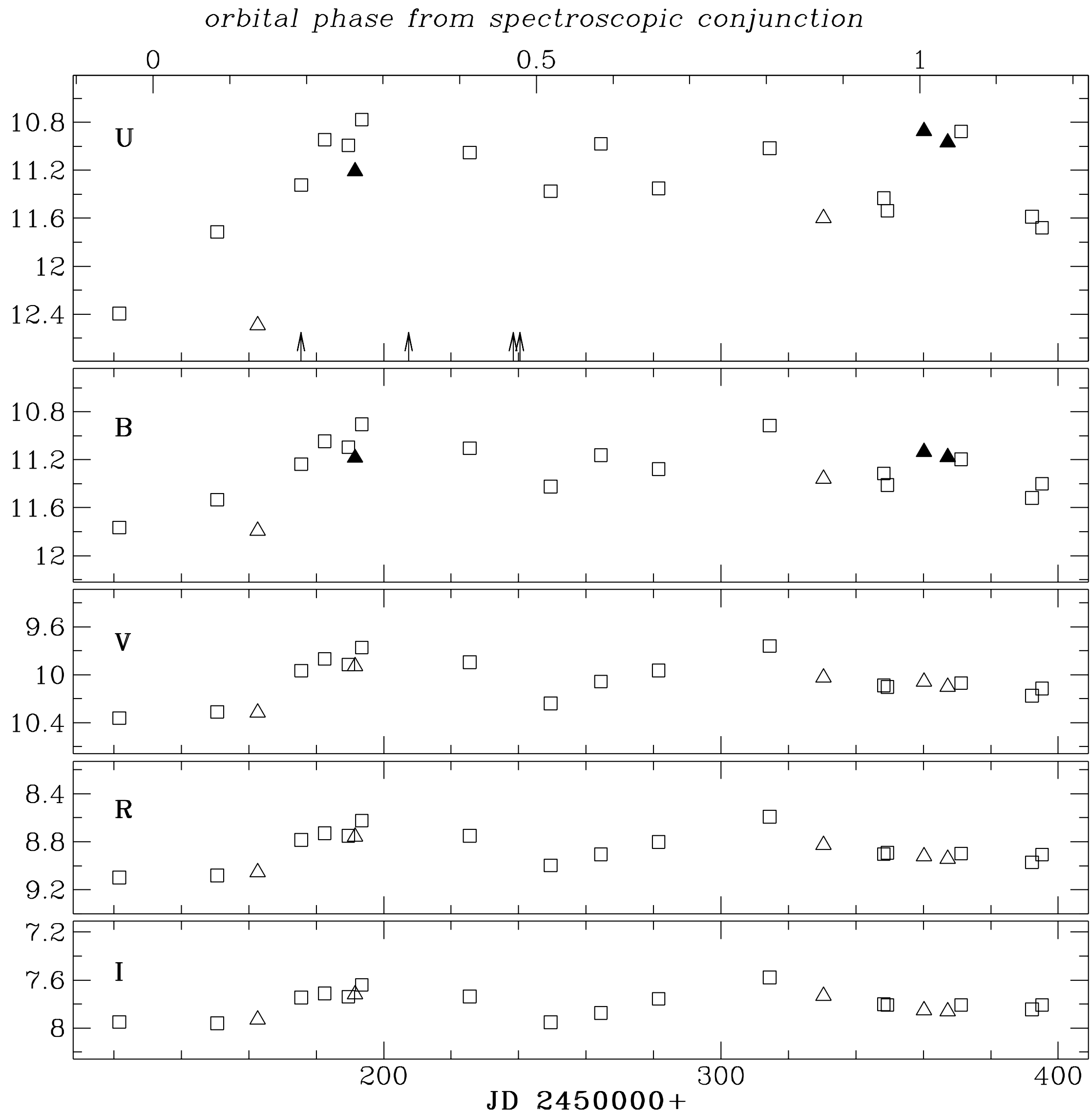

Figure 1: T CrB UBVRI light curves in 1996. Estimations derived from flickering runs are marked by *open* and *filled* triangles for negative and positive detection, respectively. The epochs of the Hα observations are marked by arrows in the U light box. The orbital phases from spectroscopic conjunction (M-giant in front) are taken from Kenyon & Garcia (1986)

In the beginning of April 1996 we observed a rapid increase in U light (Figure 1) by about $1\overset{\mathrm{m}}{.}60$. Simultaneously, flickering variations with time scales from a few minutes to half an hour and amplitudes of about $0\overset{\mathrm{m}}{.}5$ in U and $0\overset{\mathrm{m}}{.}2$ in B appeared, whereas three weeks earlier they were not detected. Afterwards, the U magnitudes changed with an amplitude up to $0\overset{\mathrm{m}}{.}8$ and time scale ~ 1.5 months, but until the end of our observations remained at least 1^{m} above the level of the "low" state in March 1996. The VRI light curves exhibit only the well known (e.g. Bailey 1975) ellipsoidal variations of the M giant with two distinct minima at spectroscopic conjunctions. The domination of the M giant in VRI is confirmed by the lack of flickering variations in these wavelengths. The B magnitudes in Figure 1 reflect both, the rotation of the M giant and the hot component activity.

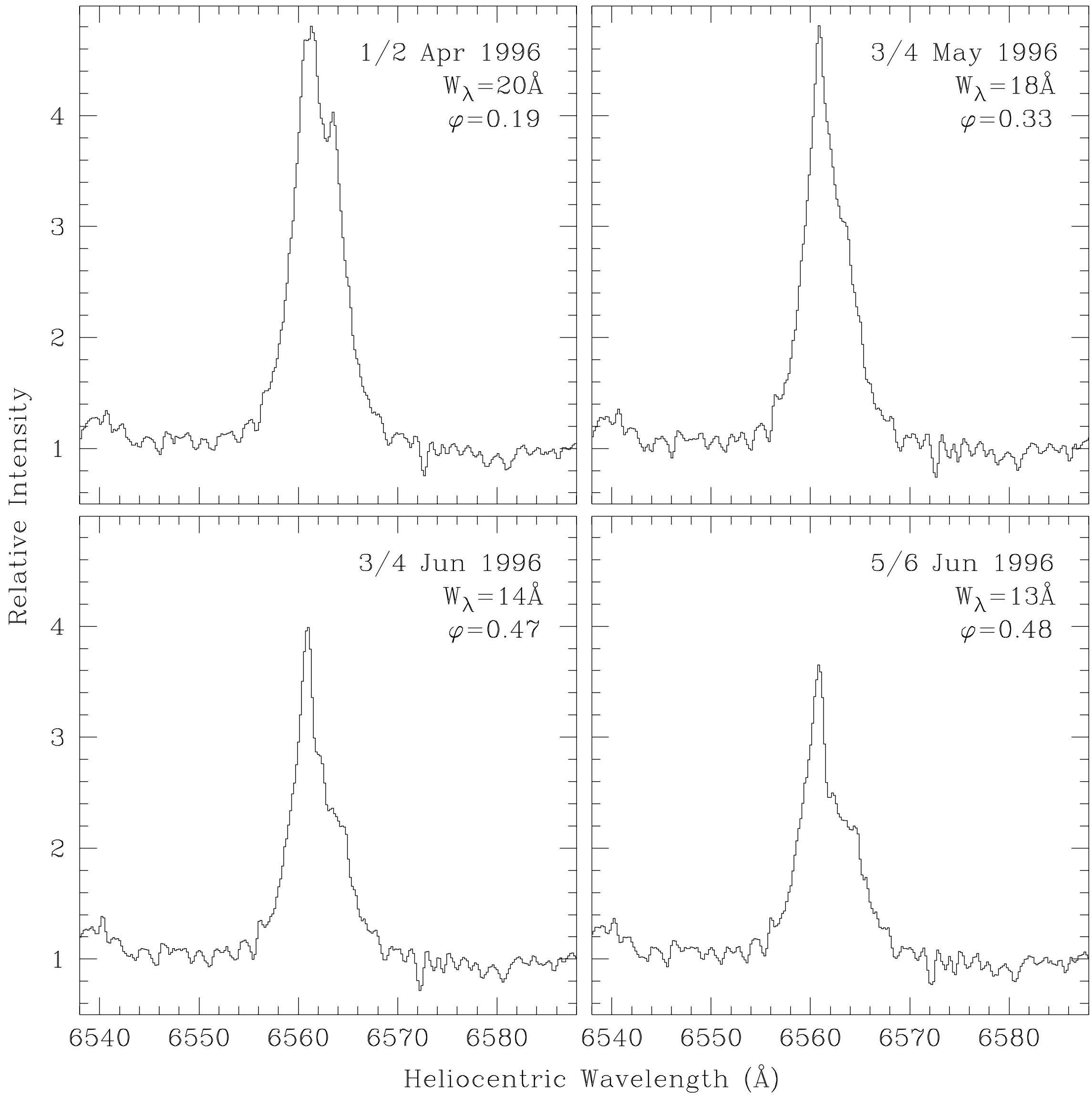

Figure 2: T CrB Hα profiles in 1996. The equivalent width and orbital phase are written in each box

Until now there is no observational evidence that T CrB is an eclipsing binary. Kenyon and Garcia (1986) mentioned that the ellipsoidal variations suggest a large orbital inclination and that several minima in the emission-line fluxes and the total UV flux occurred close to phase 0.0. Our data seemingly do not support this point of view. Just after phase 1.0 (Figure 1) the U magnitudes are close to the maximal value which we observed over the whole period and pronounced flickering variability is present as well. Nevertheless, between phases 0.8 and 1.0 a $1^{\rm m}$ deep minimum is evidently visible in U light. Moreover, we did not detect flickering variations during this minimum. The minimum looks like an eclipse of the hot component by the M-giant which almost fills its Roche lobe. On the other hand, it is very similar to the previous two minima occurring typically for 1.5 months variability. Additionally, the spectroscopic conjunctions (phases 0.0, 0.5, 1.0 in Figure 1) and the minima caused by the ellipsoidal variations of the M-giant (VRI curves) are in good agreement. So, the minimum in U significantly precedes the spectroscopic conjunction in phase 1.0 and this cannot be interpreted as an eclipse.

Our spectral data (Figure 2) cover more than 25 per cent of the orbital period, but there are no indications that any emission component of Hα reflects the orbital motion. However, we tried to measure the radial velocity of each profile's "base", after cutting everything at the level 2.2 above the continuum. The Hα "base" velocity does not change significantly and remains about 20 km s^{-1} blueshifted relative to the γ-velocity. The lack of orbital motion in Hα suggests that the dimension of the region in which this emission originates can be comparable to the distance between stars and/or that $q = M_{cool}/M_{hot} < 1$. The large amplitude $K_{hot} = 33.5$ km s^{-1} obtained by Kraft (1958) from velocities of the Hβ emission on seven plates is probably casual. Any new observations, especially during the "high" activity phase, are very needed.

The equivalent width of Hα systematically decreases from 20Å to 13Å between April and June 1996. Similar values of the equivalent widths were observed by Anupama and Prabhu (1991) during the previous activity period in 1985-87. These authors also reported a very strange behaviour of Hα with pronounced peaks of intensity at both spectroscopic conjunctions. Our observations obtained a few days before orbital phase 0.5 do not show such behaviour and the mentioned effect can rather be an artefact.

Rising U and B brightness and Hα emission, as well as flickering activity denote that T CrB was in a "high" activity state in 1996.

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ERRATUM

In the original version Fig. 1. have been erroneously inserted in place of Fig. 2. too.