Populations of High Energy Sources in Galaxies
Proceedings IAU Symposium No. 230, 2005
E. J. A. Meurs & G. Fabbiano, eds.

doi:10.1017/S1743921306007812

Long-term activity of the Rapid Burster

Vojtěch Šimon[1]

[1]Astronomical Institute, Academy of Sciences of the Czech Republic, 251 65 Ondřejov, Czech Republic

Abstract. The recurrence time $T_{\rm C}$ of outbursts of the remarkable and unique system, the Rapid Burster (MXB 1730–335), observed by *ASM/RXTE*, is analyzed by the method of the O–C residuals. The variations of $T_{\rm C}$ are large and occur all the time, but generally they are not chaotic; the mean value of $T_{\rm C}$ is 160 days between the years 1996–2005 but a large shortening of $T_{\rm C}$, accompanied by a large decrease of the maximum intensity $I_{\rm max}$ and the relative energy RE (energy output) of most outbursts, occurred in this interval. The outbursts are found to display a correlation between RE and $I_{\rm max}$, but no correlation with the outburst duration. The observed behaviour is discussed in terms of the thermal instability of the accretion disk. A comparison of this prototype with other neutron star soft X-ray transients, like Aql X-1 and 4U 1608–52, helps us find the common links in the disk behaviour in such systems.

Keywords. accretion, accretion disks, instabilities, binaries (including multiple): close, circumstellar matter, stars: dwarf novae, stars: neutron, X-rays: binaries

1. Introduction

MXB 1730–335 (Rapid Burster, RB) is a remarkable system, discovered in 1976 (Lewin *et al.* 1976). Two types of X-ray bursts are observed during the outbursts of the RB: Type I – thermonuclear runaway of the accreted matter on the neutron star (NS), and Type II – spasmodic accretion (e.g. Lewin *et al.* 1995). The RB is a prototype of a group of such systems and is the only one which displays both types of burst. The outbursts of the RB (e.g. Masetti 2002) are similar to those of soft X-ray transients (SXTs) (see e.g. Chen et al. 1997). Outbursts of SXTs are attributed to the thermal instability of the accretion disk (similar to that in dwarf novae), modified by the irradiation of the disk (e.g. Dubus *et al.* 2001).

2. Data source, analysis, results

The 1.5–12 keV sum band daily means of observations from the All Sky Monitor (ASM) onboard *RXTE* (Levine et al. 1996) (`http://xte.mit.edu`) were used. The method of the O–C residuals (e.g. Vogt 1980, Šimon 2000) was applied. It enables us to determine $T_{\rm C}$ and study its variations. Typical error with which the maximum of outburst can be determined is about 1–2 days (much smaller than the recurrence time $T_{\rm C}$ of outbursts).

It emerges that the variations of $T_{\rm C}$ of outbusts of the RB are large, but generally not chaotic. The method of the O–C residuals reveals that $T_{\rm C}$ varies all the time; the O–C curve displays a more complicated profile of the variations of $T_{\rm C}$ than found by Masetti (2002). We find that the variations of $T_{\rm C}$ in the RB are quite similar to those of the outbursts in the NS SXTs Aql X-1 and 4U 1608–52 (Šimon 2002a, Šimon 2004) and in dwarf novae (e.g. Vogt 1980, Šimon 2000, Šimon 2002b). The prevailing long-term trend in the O–C diagram for the outbursts of the RB shows that the individual outbursts are really dependent on each other. This suggests that there remains a relatively large amount of matter in the disk after every outburst. The "clock" governing the length

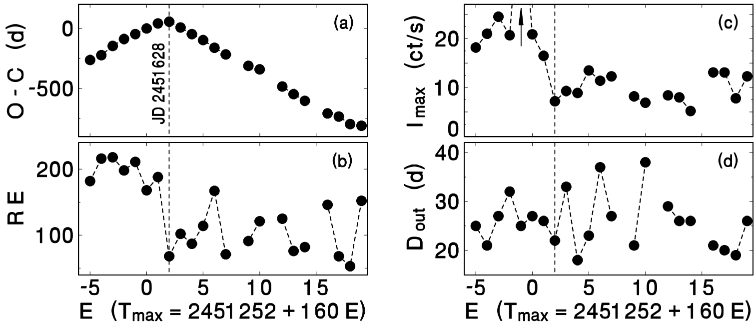

Figure 1. **(a)** O–C diagram for the moments of the outburst maxima. Time is expressed in epochs E. The long vertical line denotes the moment of the shortening of T_C. **(b)** Variations of the relative energy RE (integration of the outburst light curve (in dimensionless units)). **(c)** Maximum intensity I_{max} of outburst. **(d)** Outburst duration D_{out}.

of T_C appears to reside in the outer regions of the disk; this situation appears to be analogous to that of Aql X-1 and 4U 1608–52 and enables us to put the RB to the context of NS SXTs. A remarkable change of the O–C curve (shortening of T_C) around JD 2451628 was accompanied by an abrupt and large drop of both I_{max} and RE (Fig. 1). This suggests that the amount of matter accreted during the outburst around JD 2451628 was considerably smaller than in the previous events, and also smaller than in most subsequent events.

I_{max} of outbursts of the RB fluctuates less than RE, which suggests that the density of matter arriving to the NS fluctuates less than the total amount of matter accreted during a given outburst. The mean outburst duration D_{out} remains almost unchanged prior to and after JD 2451628, only considerably larger fluctuations appeared – this suggests that the time interval given by the propagation of the heating front and the cooling front (plus a possible state when the whole disk is in the hot state near the maximum of outburst) does not change considerably. The time averaged mass inflow from the donor star appears to remain unchanged because the relation RE/T_C is almost the same prior to and after JD 2451628. An increase of the disk viscosity may be a more plausible explanation than the variations of the mass outflow from the donor.

Acknowledgements

This research has made use of the observations provided by the *ASM/RXTE* team. This study was supported by the grant 205/05/2167 of the Grant Agency of the Czech Republic and the project ESA PRODEX INTEGRAL 14527.

References

Chen, W. *et al.* 1997, *ApJ* 491, 312
Dubus, G. *et al.* 2001, *A&A* 373, 251
Levine, A.M. *et al.* 1996, *ApJ* 469, L33
Lewin, W.H.G. *et al.* 1976, *ApJ* 207, L95
Lewin, W.H.G., *et al.* 1995, *in X-ray Binaries*, Cambridge Univ. Press, p. 175
Masetti, N. 2002, *A&A* 381, L45
Šimon, V. 2000, *A&A* 354, 103
Šimon, V. 2002a, *A&A* 381, 151
Šimon, V. 2002b, *A&A* 382, 910
Šimon, V. 2004, *A&A* 418, 617
Vogt, N. 1980, *A&A* 88, 66

https://doi.org/10.1017/S1743921306007812 Published online by Cambridge University Press