

# Modeling of the IR Light Curves of the Symbiotic Recurrent Nova T CrB

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**Abstract.** We analyze the results of our IR photometric monitoring of T CrB during 1987-2003 and describe the ellipsoidal variability of the Roche lobe filling cool component. We obtain limits to the binary inclination of  $i \in [50, 60]$  deg and binary mass ratio  $q \in [0.4, 2]$  (90 per cent confidence). The mass of the hot component is therefore 1.3-3  $M_{\odot}$ . If the hot component of T CrB is a white dwarf, its mass will be near the Chandrasekhar limit.

**Keywords.** binaries: symbiotic — stars: individual (T CrB)

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## 1. Observations

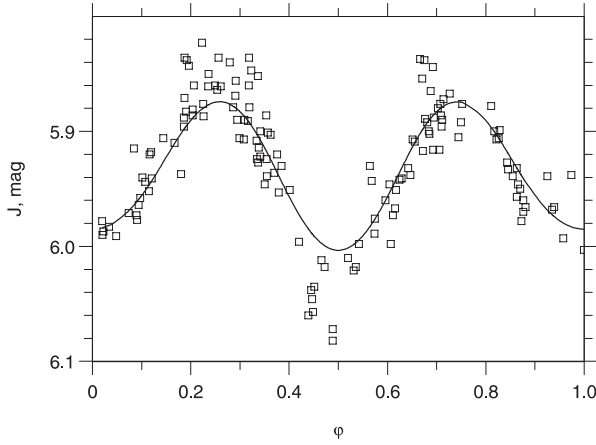
T Coronae Borealis is a recurrent nova which underwent two outbursts, one in 1866 and one in 1946. The double bump visible in the optical and IR light curves indicates that the giant of T CrB is tidally distorted (Kraft 1958; Yudin & Munari 1993).

Photometric *JK* observations of T CrB have been carried out with the 1.25-m telescope at the Crimean Station of the Sternberg Astronomical Institute during 1987 - 2003. The IR standard is BS 5947 ( $J = 2.09$  mag,  $K = 1.30$  mag). The observational errors do not exceed 0.02 mag.

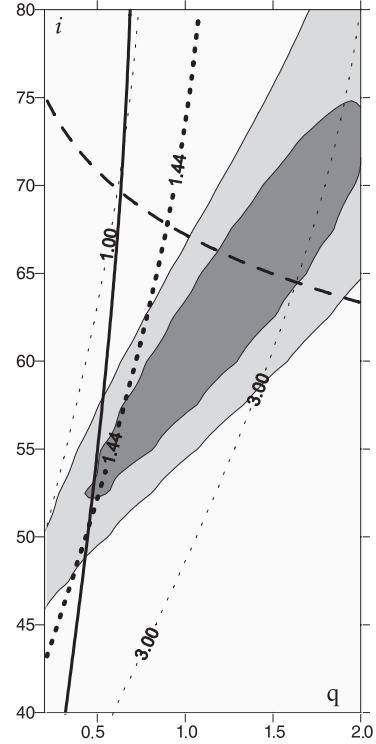
## 2. Calculations

A theoretical light curve for a tidally distorted red giant was calculated in the frames of the classical model of the ellipsoidal variability (Tjemkes *et al.* 1986). According to the radial-velocity analyses, we assumed that the orbit of T CrB is circular. Each local surface of the red giant radiates as a black body with a temperature determined by Lucy's law for stars with convective envelopes (the mean temperature is equal to the effective temperature  $T_{eff} = 3300$  K). The *J* band is the most suitable band for approximation of a real red giant's energy distribution by black body radiation (Shahbaz *et al.* 1997). A non-linear limb-darkening law has been assumed and the coefficients have been interpolated from the tables of Claret for the temperatures on the local surfaces (Claret 2000). Figure 1 shows a convolution of the *J* light curve with a period  $P(J) = 227.^d56$ , which was searched by Kolpakov's program (<http://infra.sai.msu.ru/prog/kolpakov>).

In Figure 2 we plotted two areas of possible values for binary parameters ( $q, i$ ) according to Fisher's distribution (dark grey – 75% confidence limit, light grey – 90% confidence limit). The lack of eclipses in the UV continuum observed with International Ultraviolet Explorer indicates that T CrB is not an eclipsing binary (Selvelli *et al.* 1992). The limits based on the lack of eclipses are shown in Figure 2 as a dashed line. The parameters ( $q, i$ ) of T CrB must be below this curve. A reasonable limit to the mass of the red giant is  $M_{giant} \geq 0.6 M_{\odot}$  (the secondary can evolve to a giant during the lifetime of our Galaxy). Using the mass function derived by Fekel *et al.* (2000) we plotted the line corresponding to  $M_{giant} = 0.6 M_{\odot}$  (solid line). The dotted lines are the lines of the constant hot component masses (thick dotted line –  $M_{hot} = 1.44 M_{\odot}$ ).



**Figure 1.** The  $J$  light curve of T CrB folded with orbital period  $P = 227.^d56$  and the synthetic light curve for the model with  $q = 0.5$ ,  $i = 53$ ,  $T_{eff} = 3300 K$



**Figure 2.** The parameter space diagram ( $q$ - $i$ ) for T CrB (dark grey – 75% confidence limit, light grey – 90% confidence limit). The solid line corresponds to  $M_g = 0.6 M_\odot$ . The dashed line is the limit based on the lack of eclipses. The dotted lines are the lines of the constant hot component masses (thick dotted line is  $M_h = 1.44 M_\odot$ ).

From Figure 2 we conclude that, if the hot component of T CrB is a white dwarf its binary parameters will be  $q \in [0.5, 0.8]$  and  $i \in [52, 62]$ . It should be noted that the hot component's mass is not less than  $1.25 M_\odot$ . Therefore, according to Iben & Tutukov (1996), T CrB can be considered as a real progenitor of a Type Ia supernova.

## References

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