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When will the next T CrB eruption occur ?

Jean Schneider [1]

[1] *Paris Observatory - LUX - France*

ABSTRACT

The first eruption of the periodic nova T CrB for eighty years is anticipated soon, though with an unknown date. A refinement of the future eruption date is investigated. The investigation is based on the combination of the previous eruption dates and on the orbital ephemeris of the binary system, without any hypothesis on the eruption mechanism. It is predicted that the next eruption should appear around 27 March or 10 November 2025, or later.

Keywords: T CrB - nova

1. INTRODUCTION

The binary star T CrB presents an interesting case of a historical nova with a recurrent period of about 80 years from 1217 to 1946. It becomes sufficiently bright (V= 2-3) be be visible with a naked eye. Since the last eruption was in 1946, a new eruption is expected soon, from weeks to a few months. The hope of an eruption coming as soon as 2024 has been triggered by the fact that, starting in late 2023, a dip in the light-curve has been observed similar to the 1946 pre-eruption light-curve. But, since the last 3 eruptions eruptions were not exactly periodic, with a period change of 1.36 year on average, one can presently not predict exactly the date of the next eruption. In this paper I investigate a way to predict eruption dates with a precision of a week or two.

2. THE BINARY SYSTEM AND THE PREVIOUS ERUPTIONS

It it composed by a red giant (1.12 $M_\odot$, 75$R_\odot$) and a white dwarf (1.37 $M_\odot$).
The orbit has a period of about 228 days (Fekel et al. 2000) and a semi-major axis 0.54 AU (Lindord et al. 2019).
Four previous eruptions have been recorded.
- 1217: Schaefer (2023) reports an eruption seen by the Abbott Burchard "in autumn". In absence of more precision, I take a mid-term date between the autumn equinox and the winter solstice of 1217, i.e. 4 November 1217.
After 1217, no eruption has been reported before 1787.
- 1787: Schaefer (2023) reports an eruption "in the Christmas time". He estimates that the eruption occurred around December 20, i.e. a period of 81.44 years.
- 1866: Pettit (1946) reports an eruption on May 12, i.e. a period of 78.39 yr.
- 1946: Sanford (1946) and Shears (2024b) report an eruption on February 9, i.e. a period of 79.47 yr.

3. PREVIOUS ERUPTION PREDICTIONS FOR 2024-2025

There have been a few predictions for the 2024-2025 eruption (Schaefer 2023, Shears 2024a). They are based on the similarity of the phenomenological behavior of the pre-eruption light-curve of 1946 and the light curve variations starting in 2023. These similarities were interpreted as a sign of an imminent eruption. But there ar no published pre-eruption light-curves for the 1787 and 1866 events, so that we do not know if these characteristics of the light-curve recur..

4. A NEW TENTATIVE PREDICTION

In addition to the predictions based on the similarities of pre-eruption light-curves, there is an empirical fact based on the orbit ephemeris.
By going more carefully into the dates of occurrence of the past eruptions, one finds that the successive events date

separations are an integer multiple of the orbital revolution period. Indeed by taking the mean period 227.5687 days (Scheafer 2023b), one gets:
- for the 1217 and 1787 eruptions, (2374102 - 2165874)/227.5687 = 915.007, close to 915 = 570.097 years, i.e. a mean period of 81.44 years.
- for the 1787 and 1866 eruptions, (2402734 - 2374102)/227.5687 = 125.82 close to 126 = 78.38 years
- for the 1866 and 1946 eruptions, (2431861 - 2402734)/227.5687 = 127.99, close to 128 = 79.745 years
The small fluctuation of the periods can have two, non exclusive, causes:
- the accretion rate on the white dwarf is fluctuating
- Brad Schaefer (2023a) has pointed out (table 6) a fluctuation of ± 8 days in the orbital period from 1967 to 2023. This affects the prediction by only a few days.
In summary, the eruptions are not strictly periodic, but the eruptions were all separated by an integer multiple of the orbital period 227.5687 days.
From that, I tentatively infer that the eruption date after 9 Feb 1946 should be 2431861 + N*227.5687 where N is an integer close to 128, if the orbital period remains constant. For N = 126 to 129 the Table 1 gives the predicted days of eruption, within a few days.

Table 1 Predicted days of eruption occurrence in 2024, 2025, 2026 and 2027
using 2431861 + N*227.5687

N	**Julian day**	**Civil date**
126	2460535	12 Aug 2024
127	2460762	27 March 2025
128	2460990	10 November 2025
129	2461217	25 June 2026

Since the August 24 2024 did not occur, one should have to wait for April 8 or November 10 2025 at the earliest.
These "predictions" are only empirical extrapolations. There is at this point no physical explanation behind them.

5. TOWARD AN EXPLANATION ?

The predictions above do not invoke any eruption mechanism. One can nevertheless attempt to go further into the comprehension of fact that the eruption period is N*227.5687 ±8 days, with N = 126 to 129.

Let us consider the orbital phase of the eruption. Fekel et al. (2000) give a radial velocity curve for T CrB from 1997 to 1999. There are three dates in their Table 4 close the form JD = 2431861 + N*227.5687 for this period. These three dates correspond to a phase close to 0.45 in their radial velocity curve. Fekel et al. (2000) estimate that the orbit eccentricity is 0. But for a circular orbit all phases are equivalent and why should the eruption mechanism choose always the same orbital phase ?
To break this circular symmetry, first Kenyon & Garcia (1986) estimate an eccentricity of 0.012 and an $\omega = 89$ deg. And one can introduce a third body in a highly eccentric orbit with a similar ω.
When the third body and the nova are located at their minimum mutual distance i.e. every 80 year + N*228 days. When the white dwarf is between the the red giant and the third body, it accretes matter from the two stars and the mass transfer is maximum and the eruption occurs. Once it has occurred, it cannot occur again at the next 228 d. binary period and must wait the next third body periastron 80 years later. This third body could be detected by very high precision radial velocity measurement or by high contrast and angular resolution imaging.

6. CONCLUSION

By extrapolating the empirical fact that the previous T CrB eruption dates were separated by an integer multiple of the orbital period 228 days, the next eruptions should appear at 27 March 2025, 10 November 2025, 25 June 2026 or 8 Feb 2027. No physical hypothesis is made behind this extrapolation. I urge observers to be cautious about it, since an external perturbation could happen, and to continue to monitor the light-curve of the star. An open question: what explanation of the exact periodicity of N*227.56 days, with N = 129 ± 1, of the previous eruptions in case the next eruption occurs far outside the prredicted dates?

The armada of ground-based and scheduled space-based observations, from gamma-rays to radio, before, during and after the eruption, particularly during the rapid brightness increase, will learn us more about the eruption mechanism.

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