A failed outburst of H1743−322

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ABSTRACT

We report on a campaign of X-ray and soft γ-ray observations of the black hole candidate (BHC) H1743−322 (also named IGR J17464-3213), performed with the RXTE, INTEGRAL and Swift satellites. The source was observed during a short outburst between 2008 October 03 and November 16. The evolution of the hardness–intensity diagram throughout the outburst is peculiar, in that it does not follow the canonical pattern through all the spectral states (the so-called q-track pattern) seen during the outburst of black hole transients. On the contrary, the source only makes a transition from the hard state to the hard–intermediate state. After this transition, the source decreases in luminosity and its spectrum hardens again. This behaviour is confirmed by both spectral and timing analyses. This kind of outburst has been rarely observed before in a transient BHC.

Key words: black hole physics – X-rays: binaries – X-rays: individual: H1743−322 – X-rays: individual: IGR J17464–3213 – X-rays: stars.

1 INTRODUCTION

During the outbursts of transient black hole candidates (BHCs), in addition to the large changes in X-ray luminosity, marked variations are observed in the properties of the timing and the energy spectrums often on very short time-scales (see e.g. Belloni et al. 2005). We still do not have a detailed understanding of all the mechanisms that lead to changes in the X-ray emission properties, but the physics involve the structure of the accretion flow around the black hole as well as the connection between the accretion disc and the steady or impulsive jets that can be emitted from these systems. The main cause of the changes in the X-ray emission properties is the variation of the mass accretion rate on to the black hole; however, some phenomena indicate that other parameters are also important (e.g. Homan et al. 2001).

From the observational point of view, the emission properties of accreting black holes are often classified in terms of observed spectral and timing parameters. From their combination, a number of source states have been identified (Belloni et al. 2005; Belloni 2009, for an alternative definition, see Remillard & McClintock 2006).

The high-energy spectra can be described as the combination of a soft thermal component together with a hard power-law component. The latter component often shows a cut-off at high energies (Tanaka & Shibazaki 1996). This decomposition is the simplest phenomenological model. However for the hard component, complex models can be used, as for example the Comptonization models (see e.g. Titarchuk 1985; Poutanen & Svensson 1996). The simplest decomposition is less model dependent and provides at least a qualitative measurement of the behaviour of the source. The power density spectra, used to characterize the fast variability, show a combination of power-law and Lorentzian components. When the Lorentzians are zero-centred, they are referred to as ‘band-limited noise’, while if they are narrow they are called Quasi-Periodic Oscillations (QPO; see e.g. Belloni, Psaltis & van der Klis 2002). Another important observable that can be used to trace source states is the total amount of variability in the 0.1–64 Hz band, expressed in terms of fractional integrated rms (see e.g. Belloni et al. 2005; Homan & Belloni 2005; Belloni 2009).

A BHC spends its time mostly in a quiescent state at low flux level (<10^{32}–10^{33} erg s^{-1}; e.g. Campana, Parmar & Stella 2001). When the outburst begins, the luminosity of the source increases and the X-ray spectrum is dominated by a power-law component with a hard photon index of ∼1.4–1.5 and a high-energy cut-off around 100 keV (low/hard state, hereafter LHS). The radio emission in this state indicates the presence of steady jets, while the power spectrum is dominated by a strong band-limited noise (>30 per cent fractional rms). Then the outburst evolves as the source increases its luminosity and its spectrum starts to change: the soft thermal component appears and becomes increasingly important, the energy peak of the emission softens and the photon index of the hard component steepens (∼2.0–2.5). Two different states with these spectral characteristics have been defined: the hard intermediate state (HIMS) and the soft intermediate state (SIMS). The characteristics of these two states are quite complex: the changes can be established mostly by the timing properties (Homan & Belloni 2005) and also by the ejection of relativistic jets associated with the transition from HIMS

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to SIMS. After the SIMS, the source enters a state where the X-ray spectrum is dominated by the emission of the soft thermal component (high/soft state, hereafter HSS). A non-thermal power-law tail is also present without any detectable cut-off, while the power spectrum is characterized by a low-level (1–2 per cent fractional rms) variability. Then the flux starts to decrease, most likely following a parallel decrease in accretion rate. At some point, a reverse transition is started and the path is followed backwards all the way to the LHS and then to quiescence. As mentioned above, the luminosity level of this back-transition is always lower than that of the corresponding forward-transition. The above description is the basic general pattern [the so-called ‘q-track’ pattern in the hardness–intensity diagram (see Fig. 1); several examples of ‘q-track’ patterns are reported in Homan & Belloni (2005) or in Dunn et al. (in preparation)], which has been modelled after repeated outbursts of GX 339-4 (Fender, Belloni & Gallo 2004; Belloni et al. 2005; Homan & Belloni 2005; Del Santo et al. 2008; Belloni 2009). During the HSS, minor transitions to SIMS and HIMS have also been observed in GX 339-4 (e.g. Casella et al. 2004; Belloni et al. 2005; Del Santo et al. 2009). Other sources behave in a more complicated way, but the general classification into four states holds for all of them (see e.g. Revnivtsev, Sunyaev & Borozdin 2000; Frontera et al. 2001; Chaty et al. 2003; Hynes et al. 2003). Interestingly, until now all black hole transients have shown two types of behaviour: after the initial LHS, most sources show a transition to the HIMS at a luminosity level which is always different and might be related to the previous history of the transient (Yu et al. 2007). If this transition takes place, the source always reached the HSS. However, a few sources (both NS and BHC X-ray binaries) never left the LHS at all as reported, for example by Brockopp et al. (2004) for V404 Cyg, A1524-62, 4U1543-475, GRO J0422+32, GRO J1719-24, GRS1737-21 and GS 1354-64, by Sturze & Shrader (2005) for XTE1550-564 and by Rodriguez, Show & Corbel (2006) for Aql X-1. The only possible exception to this dichotomy is represented by SAX J1711.6-38 (see Wijnands & Miller 2002), a faint transient X-ray binary classified as BHC (Liu, van Paradijs & van den Heuvel 2007).

In this paper, we present the results of the RXTE, Swift and INTEGRAL data analysis of the last outburst of the recurrent transient H1743−322 during which only two states were sampled: the LHS and the HIMS. It is the first time that this kind of outburst is analysed in detail showing that the evolution of the BHC outbursts, through the different spectral states, is still difficult to predict.

1.1 Short history of H1743−322

On 2003 March 21, INTEGRAL (MJD=52719) detected a relatively bright source (~60 mCrab at 15–40 keV), named IGR J17464−3213. The source was localized at RA (2000) = 17°46′3, Dec. = −32°14′4, with an error box of 1.6 arcmin (90 per cent confidence), and then associated with H1743−322 (Markward & Swank 2003; Revnivtsev et al. 2003), a bright BHC observed by HEAO-1 in 1977 with an intensity of 700 mCrab in the 2–10 keV (Doxsey, Bradt & Fabbiano 1977). The outburst evolution of 2003 was followed by RXTE and INTEGRAL reporting strong flux and spectral variability (Parmar et al. 2003; Homan et al. 2005; Capitanio et al. 2005; Joinet et al. 2005).

H1743−322, after the first and brightest outburst, also underwent two fainter outbursts in 2004 September and 2005 September (Swank 2004; Rupen, Mioduszewski & Dhawan 2005; Capitanio et al. 2006). On 2008 January, a third outburst was detected by RXTE/ASM (Kalemci et al. 2008). Then a Swift Target of Opportunity (ToO) was granted in order to follow the source evolution (Capitanio, Del Santo & Bazzano 2008a,b). Seven months later (on September 23, MJD=54732), another outburst was detected by INTEGRAL during the Galactic bulge monitoring (Kuulkers et al. 2008) showing that the source was in a hard state with an increasing flux. Swift, RXTE and INTEGRAL followed the outburst evolution. Furthermore, on October 23 (MJD=54762), an RXTE observation of H1743−322 indicated that the source had undergone a state transition from the LHS to the HIMS (Belloni et al. 2008). The study reported in this paper is focused on the last part of this outburst. Some preliminary results of these observations were already reported in various ATels (see e.g. Ricci et al. 2008 and reference therein), while results on the early phase of the outburst are presented in Prat et al. (2009).

2 OBSERVATION AND ANALYSIS

The RXTE campaign of pointed observations covers the period of the outburst starting from MJD=54740 (2008 October 10) to MJD=54775 (2009 November 5) for a total of 37 pointings with a total exposure time of 65.5 ks. The Proportional Counter Array (PCA) and the High Energy X-Ray Timing Experiment (HEXTE) data analysis was performed with the standard RXTE software within HEASOFT v6.6 following the standard extraction procedure. For spectral analysis, only PCA2 for PCA and cluster B for HEXTE were used. A systematic error of 0.6 per cent (Wilms et al. 2006) was added to the PCA spectra. For the fitting, the energy ranges 3–20 and 20–130 keV were used for PCA and HEXTE, respectively. For the timing analysis of the PCA data, for each of the observations, we produced power spectra from 64-s stretches accumulated in the channel band 0–35 (2–15 keV) with a time resolution of 1/1024 s. The resulting power spectra were then averaged, resulting in one power spectrum per observation. The power spectra were normalized according to the description by Leahy et al. (1983) and converted to squared fractional rms (Belloni & Hasinger 1990; Miyamoto et al. 1991). The contribution due to Poissonian
statistics was subtracted (see Zhang et al. 1995). The timing analysis was performed with custom software.

During the 2008 October outburst, a public INTEGRAL ToO campaign was carried out (Ricci et al. 2008 and references therein). Three observations were performed, respectively, on 2008 October 10 (65 ks, MJD=54749), October 22 (86 ks, MJD=54761) and October 28 (80 ks, MJD=54767), with a total of 136 science windows (SCW) of about 2500 s each (INTEGRAL revolutions 732, 734 and 736). In order to obtain a wider energy range for the spectra, our analysis was focused on ISGRI (Lebrun et al. 2003), the low-energy detector of the γ-ray telescope IBIS (Ubertini et al. 2003). The data of the INTEGRAL spectrometer SPI were not used because of the low angular resolution of the instrument (for details, see Verdenne et al. 2003). For the ISGRI data analysis, we used the latest release of the standard Offline Scientific Analysis (OSA) version 7. The ISGRI energy range considered for the fitting is 20–200 keV with a systematic error of 2 per cent as usual in the INTEGRAL spectral analysis (see also Jourdain et al. 2008). The ISGRI light curve was obtained by extracting the source count rate from the images in the 40–100 keV band for each SCW.

A Swift ToO was also performed with three pointings. We extracted the XRT spectra of the Window-Timing (WT) mode pointings (less affected by pile-up) in order to better constrain the equivalent hydrogen column. The data were processed with the standard Swift tools: XRT software version 0.12.2 and FTOOLS version 6.6.2. Only the second WT mode Swift/XRT observation was performed simultaneously with RXTE and INTEGRAL, and thus it was used to obtain a joint spectrum with the other instruments (see the bottom panel of Fig. 5). The Swift/BAT transient monitor light curve was provided by the Swift/BAT team.

3 RESULTS

3.1 Outburst evolution

The 2008 October outburst of H1743–322 was quite short and fainter than the previous ones (see Fig. 2). In Fig. 3, we show the temporal behaviour of H1743–322 in different energy ranges. For a direct comparison with the previous outbursts of the source, we show in the figure, as an example, also the light curves of the 2008 January outburst. During the 2008 January outburst, the source reached the HSS (Kalemci et al. 2008) showing the standard q-track behaviour as for the previous outbursts of H1743–322 (see e.g. Capitanio et al. 2005, 2006; McClintock et al. 2009). The top and middle panels represent, respectively, the 4–45 keV (RXTE/PCA) and the 20–100 keV (RXTE/HEXTE) light curves. Both curves are binned to a single observation. The bottom panel shows the INTEGRAL IBIS/ISGRI 40–100 keV light curve, binned to an SCW. The first outburst was observed by RXTE only during the return to the quiescent state. The monitoring of the most recent outburst (blue curve) was more complete even though RXTE missed the rising phase of the outburst and its coverage ended before the full return to quiescence. The INTEGRAL monitoring started at the end of the January outburst; a good coverage was only achieved during the October outburst (bottom panel of Fig. 3). Fig. 4 shows the Swift/BAT daily-averaged light curve (15–50 keV) of the two 2008 outbursts of H1743–322.

The Hardness Intensity Diagram (HID) of the two outbursts are compared in Fig. 5: for the first outburst (red curve), the PCA caught the source at the end of the q-track diagram (see Belloni et al. 2005; Belloni 2009), when the energy spectrum of H1743–322 was hardening again through the HIMS, then moving vertically downwards along the LHS branch returning to quiescence. For the second outburst, after the initial LHS rise (missed by RXTE), the source moves horizontally to the left, softening, then jumps to a much softer location, from which it slowly returns to the hard track
Figure 4. H1743−322 BAT daily-averaged light curve, 15–50 keV.

Figure 5. RXTE/PCU2 hardness–intensity diagram (hardness is defined as the ratio of the count rates in the 11–20 keV and 4–10 keV bands) of the two 2008 outbursts of H1743−322. The different symbols of the blue curve are associated with their averaged spectrum of Fig. 7 and Table 1 as follows: filled diamonds for (a), asterisks for (b), open diamonds for (c), triangles for (d), squares for (e), crosses for (f), circles for (g) and ellipses for (h).

along a diagonal path. Clearly, the final hard state is also missed. As shown in Fig. 5, the softest points of the second outburst reach only intermediate values of the hardness (~0.5) that correspond in the previous outburst to the HIMS. This fact is also confirmed by the HEXTE light curve of the two outbursts (see the middle panel of Fig. 3, red and blue curves): the ratio between the PCA and HEXTE fluxes shows that the October outburst is clearly harder than the January one.

3.2 Timing analysis

Fig. 6 shows the hardness–rms diagram for both 2008 outbursts. Also from this figure, it is evident that the October outburst saw the source remaining at a high level of variability, with integrated fractional rms always above 10 per cent. In contrast, in January the sampling of the final part of the outburst started at a low hardness and little variability (around 1 per cent). Together with the HID, this figure suggests that in October the source never left the HIMS.

Inspection of the power density spectra of the October outburst confirms this hypothesis. Band-limited noise is seen in all cases. All observations show a type-C QPO (see Remillard et al. 2002) with the exception of that of October 25 (MJD=54764), the softest of the sample. However, the observations before and after, on October 23 (MJD=54762) and 27 (MJD=54766), show a QPO evolving from 5.6 to 6.7 Hz, with an rms decreasing from 5.5 to 3.1 per cent. The 3σ upper limit for a 6 Hz QPO with the same full width at half-maximum (FWHM) (around 0.4 Hz) for October 25 is 3.3 per cent, which makes the non-detection compatible with neighbouring observations.

From timing analysis, we can conclude that all observations of the October outburst indicate H1743−322 being in the HIMS, a state characterized by the presence of a type-C QPO and intermediate hardness.

3.3 Spectral analysis

We analysed all the RXTE pointed observations in order to study the source spectral behaviour. The data were fitted with a simple model consisting of an absorbed disc blackbody plus a cut-off power-law component. From the analysis of the Swift/XRT data, an equivalent hydrogen column value of $N_H = (1.6 \pm 0.1) \times 10^{22}$ atoms cm$^{-2}$ was derived and in all the other fits the $N_H$ was fixed to the value derived from the Swift data analysis. To account for cross-calibration problems between the three different instruments (PCA, HEXTE and IBIS/ISGRI), multiplicative constants were added to the fits. An emission line with centroid fixed at 6.4 keV was needed to obtain good fits. The relative change of the disc inner radius is derived from the square root of the disc blackbody component normalization constant (for details, see Mitsuda et al. 1984). After a detailed study of each pointing, we averaged the spectra of contiguous observations with consistent spectral parameters. Table 1 summarizes our results, while the unfolded spectra of different groups of observations are presented in Fig. 7. Each spectrum was rebinned with HEASOFT v6.4 tool GRAPHA in order to get an adequate signal-to-noise ratio. Concerning the first group of spectra, (a) in Table 1, the best-fitting model is described by a disc blackbody with an internal temperature of about 1 keV plus a high-energy power-law component with a photon index of about 1.3 and a cut-off of 75 keV. The second group of spectra, (b), is characterized by a softening of the photon index together with the decrease of the 0.1–500 keV flux (see Table 1).

Between the observations (b) and (c), the spectrum changes fast: the cut-off reaches a value of about 100 keV (red curve in Fig. 7). Two days after (spectrum d), the cut-off is no longer detectable; at the same time the photon index becomes softer. The disc blackbody inner radius increases its value by about 70 per cent during the softening while the inner temperature remains constant (see Table 1).

After October 30, the source spectra (e) and (f) harden again: in accordance with the HID, the cut-off is again detectable at about 109 keV. Both the inner radius and the photon index approach values similar to those observed in the first two groups of observations (see...
Table 1. Best-fitting spectral parameters of the seven groups of spectra. INTEGRAL and RXTE commonly fitted spectra are represented by the MJD date in bold.

| ID | Date (mm/dd) | Date (MJD) | $T_{in}$ (keV) | $R_{in}$ (km) | $\Gamma$ | $E_c$ (keV) | FLUX$_{0.1-500}$ (erg s$^{-1}$ cm$^{-2}$) | FLUX$_{2-10}$ (erg s$^{-1}$ cm$^{-2}$) | FLUX$_{10-100}$ (erg s$^{-1}$ cm$^{-2}$) | $\chi^2_{red}$ | d.o.f. |
|----|--------------|------------|----------------|--------------|---------|-----------|-------------------------------|---------------------------------|----------------------------------|----------------|-------|
| (a) | 10/03–10/16 | 54742–54755 | $^{+0.1}_{-0.1}$ | $^{+3}_{-1}$ | $^{+0.03}_{-0.03}$ | $^{+3}_{-3}$ | 1.23 | 1.7 | 8.9 | 1.1 | 96 |
| (b) | 10/17–10/19 | 54756–54758 | $^{+0.1}_{-0.1}$ | $^{+3}_{-1}$ | $^{+0.03}_{-0.03}$ | $^{+3}_{-3}$ | 1.24 | 1.7 | 8.9 | 1.1 | 96 |
| (c) | 10/23 | 54762 | $^{+0.03}_{-0.03}$ | $^{+3}_{-1}$ | $^{+0.03}_{-0.03}$ | $^{+3}_{-3}$ | 1.24 | 1.7 | 8.9 | 1.1 | 96 |
| (d) | 10/25–10/27 | 54764–54767 | $^{+0.03}_{-0.02}$ | $^{+3}_{-1}$ | $^{+0.03}_{-0.03}$ | $^{+3}_{-3}$ | 1.24 | 1.7 | 8.9 | 1.1 | 96 |
| (e) | 10/28–10/30 | 54767–54769 | $^{+0.04}_{-0.02}$ | $^{+3}_{-1}$ | $^{+0.03}_{-0.03}$ | $^{+3}_{-3}$ | 1.24 | 1.7 | 8.9 | 1.1 | 96 |
| (f) | 10/31–11/04 | 54770–54774 | $^{+0.03}_{-0.03}$ | $^{+3}_{-1}$ | $^{+0.03}_{-0.03}$ | $^{+3}_{-3}$ | 1.24 | 1.7 | 8.9 | 1.1 | 96 |
| (g) | 11/07–11/16 | 54776–54786 | $^{+0.01}_{-0.01}$ | $^{+3}_{-1}$ | $^{+0.03}_{-0.03}$ | $^{+3}_{-3}$ | 1.24 | 1.7 | 8.9 | 1.1 | 96 |
| (h) | 11/18–11/19 | 54788–54789 | $^{+0.1}_{-0.1}$ | $^{+3}_{-1}$ | $^{+0.03}_{-0.03}$ | $^{+3}_{-3}$ | 1.24 | 1.7 | 8.9 | 1.1 | 96 |

*Swift/XRT, RXTE/PCA and RXTE/HETXE joint spectrum.

Note: All the errors are at 90 per cent confidence level. $T_{in}$: the inner temperature of the disc; $R_{in} = (R_m / D_{10}) \times \sqrt{\cos(i)}$, where $R_m$ is the inner radius of the disc in km; $i$ is the inclination angle of the system and $D_{10}$ is the distance of the source in unit of 10 kpc; $\Gamma$: power-law photon index; $E_c$: high-energy cut-off; FLUX$_{0.1-500}$: unabsorbed flux extrapolated from the models in the 0.1–500 keV energy range; FLUX$_{2-10}$: unabsorbed flux between 2 and 10 keV; FLUX$_{10-100}$: unabsorbed flux between 10 and 100 keV; $\chi^2_{red}$: reduced $\chi$ square.

Table 1. We show in Fig. 8 (bottom panel) the (f) spectrum fitted jointly with the simultaneous Swift/XRT window timing observations. This spectrum confirms the presence of the disc blackbody component and the fit parameters are all consistent within the errors with the RXTE spectrum (see Table 1). The top and middle panels show, respectively, the (a) and (d) spectra.

At the end of the outburst (spectra g and h), the flux slightly continues to decrease, the inner temperature of the disc still remains unvaried, while it is no more possible to constrain the cut-off. Note, however, that the last INTEGRAL observation that permits to extend the spectrum up to 200 keV was performed in the 2008 October 23 (MJD=54762) (spectrum c). Thus, the spectra taken after October 23 cover only energy range from 3 to 130 keV. This fact limits the possibility to constrain the cut-off for observations after that date.

4 DISCUSSION

At first inspection, the shape of the HID of H1743–322 suggests a normal evolution of the October outburst: (missed) hard state, followed by an HIMS, a fast jump to the soft state (with or without a sampling of the SIMS) and then a return path at lower flux. However, the softest points are only at an intermediate hardness, which, in the previous outburst, for example, corresponded to the HIMS. The hardness is only a rough indication of the spectral shape, and similar states have been seen to correspond to slightly different hardness values even in different outbursts of the same source. Anyway, the lack of soft states is an important fact and possibly suggests that the soft state was never reached. This fact, only supposed by the study of the HID, is confirmed by the results of the timing analysis. The spectral analysis, in accordance with the HID, sampled the softening of the source: the flux of the blackbody component increases and the $R_{in}$ decreases. This means that the disc approaches the last stable orbit, while, curiously, the $T_{in}$ remains substantially unvaried being also quite high for an HIMS.

As far as we know, this is the first time that an outburst, which left the LHS and does not reach the HSS, has ever been studied in detail. Searching for similar cases in the literature, we have found only one outburst comparable with our results, the one of SAX J1711.6–3808 in 2001. This outburst was not covered very densely, but its softest observation showed a power spectrum and a total fractional rms typical of the HIMS, while the slope of the hard part of the energy spectrum hardly reached 2.4 (Wijnands & Miller 2002). Also in this case, we have an HIMS with a relatively high inner-disc temperature as 0.86 ± 0.04 keV (Wijnands & Miller 2002) and a luminosity consistent with the softest state of H1743–322. We conclude that we observed from H1743–322 a failed outburst. In fact, the source, even if softens, never reaches the HSS during the October outburst.

The range in luminosities of hard-to-soft transitions in black hole binaries observed with RXTE is 0.2–1$L_{\text{Edd}}$ (Chen, Shrader & Livio 1997). Interestingly, the lowest transitions, at 0.2$L_{\text{Edd}}$, are those observed from Cyg X-1, which also does not reach very soft spectral hardnesses (see Wilms et al. 2006; Belloni 2009). Similarly, we...
found that the luminosity of the softest state of H1743–322 outburst (spectrum d in Table 1), computed in unit of Eddington luminosity, is $L \sim 0.1 L_{\text{Edd}}$ (considering a mass of $10 M_\odot$ and a distance of 10 kpc as estimated for H1743–322 by McClintock et al. 2009). Although the mass accretion rate is a very important parameter involved in the transition, another parameter seems to be involved in the transition out from the hard state. This second parameter, whose nature is still not clear (Esin, McClintock & Narayan 1997; Homan et al. 2001), drove the October 2008 transition from the LHS to the HIMS. Then probably an accretion rate decrease did not permit to continue the canonical transition pattern to the HSS. This means that the source did not pass the jet-line in the HID (see Homan & Belloni 2005) and probably there was not any jet major ejection (Fender et al. 2004). This was despite the fact that the inner disc radius was seen to decrease and according to the Fender et al. (2004) model, the acceleration of the jet to higher Lorentz factor had already started. The results reported in this paper demonstrate that the processes starting at the beginning of the outburst can be reversible even after the transition to HIMS.

Other cases previously presented in the literature as failed outbursts of transient X-ray binaries are LHS-only outbursts without any sign of state transitions at all (see e.g. Brocksopp et al. 2004 and Sturmer & Shrader 2005). Conversely, the data presented here show that the full pattern (LHS, HIMS, SIMS, HSS) and LHS-only pattern are not the only two possibilities for the temporal evolution of a BHC outburst.

The 2008 October outburst of H1743–322, showing only LHS and HIMS, takes place at low luminosity ($L \sim 0.1 L_{\text{Edd}}$) and the lack of soft-state transitions is probably connected to a premature decrease of the mass accretion rate. Again, this brings us back to one of the major problems for the interpretation of the spectra/timing evolution of the outbursts: what physical parameter determines the transitions starting from the low hard state.

**ACKNOWLEDGMENTS**

This work has been supported by the Italian Space Agency through grants I/008/07/0 and I/088/06/0. TB acknowledges support from the International Space Science Institute. We acknowledge the use of public data from the Swift data archive and all the Swift team for its support. Our particular thanks go to Dr J. M. Miller and his colleagues who immediately returned to the scientific community their INTEGRAL ToO data.

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