Long Term Optical Photometry of the Black Hole Binary J1118+480

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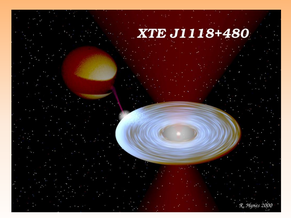

Fig 1. Rendition of XTE J1118+480 in outburst.
Credit: R. Hynes

Abstract

The black hole LMXB J1118+480 was observed using the Argos photometer on the 2.1-m telescope of McDonald Observatory on 30 nights from 2004 to 2012. Integration times were 10s and a broad-band (BVR) filter was used. All the light curves display a two-humped orbital modulation that has been interpreted as ellipsoidal variations. In addition, flickering is observed predominately during the bright phases of the orbital variation. The bright phase intensity and flickering variability is found to change from run to run over the course of our observations while both minima in the ellipsoidal variations remain relatively constant. High quality light curves covering many full orbital cycles and a baseline of eight years allow for an improved orbital ephemeris.

Introduction

The black hole binary XTE J1118+480 was first discovered with the Rossi X-Ray Timing Explorer (RXTE) All-Sky Monitor (ASM) when an outburst was detected on March 29, 2000 by Remillard et al. (2000). Cook et al. (2000) derived an orbital period of 0.1706(9) from five nights of photometry. Later in 2004, Torres et al. (2004) gave an orbital period of 0.1699339 ± 0.0000002 day using spectroscopic observations.

New Long Term Ephemeris

$$HJD_{min} = 2455978.8738(45) + 0.16993379(^{+50}/_{-10})E$$

The zero point of the ephemeris is defined as the primary minimum of the light curve.

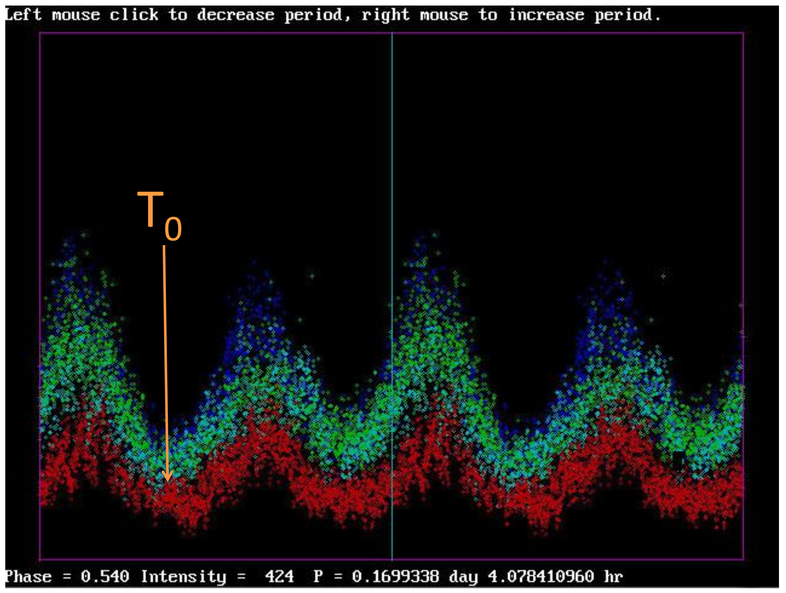

Fig 2. Phased light curves from 4 nights showing a gradual fading from 2004 (dark blue), 2005 (light green), 2010 (light blue), and 2012.(red).

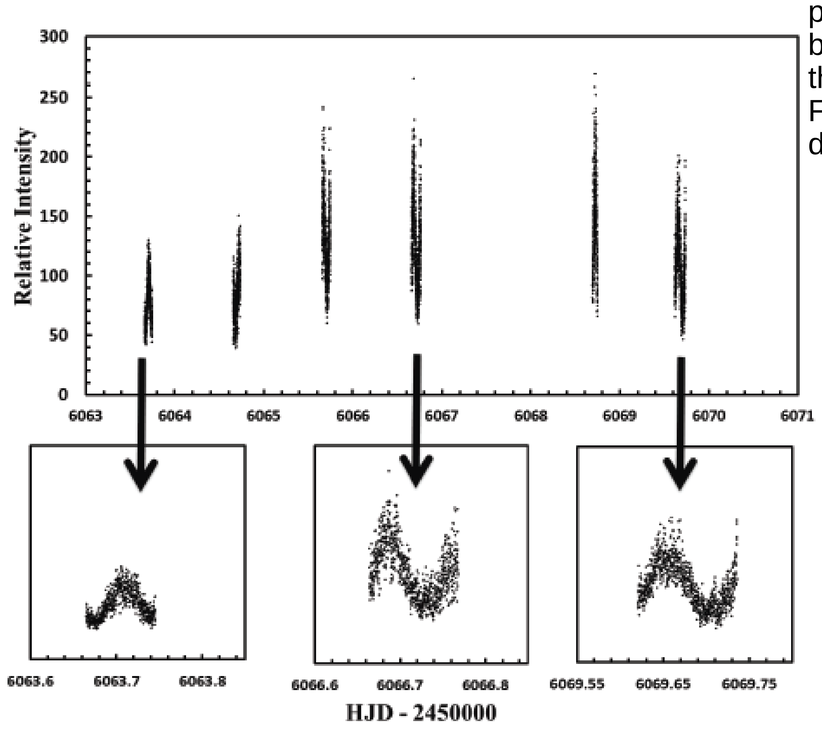

Fig 3. Light curves from 6 nights in Feb. 2012 are shown. The increase of brightness from the 2nd to 3rd nights, in the upper plot, coincided with an increase in amplitude and flickering as seen in the lower close-ups.

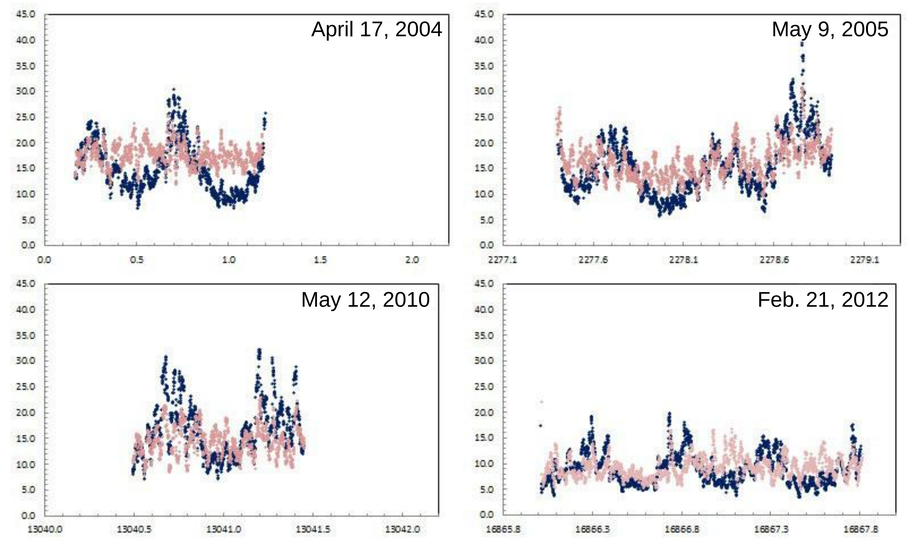

Fig 4. Optical variability of J1118+480 is shown two different ways. The dark blue plots are running standard deviations of 25 photometry points, the same light curves in Figure 2. The light pink curves are the standard deviation – the blue curve – divided by the average of the 25 10-second photometry points. Notice that the blue curves looks very similar to the light curves shown in Figure 2. However, the variability flattens out (pink curves) when divided by the mean intensity.

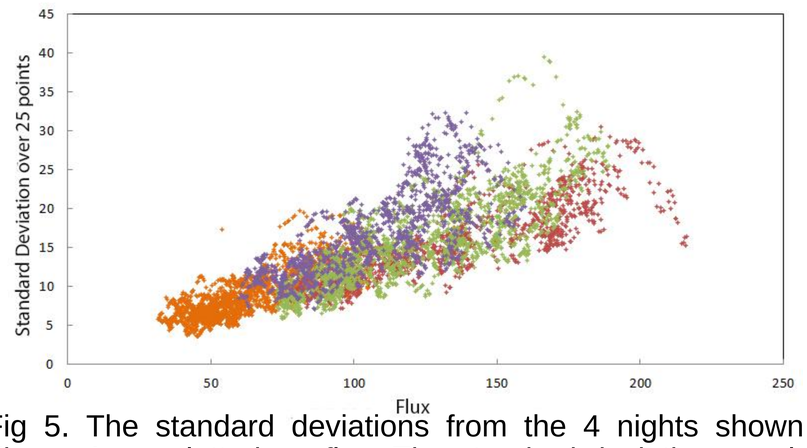

Fig 5. The standard deviations from the 4 nights shown in Figure 4 are plotted vs. flux. The standard deviations evolved from the middle of the diagram towards the bottom left corner over time, indicating a gradual decrease in flickering as well as flux. They are color coded as follows: 2004 (red), 2005 (green), 2010 (purple), and 2012 (orange).

Discussion and Results

The flickering is evidence for continued mass transfer in the system (Figure 3). The lack of detectable X-ray flux from J1118+480 means that most of transferred mass is retained in the outer accretion disk and not flowing down to the inner accretion disk. The strong and immediate correlation between the flickering amplitude and the mean flux at optical wavelengths shows that most or all the accretion-induced optical flux (as opposed to the flux from the secondary star) is being generated locally in the outer disk. Again, this is evidence that most of the transferred mass is being retained in the outer disk. This behavior is expected in the disk instability model for X-ray transients. Finally, the mass transfer is clearly distorting the ellipsoidal variations since the asymmetric and rapidly-variable orbital light curve cannot be produced by pure ellipsoidal variations. Furthermore, the amount of mass transfer and the amount of distortion varies strongly on time scales as short as one day. This work is supported by the NSF/PAARE grant No. 0958783.

References

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