A Multi-wavelength Study of the Close M-dwarf Eclipsing Binary System BX Tri

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Abstract. We present the first detailed X-ray study of the close dMe binary system BX Tri, whose optical variation has been continously monitored in the frame of the DWARF project (Pribulla et al.(2012)). We observed BX Tri with XMM-Newton for two full orbital periods and confirm that the system is an ultra-active M-dwarf binary showing frequent flares and an X-ray luminosity close to the saturation limit. The strong magnetic activity could have influenced the angular momentum evolution of the system via magnetic braking.

1. BX Tri – Scientific motivation

BX Tri is the closest known eclipsing M-dwarf binary with a period of only 0.19 days and a separation of $1.22 \pm 0.04\ R_{\odot}$. It consists of two M-dwarfs with effective temperatures of $T_1 = 3735 \pm 10$ K and $T_2 = 3106 \pm 10$ K and masses of $M_1 = 0.51\ M_{\odot}$, $M_2 = 0.26\ M_{\odot}$ (Dimitrov and Kjurkchieva(2010)). Due to the tight orbit, the two components of BX Tri are tidally locked and therefore fast rotators, which are expected to be highly active.

Short-period binary systems are extremely interesting from the point of view of angular momentum evolution. It is believed that such systems form at much larger distances with longer periods and develop into the presently observed ultra-short binaries only in their further evolution (Maceroni & Montalbán(2004)). This implies an efficient mechanism of angular momentum loss, likely related to magnetic activity, since gravitational radiation from these systems is far too weak at this evolutionary stage.

2. The DWARF project

The DWARF campaign[1] was initiated in 2012 and is aimed at the detection of circumbinary extrasolar planets around low-mass eclipsing binaries using eclipse timing. The observations are performed within an extensive network of telescopes with apertures of 20-200 cm. The target sample contains (i) low-mass eclipsing binaries with M and K components, (ii) short-period binaries with sdB or sdO component, and (iii) post-common-envelope systems containing a WD. Since the amplitude of the timing signal increases with the orbital period of a hypothetical third component, the timescale of the project is long, at least 5-10 years. So far, more than 1000 minima timings have been acquired.

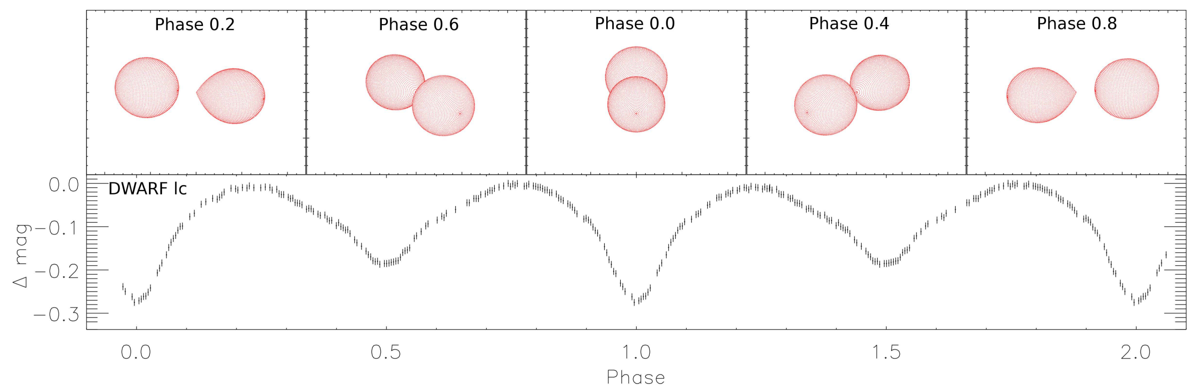

Figure .1: Optical light curve of BX Tri obtained in the course of the DWARF project (bottom) and the phase-dependent system geometry computed with the *Nightfall*-algorithm written by R. Wichmann (top).

3. Results

The (phased) optical DWARF light curve (fig. 1) shows pronounced primary and secondary minima, with the former causing a 0.25 mag (i.e., 40%) drop in flux. The primary minima are clearly seen in the UV light curve (see inlets in fig. 1) pointing towards substantial plage surface coverage. In contrast, the X-ray light curve does not show any distingishable eclipse modulation, which may be the result of an extended corona or a disadvantageous distribution of coronal plasmas.

Our analysis of the X-ray spectrum confirms BX Tri to be a highly active stellar system showing a mean X-ray luminosity of 1.5×10^{29} erg/s yielding $L_X/L_{bol} = 6.4 \times 10^{-4}$ close to the saturation limit. The UV light curve (fig. 2, top panel) shows two pronounced flares and a couple of minor events lasting for ≤ 30 min, which are echoed in the X-ray light curve with extended duration. This is characteristic of the X-ray emitting material filling the coronal loops.

[1]For more information visit *http://astronomy.science.upjs.sk/projectdwarf/*.

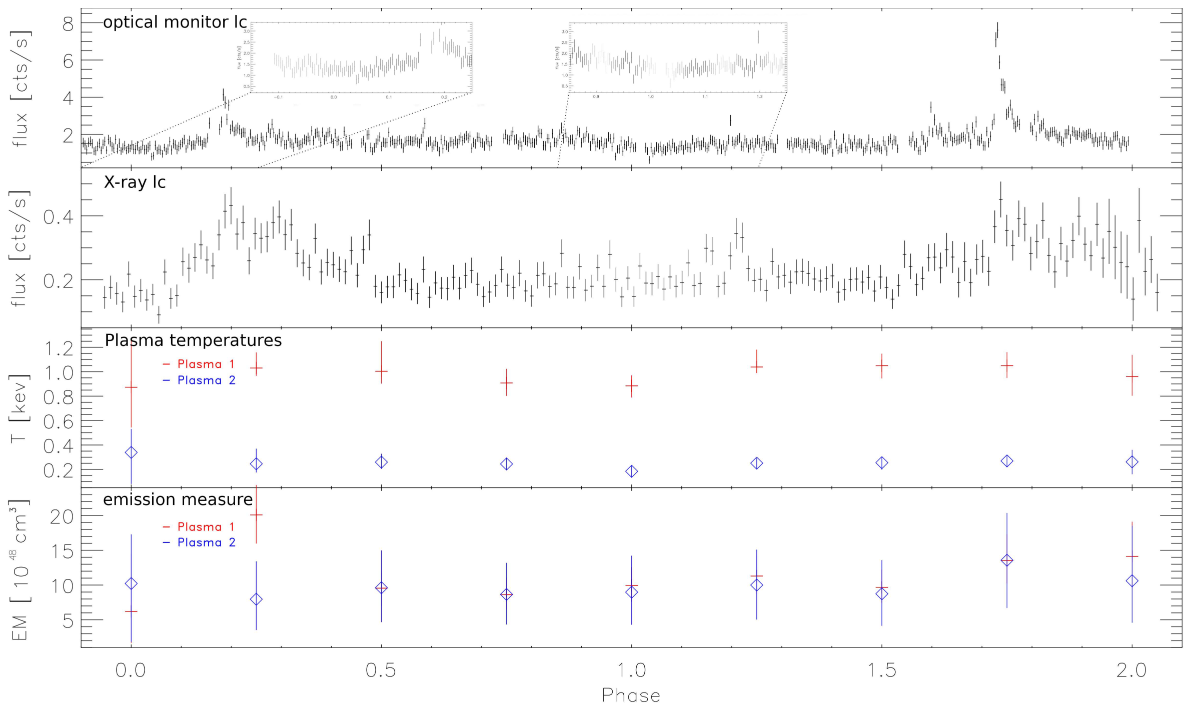

Figure .2: XMM-Newton observations of BX Tri. The upper panel shows the light curve acquired with the optical monitor using the UVW1 filter ($\lambda_{eff} = 291\ nm$), the second panel shows the coronal light curve in the range $0.2 - 1.4$ keV and the last two panels show the variation in plasma temperature and emission measure derived with time-resolved spectroscopy.

To study phase-dependent coronal variations, we carried out time-resolved spectroscopy by binning the data into 9 intervals. Individual spectra were fitted with an absorbed two-component thermal model. The corresponding plasma temperatures and emission measures of the best-fit models are plotted in the two bottom panels of fig. 2. The first flare is clearly seen as a moderate increase in coronal temperature and a doubling of the emission measure of the hot component. Additionally, we find a tentative periodic modulation in the hot plasma temperature in phase with the orbital motion, whose reality has yet to be confirmed.

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References

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