[**] Presenting Author: Celebrating 20yrs of Swift Discoveries Abstract #49

T Corona Borealis Will Be the Brightest Classical or Recurrent Nova Ever Observed in X-rays

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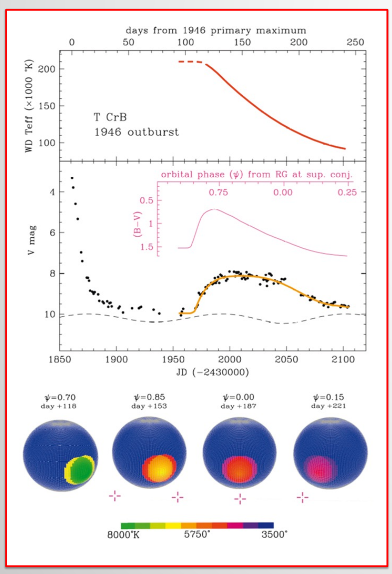
Classical and Recurrent novae (CN/RN) occur on the white dwarf component of a close, or not so close, binary system. They participate in the cycle of Galactic chemical evolution in which grains and metal enriched gas in their ejecta are a source of heavy elements for the ISM. Once in the diffuse gas, this material is ultimately incorporated into new regions of star formation. TCrB is a Symbiotic Recurrent Nova (SyRN). It consists of a massive white dwarf (WD) orbiting a red giant (M3-M4 III) with an orbital period of ~227.6 days (Anupama 2008). TCrB had possible outbursts in 1217 and 1787 (Schaefer 2023), and recorded outbursts in 1866 and 1946. Based on its current behavior, it is likely that it will explode again shortly. A distinguishing feature that separates TCrB from the other SyRNe (except for RT Cru) is that it exhibits hard X-ray emission (Kennea et al. 2009). Highlighted here are results of a new study with NOVA (Starrfield et al. 2025), a one-dimensional, fully implicit, hydrodynamic code that incorporates a new major change to the initial WD structure for massive WDs ($M_{wd} \geq 1.35\, M_{\odot}$). This update includes both improved equations of state (EOS) and the incorporation of general relativity (GR) (Althaus et al. 2023). We employ five different compositions of accreted matter with an initial WD luminosity of $10^{-2} L_{\odot}$ and an $\dot{M}$ that result in a WD TNR on ≈ 80yrs time scales appropriate for the T CrB system. The evolutionary results of accretion onto 1.35 $M_{\odot}$ WD with 3 different radii were considered for both of carbon-oxygen and oxygen-neon core compositions.

T CrB Key Simulations Insights:

- The oxygen-neon GR radius results in simulations that produce more explosive events resembling the observed outburst of T Crb; however, the predicted peak ejecta velocities of ~ 3600 km/s are lower than the ~ 5000 km/s reported from photographic estimates of the 1946 outburst.
- The oxygen-neon GR radius results in simulations that predict more ^{13}C is produced than ^{12}C, however, to our knowledge there are no observations of CN in the ejecta, and we suggest that the ejected material mixes with a large amount of material surrounding the WD and the binary system.
- Evolving the WD after the ejected matter has been removed from the simulations results in extremely high predicted luminosities ($L > 10^5 L_{\odot}$) and effective temperatures ($T_{eff} \geq 2{\times}10^6 K$). Two of our simulations result in evolution times that are close to those predicted by Munari (2023b).
- T CrB (< 1 kpc distant) will become, for a short time, the brightest nova ever observed in the X-rays, hence an excellent candidate for detailed Swift investigations.

References: Althuas, L. G. et al. 2023, MNRS 523, 4492; Anupama, G.C. 2008, PASP Conf. Series 401, 31; Kennea, J. A. et al. 2009, ApJ 701, 1992; Lodders, K. 2021, SSRv 217, 44; Munari, U. 2023a RNASS 7, 145; Munari U. 2023b, RNASS 7, 251;Pepin, R. O. et al. 2011, ApJ 742, 86; Schaefer, B. E. 2023, J. Hist. Astron. 54, 436; Starrfield, S. et al. 2025, arXiv250210925S



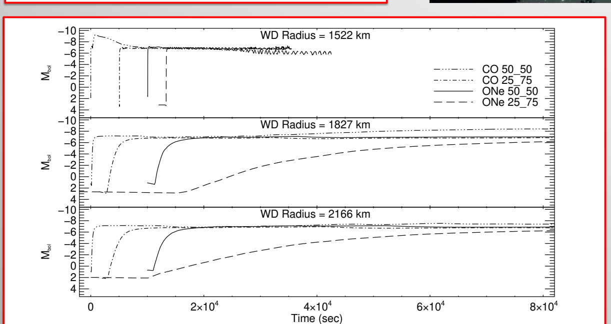
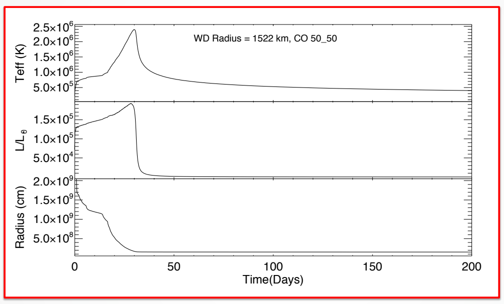


Figure 1. An apparently unique aspect of the T CrB light curve is the second maximum that occurs about 100 days after the initial outburst as illustrated above (adopted from Munari 2023a). The cause of the second maximum is still unexplained, although it has been suggested that this is caused by the radiation from a cooling WD (~2 × 10⁵ K to ~1 × 10⁵ K over a 150-day interval) reflecting off the red giant companion. We test this theory by following the evolution of just the WD after the ejected matter is removed from the 1-D hydrodynamic NOVA simulation. The simulated light curve is shown in the bottom panel that shows the time variation of the absolute bolometric magnitude as a function of WD mass. The oscillations are real.



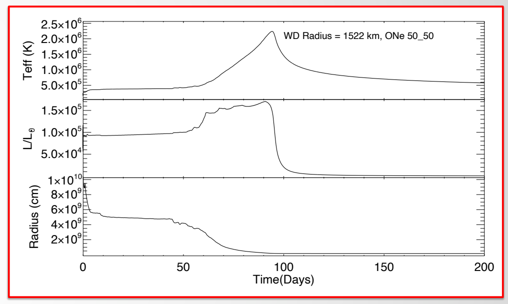
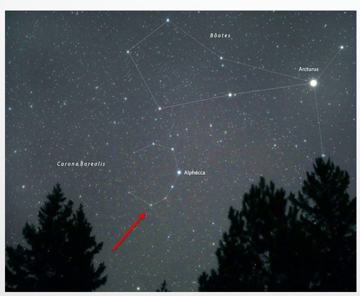


Figure 2. The evolution (1522 km WD simulations) of the effective temperature, the luminosity, and the radius (cm) of the surface layers of the remnant WD after the removal of the ejected matter. They are all for the same initial WD radius but for each of the 2 mixed compositions (as given in the plot insert). They show that the surface conditions are relatively constant for a short time (days to weeks depending on the conditions) and then as the hydrogen burns out the radius begins a decline, the luminosity and effective temperature increase, and then decline.



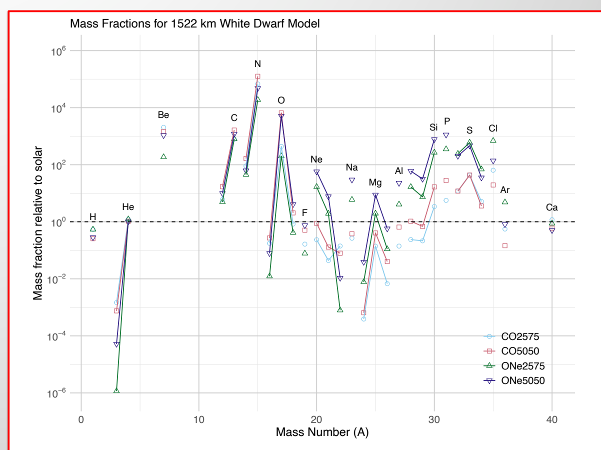


Figure 3. The abundances of the stable isotopes from hydrogen to calcium (plus ^{7}Be) in the ejecta for the 1522 km WD simulations. The x-axis is the atomic mass, A, and the y-axis is the logarithmic ratio of the isotopic abundance divided by the solar abundance (Lodders 2021). ^{7}Be is included in this plot because of its large overproduction. All isotopes of a given element are connected by solid lines. We plot the results for all four mixed compositions indicated in the legend. Several light, odd isotopes are significantly enriched in the ejecta. The large depletion of ^{3}He is shown and was used, in part, by Pepin et al. (2011) to identify ONe nova grains in anomalous interplanetary particles. In virtually all cases the simulations predict an abundance of ^{13}C exceeds that of ^{12}C, ^{15}N exceeds ^{14}N and ^{17}O exceeds ^{16}O. Determination of the $^{12}C/^{13}C$ ratio during the imminent eruption of T Crb will be crucial to constraining hydrodynamical simulations of the outburst.