# 21st century observations of AX J1745.6−2901 and GRS 1741.9−2853 in the Galactic Centre

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Abstract

We here present the results of the X-ray observations of two X-ray binaries, an eclipsing X-ray burster AX J1745.6−2901 and a recurrent X-ray burster GRS 1741.9−2853, in the Galactic Centre Region, conducted with *XMM-Newton*, *Swift* and *INTEGRAL*. We have detected AX J1745.6−2901 with *XMM-Newton* in its outburst in 2007, identifying seven eclipses with the period of 8.4 hours, as well as one type-I X-ray burst. We have also found pseudo-periodical dipping natures in the light curve roughly 4000 seconds prior to each eclipse, though seen only in 5 cases out of 7 eclipses. Based on the spectral and timing natures, we conclude that those dips are likely to be caused with lumps of materials with each size of $< 10^8$ metres at the inner edge of the accretion disk. From GRS 1741.9−2853 we have detected 15 type-I bursts in total, during its outburst with the luminosity of $10^{36}$ to $10^{37}$ erg s$^{-1}$, while we detected no burst during its quiescent state for 2.8 Ms exposure with *INTEGRAL*. The characteristics of the observed bursts suggest pure helium explosions.

Key words: X-ray: sources — X-ray: binaries — Eclipse

## 1. Introduction

The Galactic Centre Region is the home of X-ray transients, most of which are type-I bursters, *i.e.*, low-mass X-ray binaries. Among those AX J1745.6−2901 (identified as CXOGC J174535.6−290133) is one of the most peculiar, which showed both eclipses and type-I X-ray bursts (Maeda et al. 1996, Sakano et al. 2002). It was detected in three occasions between 1993 and 1997, but became quiescent since then until it was rediscovered with *Suzaku* and partly with *Chandra* in 2005 and 2007 (Hyodo et al. 2009).

GRS 1741.9−2853 is another burster in the region, which was first discovered in 1990 in its high state and has been detected several times with various satellites since then (Trap et al. 2009).

## 2. AX J1745.6−2901

### 2.1. Results

During the three *XMM-Newton* observations between 30 March and 4 April 2007, we have detected 7 eclipses with the period of 8.4 hours. We have also found deep dip structures in the light-curves prior to 5 of these eclipses (Fig. 1), thus confirmed the discovery by Hyodo et al. (2009).

The dip structures are highly irregular with a rapid variability with the timescale of ∼1 ksec. When the dip was the deepest, the emission was as low as the eclipse, where the remaining emission is well explained with the dust scattering by the interstellar materials towards the Galactic Centre Region (Maeda et al. 1996). The structures of the dips also vary from one to another. As an example, Fig. 1 demonstrates that the dip prior to the first eclipse is the deepest, the one prior to the second eclipse is roughly half in depth, and that there is no apparent dip prior to the third eclipse. We also found that there was no apparent dip 5 periods before the first eclipse in Fig. 1 and that there were a series of full-scale dips 4 periods after the last eclipse in Fig. 1.

The X-ray spectrum in the persistent emission[1] is consistent with the previous results (Maeda et al. 1996, Hyodo et al. 2009), which has, when approximated with a simple absorbed power law, a photon index Γ and column density of $\sim 2.5$ and $\sim 2.2 \times 10^{23}$ H cm$^{-2}$, respectively, for the observed 2–10 keV flux of $\sim 1 \times 10^{-10}$

*1 We used the annular region to accumulate the spectrum to avoid the pile-up effects.

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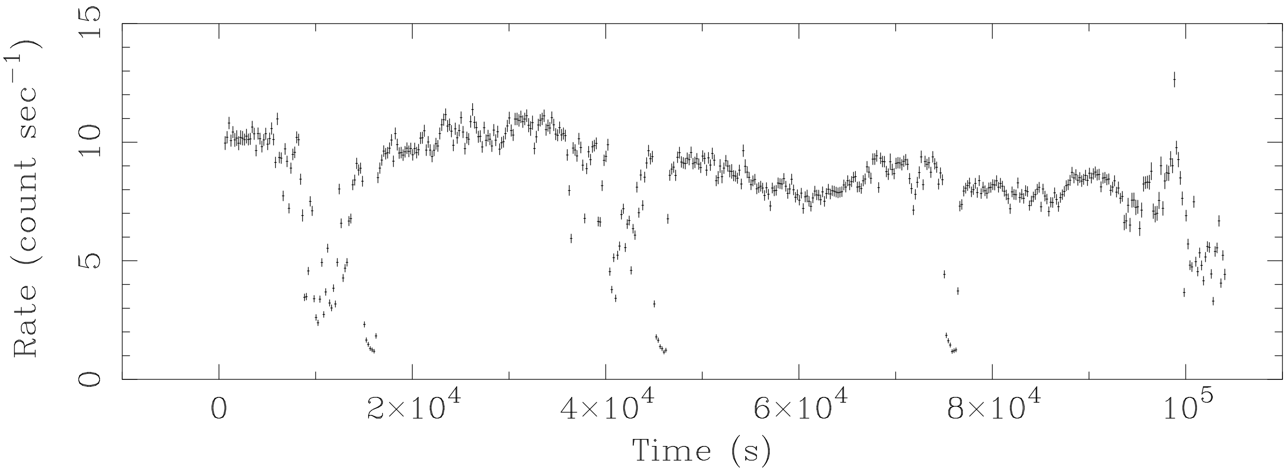


Fig. 1. Background-subtracted light-curve of AX J1745.6−2901 with *XMM-Newton*/pn. The X-axis starts at MJD 54191.6324138, whereas the bin size is 200 sec. Pile-ups are not corrected. Three eclipses are seen, the first two of which are associated with the prior anomalous and deep dipping structures, whereas the last one shows no apparent dip before or after it.

erg $s^{-1}$ $cm^{-2}$. On the other hand, the spectra during the dips were found to show the similar index but heavier absorption. We confirmed the existence of an iron absorption-line at 6.7 keV (Hyodo et al. 2009), which is deeper during the dips.

### 2.2. Discussion

The rapid change of the dips, which can disappear in two periods, suggests that it is likely to be caused with something in the inner edge of the accretion disk. For example a precession of the accretion disk at its inner edge could cause this. Although this sort of appearance and disappearance of dips are often seen in other dipping compact sources, the rapid timescale of 2 periods or 17 hours is rather extreme.

Given a large change of the flux while the spectral index was stable, the apparent dips must be a result of blockage of the incoming X-rays. Partial-covering absorption must be therefore appropriate, as suggested by Hyodo et al. 2009.

We have estimated the upper-limit of size of the lump, which causes the absorption for dips, based on the orbital period and timescale of the variability ($\sim$1 ksec), to be $< 10^8$ m. Considering the fact that it sometimes causes almost complete blockage of X-rays, its column density should be $\geq 10^{24}$ H $cm^{-2}$. Hence the averaged density of the lump should be extremely large, $n_H \geq 10^{14}$ H $cm^{-3}$.

## 3. Results and discussion on GRS 1741.9−2853

We analysed the *INTEGRAL*/JEM-X data for its 2626 individual observations, which points the Galactic Centre in every spring and autumn since October 2002. GRS 1741.9−2853 was detected in two periods, February to April 2005 and February to April 2007, as well as four and seven type-I bursts, respectively. We also analysed 11 and 3 observations with *XMM-Newton*/pn and *Swift*/XRT, respectively, between February 2002 and March 2008. Whenever a burst is detected, it was found to be during the outburst, in which the X-ray luminosity is $> 10^{35}$ erg $s^{-1}$, whereas the quiescent luminosity is $\leq 10^{32}$ erg $s^{-1}$.

The spectral parameters of the persistent emission during the outburst for the unabsorbed 2–8 keV flux of $(1 - 14) \times 10^{-11}$ erg $s^{-1}$ $cm^{-2}$ were found to be almost stable from observation to observation, and were consistent with the past observations (Sakano et al. 2002). So was the upper-limit of the distance, $\sim$7 kpc, derived from the peak luminosity of the brightest burst that we have observed.

Based on the observed fluence of the bursts for the distance of 7 kpc and for the standard neutron star parameters of mass and radius, the theoretical recurrence times of the bursts for the pure helium composition are estimated to be 0.2–5.1 days, whereas it is shorter for the hydrogen-rich mixed burst, for example, it is $\sim$0.3 days for the *XMM-Newton* bursts for the solar composition (see Trap et al. 2009 for detail). Hence the latter case is rejected from our results. The relatively short timescales of our observed bursts, $\sim$10 sec, also support the case for the pure helium burning in the bursts. Therefore we conclude that unstable pure helium fusion matches the observations well in GRS 1741.9−2853.

### References

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