HIGH AND LOW STAGES OF T CrB

T. Iijima
Astronomical Observatory of Padova, Asiago Section
Osservatorio Astrofisico, I-36012 Asiago (Vi)
Italy

Presented at the First European Meeting of the AAVSO
Brussels, July 24-28, 1990

Abstract

In the period from 1981 to 1987, probably except for some months in 1982, T CrB showed the usual spectrum of an M-type giant with prominent emission lines of H I, He I, etc. The emission of He II 4686 was temporarily observed. All emission lines weakened or disappeared in the early half of 1988. At the same time the luminosity slightly decreased (B=11.8). This stage continued until March 1990. Then in April the emissions of H I again became prominent and a weak emission of He II 4686 was detected. The intensity of H I emissions has been largely varying in the period from April to July 1990, which might have been related to a pulsation of the cool component. It seems that the mass transfer in the binary system ceases in a certain unknown condition.

1. Observations and Results

As one of the objects of the spectroscopic monitoring of symbiotic stars, T CrB has been observed at Asiago Observatory since 1981. The mono-prismatic spectrograph, Camera VI, with RCA S-20 image tube ($\lambda\lambda$380 - 800 nm, $\Delta\lambda/\lambda = 10^{-3}$ at Hα) mounted on the 122-cm reflector has been used. Since 1987, spectrophotometric observations have also been made with the Boller and Chivens spectrograph with Thomson TH7882 CCD ($\lambda\lambda$370 - 800 nm, $\Delta\lambda/\lambda = 10^{-3}$) mounted on the 182-cm reflector at Mt. Ekar station.

In the period from 1981 to 1987, T CrB showed the well known symbiotic spectral feature, that is, a spectrum of an M-type giant with prominent emission lines of H I, He I, etc. Kenyon and Garcia (1986) did not report the emission of He II 4686 in their observations on April 9 and 14, 1984, and June 1 and 2, 1985. In our spectra, however, a weak emission of He II 4686 was seen in February-March 1982, January 1983, April 1983, March-April 1984, May 1986, and March 1987. All emission lines significantly weakened or disappeared in the period from May to June 1988. Only Hα and Hβ were barely visible as weak emissions in the spectra taken in June 1988. This stage continued, slowly recovering the intensity of the emissions, until March 1990.

The results of the spectrophotometric observations are given in Table 1, where the phase depends on the ephemeris of Kenyon and Garcia (1986). These spectra were calibrated using the spectrophotometric standard stars BD +33°2642 and BD +25°3941 (Stone 1977). The observational error is about 5%. The values with lower accuracy are denoted by a colon. The luminosity of T CrB was determined integrating the spectra in the range from 410 to 470 nm which roughly corresponds to the B band. Then the integrated flux was converted to magnitude assuming that the fluxes of BD +33°2642 and BD +25°3941 in the same range are equivalent to the B = 10.68 (Iriarte 1958) and 11.11 (Hiltner 1956), respectively. The derived B magnitudes are given in the last column of

Table 1. Figure 1 shows the B magnitude and the intensity of Hβ emission. Their variations in 1990 are shown in more detail in Figure 2. The phase in the abscissa is that of Kenyon and Garcia (1986). The upper panel of Figure 2 does not show B magnitude, but shows the deviation from the mean photographic magnitude at the corresponding phase given by Peel (1990: Figure 2 in his paper). The little difference between B magnitude and photographic magnitude is not important in this argument.

Table 1. Spectrophotometric observations of T CrB

No.	*Date*			*JD*	*Phase*	*Range (nm)*	*HeII* 4686*	*Hβ**	*Hα**	*B*
246	19	Sep.	1987	2447058.4	0.473	370-540		78.6		11.6
694	8	Jan.	1988	2447169.7	0.962	400-510		75.9		11.5
1073	23	May	1988	2447305.5	0.559	400-510	4:	53.5		11.8
1246	23	July	1988	2447366.5	0.827	400-510		30.2		11.7
2824	26	Jan.	1989	2447553.7	0.650	410-520		56.4:		11.5:
5150	2	Mar.	1990	2447953.6	0.407	390-500		55.4		11.7
5174	3	Mar.	1990	2447954.6	0.412	400-510		54.5		11.7
5476	19	Mar.	1990	2447970.6	0.482	400-510		57.1		11.9
5501	20	Mar.	1990	2447971.6	0.486	560-670			320.0	
5550	10	Apr.	1990	2447992.4	0.578	400-510	9.0	118.5		11.5
5554	10	Apr.	1990	2447992.5	0.578	600-710			546.1	
5646	3	May	1990	2448015.4	0.679	400-510		102.4		11.4
5673	7	May	1990	2448019.5	0.697	400-510		76.4		11.6
5771	30	May	1990	2448042.5	0.798	400-510	16.9	164.6		11.3
5832	28	June	1990	2448071.5	0.926	400-510	6:	120.6		11.2
5890	11	July	1990	2448084.5	0.983	380-600	11.4	95.3		11.5

* Intensity in 10^{-14} erg cm^{-2} s^{-1}

2. Periodical Variations of 55 Days

As seen in Figure 2, two peaks of the intensity of Hβ emission were observed with an interval of about 50 days (JD 2447994.2 and 8042.5). The intervals between the minima are also an order of 50 days. As a matter of course, our data are not sufficient to discuss about the periodicity of the variation. It is, however, sure that this phenomenon is similar to the semi-periodical variation of the luminosity of T CrB in U, B, and V bands with a period of 55 days reported by Lines *et al.* (1988). One peak of B magnitude is found on JD 2447992.4 (Figure 2) which is consistent with the variation of Hβ. The successive behavior of B magnitude, however, is much different from that of Hβ. This inconsistency might be due to an ambiguity in the mean light curve near eclipses.

Peel (1990), analysing numerous photometric data, reported a negative result for the periodicity of 55 days. The recent behavior of Hβ emission (Figure 2), however, seems to support the result of Lines *et al.* (1988). The light variation, which was more prominent in the bluer bands (Lines *et al.*, 1988), and the variation of Hβ emission suggest that the temperature and the luminosity of the hot exciting star have periodically varied. The period of 55 days, however, is too long to be a time scale in the hot star itself (a main sequence star: Kenyon and Garcia 1986), but is consistent with that of a pulsation of an M giant. The model with a pulsating M giant proposed by Lines *et al.* (1988) seems to explain well these phenomena. The variations of the hot star might be derived from a periodical change of the mass transfer rate owing to the pulsation.

Oskanian (1983) found an unusual fading of T CrB in June 1982 and reported that the light variation in U band disappeared during the fading. In this work also, unfortunately we have only a few points in 1988-89, it seems that the intensity of Hβ emission did not significantly vary when it was very faint (Figure 1). Probably the variation with a period of 55 days disappears in a certain condition. The negative result of Peel (1990) might be due to a mixing of data in the stage with no variation.

3. Weakening of Emission Lines and Light Fading

Because of the lack of spectroscopic data in June-July 1982, direct comparison cannot be made between the fading in 1982 and the weakening of the emission lines in 1988-89. These phenomena, however, seem to be similar. The fading in 1982 (Oskanian 1983) occurred around a conjunction of the binary system (phase: 0.993-0.085), but it cannot be explained with an eclipsing effect, because the luminosities in U, B, and V bands were much fainter than those of the next conjunction (Oskanian 1983). The weakening of the emission lines was surely not due to the eclipse, because it occurred when the hot star was in front of the M giant. It seems that these phenomena are results of a decrease of the mass transfer rate in the binary system. Peel (1985) proposed a binary model with an elliptical orbit for T CrB. The mass transfer rate should change periodically in such a system. The weakening, however, may not have been due to this effect, because its duration was more than two years, namely much longer than the orbital period. The author feels that the M giant in the binary system of T CrB shrunk in 1982 and 1988-89. If the M giant nearly fills its Roche lobe, the mass transfer rate varies according to the pulsation with a period of 55 days. As a result, the temperature and the luminosity of the hot component vary with the same period. On the other hand, when the M giant is sufficiently smaller than its Roche lobe, the mass transfer rate decreases and is not affected by the pulsation. At the present time, however, at least so far as the author knows, it is not clear if such a temporal shrinkage is possible in an M giant. Further works are waited.

4. Conclusions

As mentioned above, the system of T CrB may have two stages. In one (high) stage the emission lines and the blue continuum light are strong, while they are weak in the other (low) stage. The difference between the two stages might be due to the mass transfer rate in the binary system. The variations of the blue continuum and the intensities of the emission lines with the period of 55 days seem to appear only in the high stage. When we analyse photometric data of T CrB, we must take care not to mix the data in the different stages.

References

Hiltner, W. A. 1956, *Astrophys. J. Suppl.*, **2**, 389.
Iriarte, B. 1958, *Astrophys. J.*, **127**, 507.
Kenyon, S. J., Garcia, M. R. 1986, *Astron. J.*, **91**, 125.

Lines, H. C., Lines, R. D., McFaul, T. G. 1988, *Astron. J.*, **95**, 1505.
Oskanian Jr., A.V. 1983, *Inf. Bull. Var. Stars,* No. 2349.
Peel, M. 1985, *J. Amer. Assoc. Var. Star Obs.*, **14**, 8.
Peel, M. 1990, *J. Brit. Astron. Assoc.*, **100**, 136.
Stone, R. P. S. 1977, *Astrophys. J.*, **218**, 767.

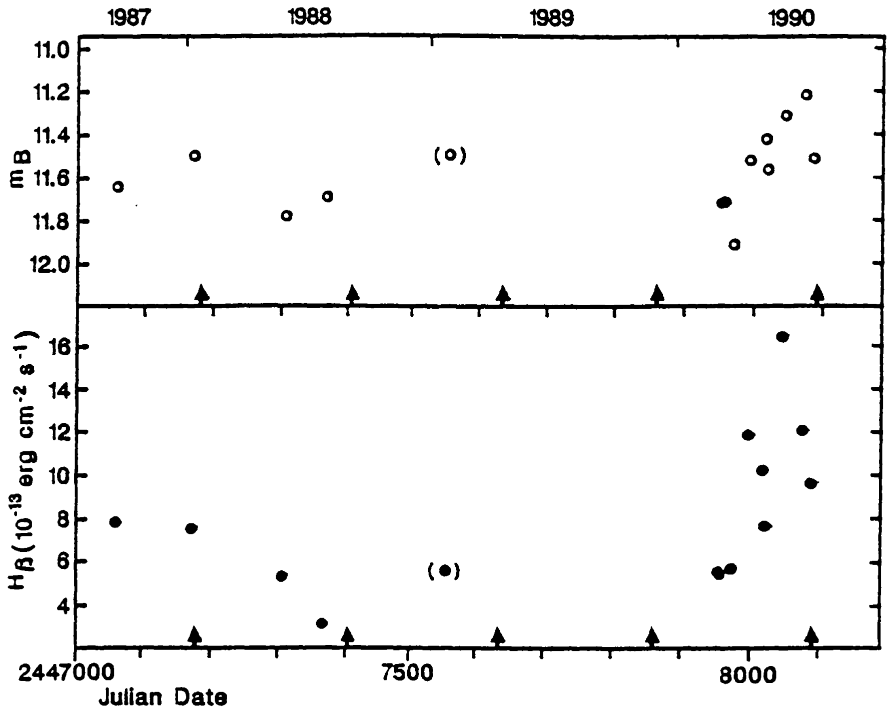

Figure 1. The B magnitude and intensity of Hβ emission line of T CrB. Values with lower accuracy are parenthesized and arrows indicate the dates of eclipse.

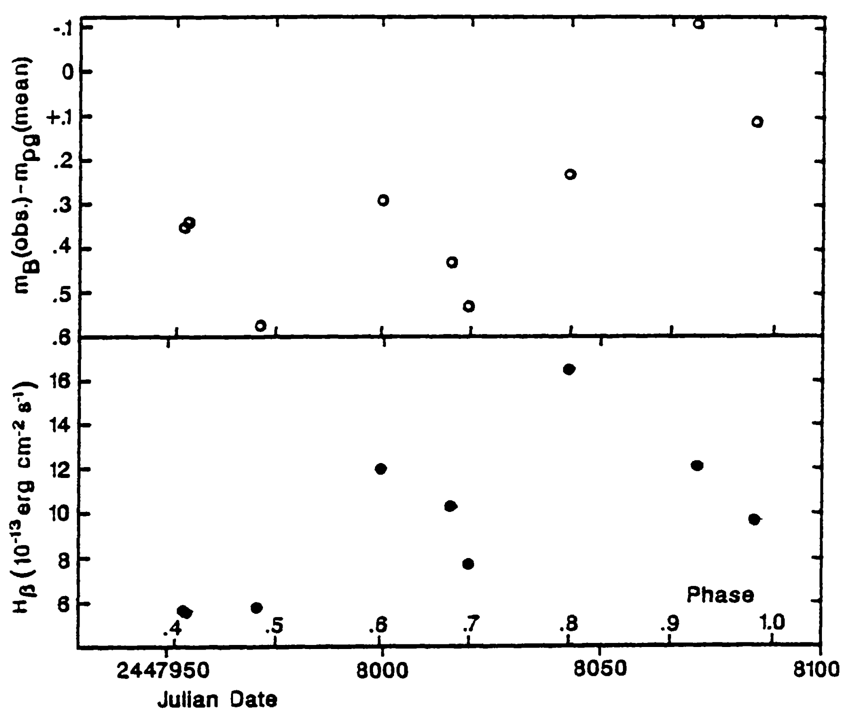

Figure 2. Deviation of B magnitude from a mean light curve and intensity of Hβ emission in 1990. Phase of the orbital motion with a period of 227.53 days is shown in the abscissa