Optical Monitoring of the Black Hole X-ray Binary, XTE J1118+480

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Abstract

We present results from the long-term optical monitoring (in V, R and i' bands) of the Black Hole X-ray Binary (BHXB), XTE J1118+480 using the 2-metre Faulkes Telescope North (Haleakala, Hawaii). This is one of the 35 XRBs currently being monitored (http://www.faulkes-telescope.com/xrb; see Lewis et al., 2008, arXiv:0811.2336).

The flexibility of our monitoring campaign allows us to alter the cadence of our observations in response to ATels, outbursts or state transitions. We show that the long-term (~ 5 years) variability of XTE J1118+480 can be accounted for by just the variability of its (orbital) ellipsoidal modulation. We also show that the system is bluer when brighter, commensurate with emission from a blackbody, most likely the donor star.

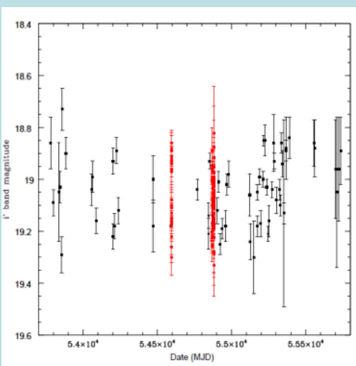

Fig. 1 Long-term FT i' band light curve. In red, we plot the range of values from the three dates as shown in Fig. 2.

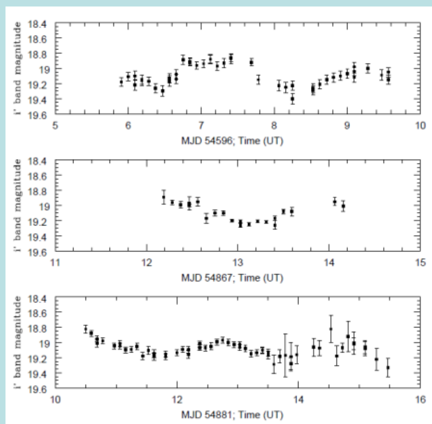

Fig. 2 Short-term FT i' band light curves.

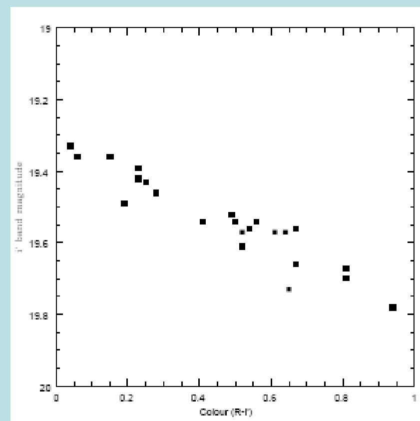

Fig. 3 Colour magnitude diagram showing (R-i') against i'.

The transient Galactic halo BHXB, XTE J1118+480 (= KV UMa) was discovered in outburst (lasting ~ 7 months) using RXTE in 2000 March (Remillard et al., 2000). Its orbital period is 4.04 hours (Patterson et al., 2000, Uemura et al., 2000a) with a distance of 1.72 ± 0.10 kpc. It is above the plane of the Galaxy (with a galactic latitude, b = + 62º) and therefore a very low interstellar extinction of E(B-V) = 0.024 (Garcia et al., 2000). Together with its prodigious proper motion (~ 145 km s^{-1}; see Mirabel et al., 2001), this suggests that it may have formed within and was subsequently kicked out of a globular cluster (Fragos et al., 2009). Radial velocity measurements of the secondary yielded a mass function of 6 solar masses (McClintock et al., 2001), further refined to a black hole mass of ~ 8.5 ± 0.6 solar masses by Gelino et al. (2006). The companion has been identified as a K5 – K7V star (Gonzalez Hernandez et al., 2008). At discovery, the system's magnitude was V ~ 13 (Uemura et al., 2000b), and during its 2005 outburst, R ~ 13 (Kiziloglu et al., 2005), its quiescent magnitude is V ~ 19 (Uemura et al., 2000b).

McClintock et al. (2001) discovered a double-humped optical variation, consistent with ellipsoidal modulation. Its initial outburst consisted of a peak followed by a decay towards quiescence of ~30 days and then a return (within ~ 20 days) to a 'plateau' for a further 5 months, remaining entirely in the low/hard state throughout (Chaty et al., 2003, Brocksopp et al., 2004). Its second outburst was in 2005, initially seen at optical wavelengths (Zurita et al., 2005), later confirmed using radio (Pooley, 2005) and X-ray (Remillard et al., 2005) observations. The source remained in the low/hard state, but in this outburst it faded back to quiescence over one month, with no 'plateau', although there was evidence for one re-flare event (Chou et al., 2005). This outburst was followed by a multi- wavelength campaign from radio – X-ray and saw a delayed optical fade relative to that of X-ray as well as providing evidence for both jet and disc emission from the system (Maitra et al., 2009, Brocksopp et al., 2010). To date (2012 March) no further outbursts have been seen.

Much of the data shown in this work was collected by schools and other FT educational users in the 'real-time' mode, for which we are extremely grateful. The long-term light curve (Fig. 1) shows ~ 5 years observations, and includes (in red) data from the short-term studies. The data suggest that the source has not exhibited any variability which cannot be accounted for by orbital modulation alone. Fig.2 displays three short-term light curves taken over 4-5 hours, each of which shows both ellipsoidal and orbital modulation, consistent with the known orbital period of the system. We show the object's 'colour' by plotting the (R-i') index in a form of colour-magnitude diagram against i' magnitude in Fig. 3. A correlation between colour and brightness was seen, consistent with blackbody heating such as that of the donor star.

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