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The failed state transition of the ATOLL source GRS 1724–308

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ABSTRACT
The 2004–2012 X-ray time history of the NS LMXB GRS 1724–308 shows, along with the episodic brightenings associated with the low-high state transitions typical of the ATOLL sources, a peculiar, long lasting (∼300 d) flaring event, observed in 2008. This rare episode, characterized by a high-flux hard state, has never been observed before for GRS 1724–308, and in any case is not common among ATOLL sources. We discuss here different hypotheses on the origin of this peculiar event that displayed the spectral signatures of a failed transition, similar in shape and duration to those rarely observed in black hole binaries. We also suggest the possibility that the atypical flare occurred in coincidence with a new rising phase of the 12-yr superorbital modulation that has been previously reported by other authors. The analysed data also confirm for GRS 1724–308 the already reported orbital period of ∼90 d.

Key words: stars: neutron – X-rays: binaries – X-rays: individual: GRS 1724–308.

1 INTRODUCTION

GRS 1724–308, alias 4U 1722–30, or H1724–307, is a LMXB containing a weakly magnetized NS, revealed by the presence of type-1 X-ray bursts in its X-ray light curve (Swank et al. 1977). The bursts are typically Eddington limited (Cocchi et al. 2001) thus allowing us to determine a distance of about 9.5 kpc to the source (Kuulkers et al. 2003). GRS 1724–308 is located in the globular cluster Terzan 2 (Grindlay et al. 1980) and even if it is known since 70s that the cluster hosts a bright X-ray source, the GRS 1724–308 position has been set only in 2002 (Revnivtsev, Trudolyubov & Borozdin 2002) by *Chandra*, at confidence level above 4σ within the radius containing half of the cluster mass.

GRS 1724–308 is one of the first NS systems known to have hard X-ray emission (E >35 keV) as revealed by SIGMA in 1991 with a power law emission extending above 100 keV and a photon index $\Gamma \sim 1.65$ (Barret et al. 1991). Its spectral/timing properties are typical of the ATOLL sources (Olive et al. 1998; Altamirano et al. 2008); the source spends most of the time in a low hard state (LHS) with occasional flares signalling a transition to the high soft state (HSS). The first detailed broad-band study performed with *BeppoSAX* and *RXTE* showed a LHS Comptonized spectrum extending up to 200 keV of temperature ∼30 keV, plus an additional soft disc component of ∼1.5 keV (Guainazzi et al. 1998).

1.1 The long term monitoring of GRS 1724–308

Our study reports on the monitoring of GRS 1724–308 over 12 yr. This period of time covers all the RXTE/All-Sky Monitor (ASM) operational life plus an year of data collected only by INTEGRAL and SWIFT satellites (see Fig. 1). However, exploiting further literature informations, we reconstructed the source behaviour over about 40 yr that we resume herewith:

(i) **MJD 42000–48000:**
Observations with *Uhuru*, OSO-8, *Einstein*, and *EXOSAT* showed the source with a flux up to 30 keV below 30 mCrab with no particular flare events (Swank et al. 1977; Forman et al. 1978; Grindlay et al. 1980).

(ii) **MJD 48000–52000:**
Emelyanov et al. (2002), reported on a *RXTE*/PCA observation that showed a flux increase throughout a long rise time of about 5 yr, that reached a peak around the end 1996/early 1997 (MJD 50300-50500) and then showed a long decay phase, again of about 5 yr.

This modulation of the flux was tentatively associated with an intrinsic accretion rate variation from the donor star, or the passage of a third body, or even to a gravitational microlensing effect.

(iii) **MJD 50000–53550:**
As metioned before, Guainazzi et al. (1998) reported on X-ray broad-band observations performed with *BeppoSAX* satellite in August 1996.The data were collected before and after a type I X-ray burst and revealed a spectrum that extends up to 150 keV, typical of a LHS. This behaviour appears to be very similar to that of an observation performed by ASCA and RXTE in 1995 and reported by Barret et al. (1999).

The *RXTE*/PCA observations published by Altamirano et al. (2008) show that the source spent a long period (from MJD 51214 to 52945) without any particular variation with a flux of about 25 mCrab in the 2–20 keV band. This period is partly overlapping and in agreement with the decay phase of the long term peak of the observations reported by Emelyanov (see above). After MJD 53000,

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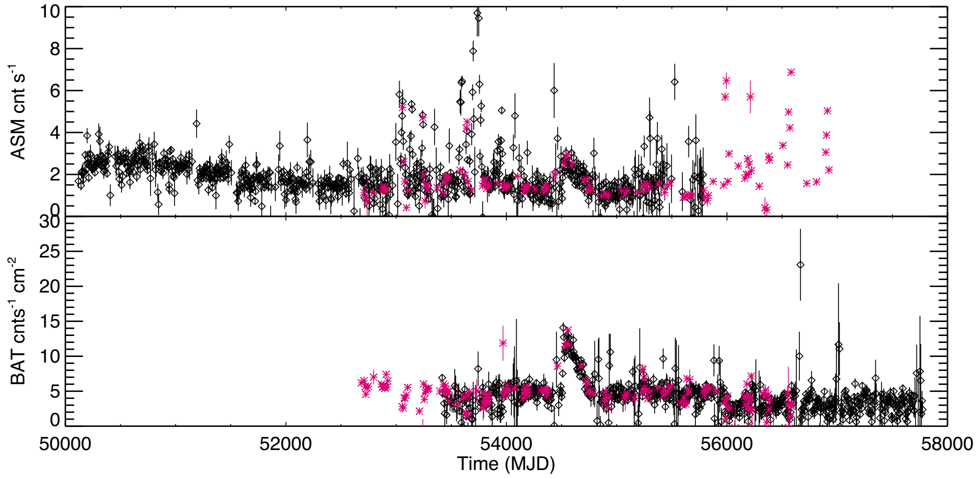

Figure 1. Top panel: ASM/*RXTE* 2–12 keV 10 d bin light curve of GRS 1724–308. The pink asterisks represent the *INTEGRAL*/JemX 2–12 keV 10 d bin light curve rescaled in arbitrary units. Bottom panel: *Swift*/BAT 15–50 keV 10 d bin light curve of of GRS 1724–308. The pink asterisks represent the *INTEGRAL*/IBIS 20–100 keV 10 d bin light curve rescaled in arbitrary units.

the source changed its behaviour, and showed different flares with peak fluxes up to 80 mCrab, until the end of the observations. A Lomb–Scargle periodogram in the PCA 2–20 keV band data showed a periodicity of about 90.55 d. This periodicity could be related to the orbital period of the binary system.

(iv) **MJD 50000–55000:**
Kotze (Kotze et al. 2010) studied the long term X-ray variability in a sample of LMXBs, including GRS 1724–308 , to search for superorbital periods using the ASM data from 1996 to 2009. Even though the period of observation is not enough to include more than one cycle, the source seems to have a super orbital modulation of 12±3 yr. Such a long-term modulation has been supposed to be produced by variation of accretion rate due to long magnetic-activity cycle of the donor star, a mechanism that has been proposed first in the Cataclysmic Variable objects (Applegate & Patterson 1987; Warner 1988).

2 DATA ANALYSIS AND OBSERVATION SETS

In order to follow the flux evolution of the source, we used the near-continuous coverage of the daily light curves from the *RXTE*/ASM (Levine et al. 1996) and *Swift*/Burst Alert Telescope (BAT) (Krimm et al. 2013) monitors. The daily light curve of the soft X-ray monitor (2–12 keV) ASM is provided by the ASM/RXTE teams at MIT and at the RXTE SOF and GOF at NASA's GSFC and can be downloaded from the public web site.[1] The daily light curve of the *Swift* hard X-ray monitor BAT are available from the public web site[2] and provided by the Swift/BAT team. The BAT/ASM hardness ratio has been calculated using the 1-d averaged light curves of both instruments expressed in Crab units and selecting the simultaneous observations. We used the conversion values reported in Yu & Yan (2009): 1Crab = 75 count s^{-1} for ASM; 1 Crab = 0.23 count s^{-1} cm^{-2} for BAT.

The IBIS and JEM-X light curves were collected using the HEAVENS tools provided by the INTEGRAL Science Data Centre web site (Walter et al. 2010).[3]

[1] http://xte.mit.edu/ASM_lc.html
[2] http://swift.gsfc.nasa.gov/results/transients/
[3] http://www.isdc.unige.ch/integral/heavens

The *INTEGRAL* data, used for the spectral analysis, were reduced using OSA 10.2 (Goldwurm et al. 2003; Winkler et al. 2003), and include the X-ray monitor JEM-X (Lund et al. 2003) and ISGRI (15 keV–1 MeV) (Ubertini et al. 2003), the low-energy detector of the γ-ray telescope IBIS (Lebrun et al. 2003). For the spectral analysis, XSPEC software v.12.7.1 (Arnauld et al. 1996) has been used. Within XSPEC, a systematic error of 0.02 has been added to the spectral data, the instrument constant was fixed to one for IBIS and kept free for JEM-X.

The periodicity study performed on these data sets, has been performed by the XRONOS package v. 5.21.

3 TIME EVOLUTION OF THE SOURCE

The first two panels of Fig. 1 show the 2–12 keV RXTE/ASM and 15–50 keV Swift/BAT light curves, respectively (black diamonds), the pink asterisks represent the JEM-X (top panel) and the IBIS light curves (bottom panel) extracted in the same energy range of ASM and BAT, respectively, and rescaled in order to obtain similar average counting rates.

3.1 The state transition flares

Fig. 1 shows GRS 1724–308 is clearly variable, presenting several flare-like episodes with typical durations of ~30 d most likely related to the spectral state transitions typical of the ATOLL sources. These flare-like episodes show a peak flux in the soft X-rays (<20 keV) usually characterized by a short-time rise and a slower decay. The soft flux increase is generally followed by a delayed increase in the harder band (>20 keV). As an example, in Fig. 2, we show the ASM and ISGRI light curves of a state transition flare-like event occurred on 2004, where the anticorrelation between the soft and hard flux is evident.

3.2 The 2008 long peculiar flare-like episode

Fig. 1 clearly shows that roughly between MJD 54500–54900, the light curves present an evident simultaneous increase of the flux in both the soft and the hard energy bands.

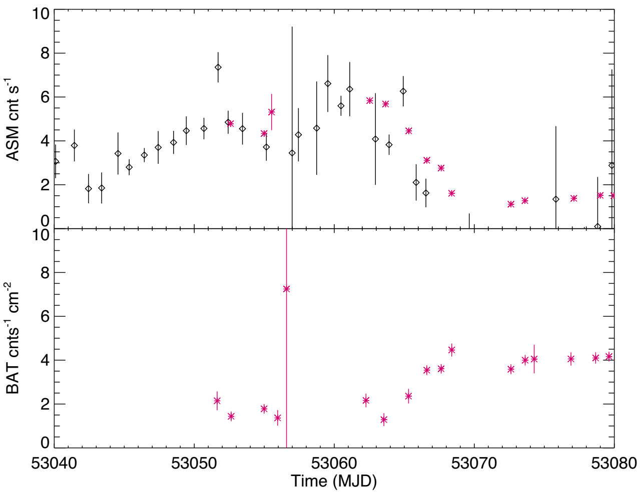

Figure 2. Example of soft and hard flux anticorrelation during a typical state transition flare of GRS 1724–308. Top panel shows the 1 d averaged 2–12 keV ASM light curve super imposed with the Jem-X light curve at the same energy range. The bottom panel shows the 20–30 keV IBIS light curve. The INTEGRAL curves have a 1 d time bin. This flare occurred in 2004, before the launch of the Swift satellite, thus the BAT data are not available.

This episode (hereafter termed *2008 flare*) is displayed in a zoomed view in the first two panels of Fig. 3. The 2008 flare has *profile* and *duration* very different from the ones of the state transition flares. In fact, this smoothly varying event shows NO anticorrelation in the hard and soft energy bands and lasted for more than 200 d (54500 MJD–54725 MJD), i.e. ∼7 times the typical duration (∼30 d) of the state transition flares. The intensity 'bump' is clearly evident in the BAT 15–50 keV lightcurve. During this peculiar flare the average hard flux (>20 keV) reached a peak value never observed before in the GRS 1724–308 history. Moreover, there is no indication of significant hard colour variability during the flare (see Fig. 3, 3rd panel).

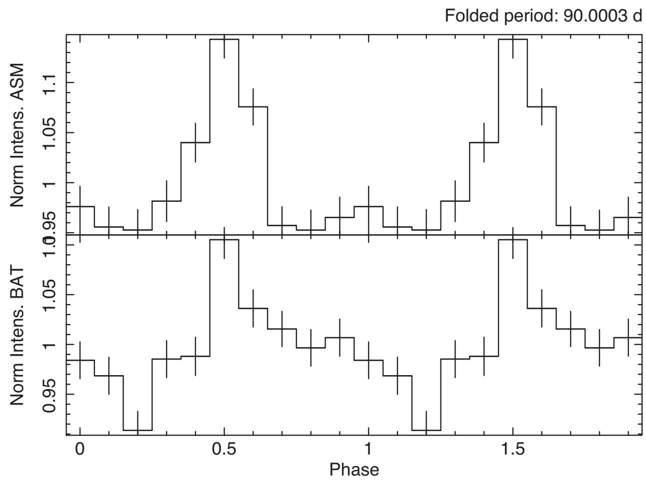

Figure 4. Top panel: ASM folded light curve of GRS 1724–308. The period corresponds to 90 d. Bottom panel: BAT folded light curve for the same period.

3.3 Periodicity studies

If we assume that the first maximum of the super orbital modulation reported by Kotze et al. (2010) coincides with the peak flux in late 1996 – early 1997 reported by Emelyanov et al. (2002) (i.e. the authors reported on the same super orbital cycle), the 2008 flare occurs at the beginning of the next super orbital cycle i.e. within the errors, at the new minimum. Of course this statement needs to be verified on a much longer time basis including more than a single cycle of long term modulation.

Our short term periodicity studies confirm the ∼90 d period firstly reported by Altamirano et al. (2008) in the PCA data. The 90 d period is present both in our ASM and BAT data sets. For this periodicity, the folded light curves of both ASM and BAT are shown in Fig. 4. This modulation is most likely related to the orbital period of the binary system (Altamirano et al. 2008) and not to the super orbital modulation proposed by Emelyanov et al. (2002).

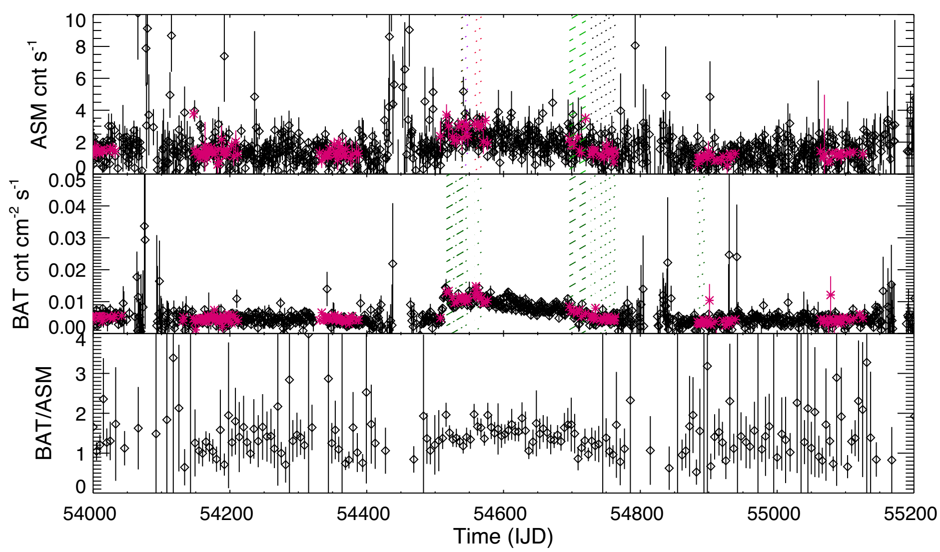

Figure 3. First two panels: ASM and BAT light curves as in Fig 1, but zoomed around the peculiar 2008 long flare (bin time 1 d). The green zones of the plots represent the INTEGRAL observing periods throughout the flare (during the periods represented with dashed zones the source has been observed only by IBIS, while during the dotted periods the source has been observed by both IBIS and JEMX). Bottom panel: ratio between BAT and ASM fluxes (bin time 5 d)

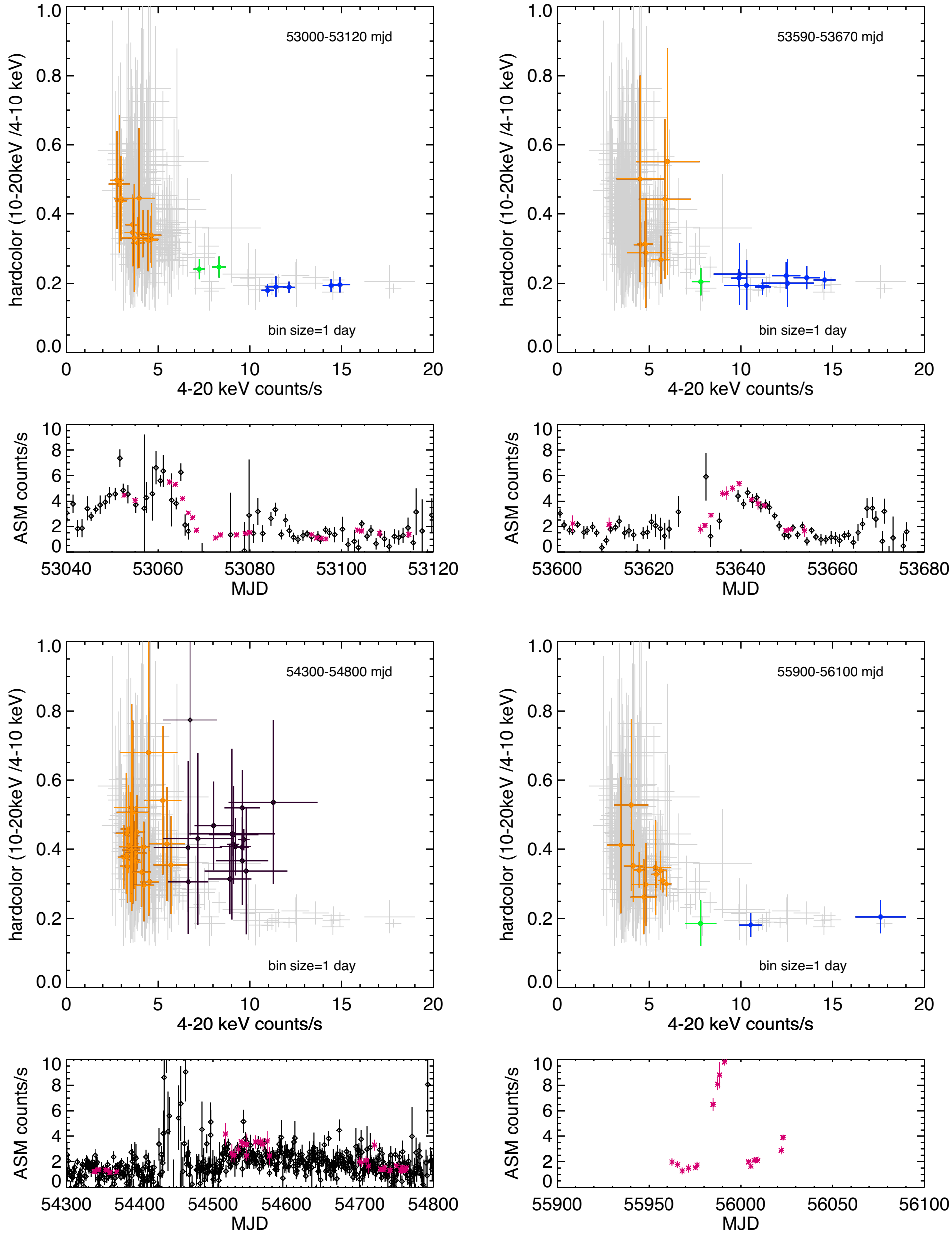

Figure 5. Jem-X colour Intensity diagrams. The time bin of each point is equal to 1 d, the coloured points in each figure represent the evolution of the state transition of a single flare of the source. The points of the same colour represent the same spectral state (yellow for hard states, green for intermediate states, and blue for soft and very soft states). Instead, the background grey data represent the whole data set including the persistent emission. The black points represent the peculiar state observed only during the 2008 flare (for clarity these points were omitted in the background grey data, in order to highlight the ATOLL source HCI track of GRS 1724–308).

4 COLOUR–INTENSITY DIAGRAMS

We used the INTEGRAL data to construct hard colour versus intensity (or hardness–intensity) diagrams (HID). JEM-X counts have been collected in two energy ranges (soft, 4–10 keV, and hard, 10–20 keV), along with simultaneous IBIS counts in the 20–30 keV range.[4] Two sets of HID have been constructed: hard/soft JEM-X ratio and ISGRI/soft JEM-X ratio, in function of the total count rate in the two bands.

[4] The ASM and BAT data are too noisy to produce good HIDs but for the 2008 flare data.

The JEM-X HIDs are displyed in Fig. 5. Each HID diagram refers to a different flare (coloured points), whose points are over-plotted on the ones of the whole data set, including both flares and steady emission (background grey crosses). The corresponding light curve is reported in the figure at the bottom of each HID.

For each diagram, we have used different coloured symbols to group the data with similar spectral states. Spectra groups have been defined imposing a fixed range of values of hard colour and intensity. The orange points indicate the hard state data, the blue points the soft state data, the green ones the intermediate state data. The black points are the ones of the 2008 peculiar flare. As the HIDs show, the source spends most of its time in a hard state and during

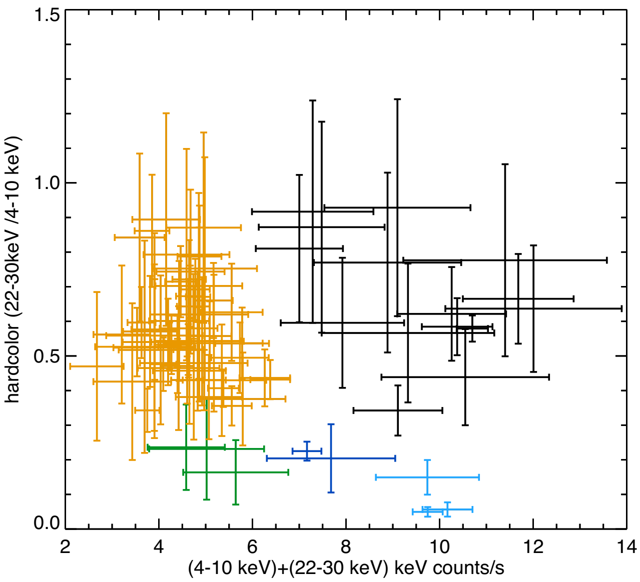

Figure 6. Hardness–intensity diagram for IBIS/JEM-X simultaneous pointings. The time bin of each point is one day. the different colours correspond to the same spectral states as used in Fig. 5: hard state (orange points), peculiar-hard state in 2008 (black points), intermediate state (green points) and soft state(blue/light blue points).

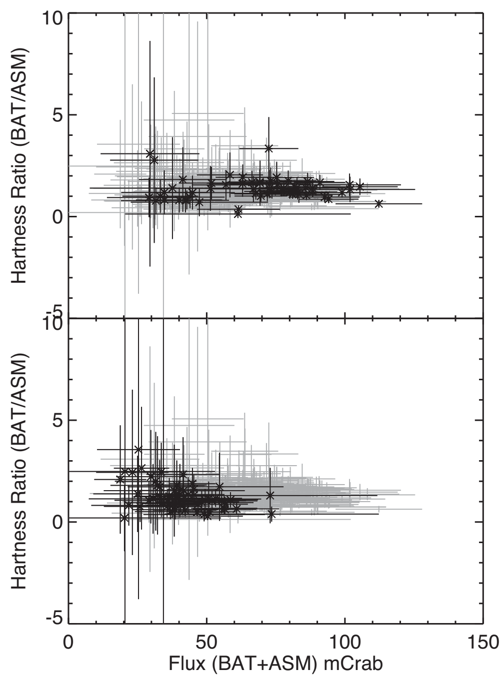

Figure 7. First panel: BAT/ASM HID of the entire 2008 peculiar flare (grey points). The black points represent the 1st 60 d of the flare. Second panel: As in the top panel, for the last 60 d of the flare (in black). Time range is (MJD)=54489–54781, bin time is 1 d (see also Fig 3 for light curve details).

an occasional flare it typically shows a state transition. During the various ‘standard’ flares the source tracks similar curves in the diagram. Conversely, during the 2008 flare the source exhibited a bright hard state (black points) with a different position in the HID. This position was never reached again in the 12 yr that are the subject of our study and this peculiarity was previously unreported.

Fig. 6 displays the HID derived from simultaneous JEM-X and IBIS pointings throughout the monitoring period.[5] The colours of the points have the same meaning as in Fig. 5. The separation of the various spectral states, included the peculiar bright hard state of the 2008 flare, is evident also in this figure.

4.1 2008 flare: BAT/ASM HID

Due to observatory and time allocation constraints, INTEGRAL daily monitoring of GRS 1724–308 is not available and this could prevent the detection of possible short time-scale state transitions during the 2008 flare. Nevertheless, the flare is bright enough, compared to the rest of the GRS 1724–308 time history, to allow the construction of a significant BAT/ASM HID of the event. In particular, the first and last 60 d of the flare were investigated in comparison with its total HID evolution (Fig. 7).

The first panel of the figure shows a clear flux increase with constant hardness at the beginning of the flare. In its last part, the flux decreases slowly (see also e.g. Fig 3) and the flux drop is less evident in the HID of the last 60 d.

The calculated averages of the hard colour are 1.50 ± 0.58 for the entire flare and 1.36 ± 0.15, 1.6 ± 2.9 for the leading and trailing 60 d, respectively. Their consistency within the errors indicates there is no time evolution in the hard colour during the 2008 event, as already suggested by Fig 7. Also The calculated χ^2 for the 1 d ratios are compatible with no HR variability.

5 SPECTROSCOPY OF THE SOURCE

We performed the analysis of the averaged simultaneous IBIS and JEM-X spectra constructed by collecting data of different flares with the same hardness characteristics, i.e. data with the same colour in the Jem-X/IBIS hardness-intensity diagram (see Fig. 6). Fig. 8 shows the spectra of the two hard states of GRS 1724–308 corresponding to the orange and the black points in Fig. 6. The model used for the fitting procedure is a disc blackbody component (Mitsuda et al. 1984) plus a Comptonization of soft photon via relativistic electron plasma (Poutanen & Svensson 1996), DISCBB+compPS in XSPEC. CompPS is effective in modelling Comptonized emission from a hot, optically thin plasma region like that of the NS-LMXB in a LHS. The plasma parameters commonly observed in LHS (kTe $> \sim$20 keV, $\tau_s < \sim 3$) are safely within the model's validity parameter space. Instead, when analytic models assuming a diffusion regime (e.g. the largely adopted CompTT, Titarchuk 1994), are applied to low opacity plasma clouds, the fit values obtained could be unreliable.

The fitted parameters for the two LHS (see Table 1) are consistent to each other within the errors and with the ones reported in literature for the source LHS (e.g. Guainazzi et al. 1998; Barret et al. 1999). The two spectra have instead very different flux : in fact, the 2008 peculiar LHS is $\sim$50 per cent brighter than the standard one. Although the rising of the 2008 flare is not covered by INTEGRAL observations, the HR versus time of the final part of the flare does not show variations within the errors, therefore, we presume that the flare substantially evolved at constant spectrum as already shown by the BAT/ASM flux ratio in Fig. 3.

As far as the standard flares HSS spectra are concerned, only Jem-X data have been used for spectral extraction. We obtained

[5] Due to the INTEGRAL observation strategy and the different FOV of the two instruments, only part of the JEM-X and IBIS data are simultaneous.

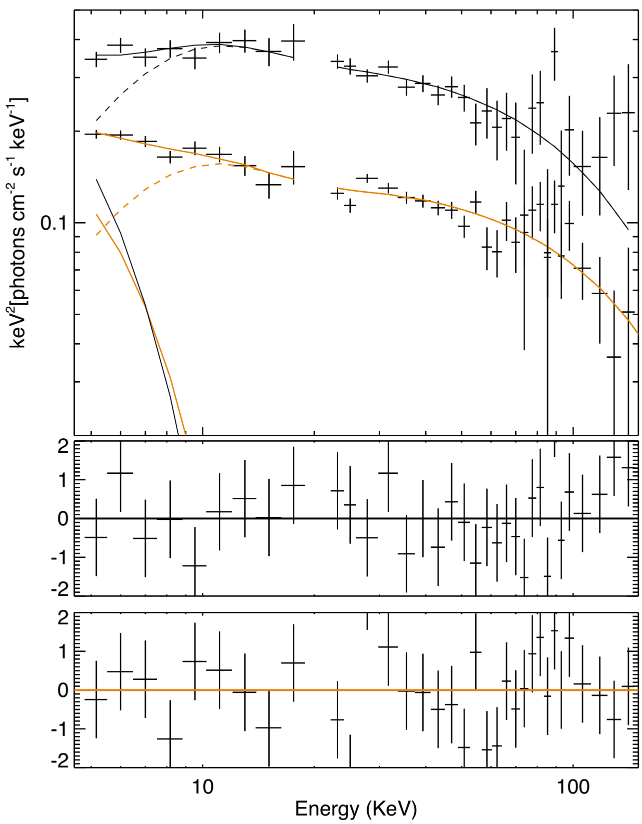

Figure 8. Top panel: GRS 1724–308 IBIS and JEM-X hard state unfolded spectra. The spectrum with orange lines corresponds to the orange points in Fig. 6 (regular GRS 1724–308 hard state.) The spectrum with black lines corresponds to the black points in Fig. 6 (2008 peculiar hard state). Middle and bottom panel: respective fit residuals in terms of sigmas with error bars of size one.

good quality spectra only for the data sets corresponding to blue and light blue points in Fig. 6.

We modelize the soft spectra with a disc blackbody component plus an inverse Compton component. In this case the Comptonization model is CompTT (Titarchuk 1994). `CompTT` is effective for low temperature, highly opaque electron plasmas as the HSS ones. Unfortunately the disc blackbody component could not be constrained because it is confused into the Comptonized one. In the hard state spectra, instead, the Comptonized component peaks at higher energy (>20 keV) and let the disc blackbody component clearly visible even with the Jem-X spectral capability. Fitting the HSS data only with `CompTT`, we obtained spectral parameter values in agreement with those reported in literature for other NS LMXB (see, for example, Barret et al. 2000; Paizis et al. 2006; Tarana et al. 2008, and reference therein). Compared to LHS spectra, the electron plasma temperature decreases to ∼3 keV, while the optical depth τ exceeds the value of 5 (see Table 2).

6 DISCUSSION

The time history of GRS 1724–308 alternates long-lasting low luminosity periods of negligible activity to other phases, generally shorter, with strong activity characterized by bright flares and LHS to HSS transitions. This is a typical time behaviour of the persistent low-luminosity ATOLL sources. For this subclass, the state transitions to the HSS are relatively rare episodes as their canonical spectral state is a LHS of $L \sim 10^{36}$ erg s^{-1}. Conversely, the bright persistent ATOLLs (e.g. most of the so-called GX sources) exhibit an HSS ($L > 10^{37}$ erg s^{-1}) as their canonical state, with no or rare transitions to the LHS. The different behaviour supposedly reflects intrinsic differences in the binary systems, such as donor mass and activity, orbital parameters, star population, etc. As an example, the persistent emitters located in a globular cluster are generally faint, LHS, ATOLLs. Among the latter sample, GRS 1724–308 in Terzan 2 seemed to show no peculiarities.

This work reports on the observation of an atypical, long lasting (>300 d) *hard flare*, which is an unprecedented event in the source time history. The 2008 flare, for its shape, time-scale and coverage of an unusual bright-hard region in its HID, shares similarities with the failed state transitions (or failed outburts) observed in some cases in black hole binary systems (Brocksopp, Bandyopadhyay & Fender 2004; Capitanio et al. 2009; Ferrigno et al. 2012). The main difference is the persistence of the emission of GRS 1724–308, as almost all the BH LMXB are transient sources.

Among NS LMXB similar failed transitions are much less common. An interesting case is the one of Aql X–1, a nearby, quasi-persistent (or quasi-transient) NS which exhibited a failed state transition during an outburst (Rodriguez, Show & Corbel 2006). However, unlike the GRS 1724–308 one, the failed outburst of Aql X–1 shows both duration and luminosity similar to the standard outbursts of the source but in that case, according to the authors, the LHS to HSS state transition generally observed during the outbursts did not occur. Moreover, even though Aql X–1 is classified as an ATOLL source, Rodriguez et al. (2006) underline its behaviour similar to that of a number of BH binaries, XTE 1550–564 in particular. Conversely, as mentioned above, GRS 1724–308 has no peculiarities among its class of objects. So the two episodes are likely intrinsically different in their nature.

For comparison sake, we investigated the critical luminosities for the atypical failed transitions of both GRS 1724–308 and Aql X–1 , here defined as the luminosities where the LHS to HSS transition is expected to occur. Extrapolating the Aql X–1 unabsorbed cut-off power-law spectrum published by Rodriguez et al. (2006), a bolometric luminosity (for a 5 kpc distance) of $\sim 2 \times 10^{37}$ erg s^{-1} is obtained for the peak of the failed outburst. This value should equal,

Table 1. Comparison of spectral fitting results for the JEM-X and IBIS hard state spectra of GRS 1724–308. The model used for the fitting procedure consists in a disc blackbody component, Diskbb in XSPEC (Mitsuda et al. 1984), plus a Comptonization model, COMPPS in XSPEC (Poutanen & Svensson 1996). A renormalizing constant has been included in the spectral fit in order to take into account calibration differences between the two instruments. The colours corresponds to those used in the hardness–colour diagram (Fig. 6). All the errors and upper limits reported in the table correspond to the 90 per cent confidence level.

Spectrum	Factor	Tin	*Norm*$_D$	KTe	tau-y	*Norm*$_C$	$\chi^2_{\rm reduced}$/dof	Flux$_{2-10\,\rm keV}$	Flux$_{10-150\,\rm keV}$
–	–	keV	–	keV	–	–	–	erg cm^{-2} s^{-1}	erg cm^{-2} s^{-1}
Orange	$0.87^{+0.18}_{-0.17}$	$1.20^{+0.40}_{-0.34}$	12^{+44}_{-9}	45^{+15}_{-12}	$1.01^{+0.52}_{-0.34}$	$4.07^{+0.66}_{-0.51}$	1.1/30	4.9e−10	5.0e−10
Black	0.90 ± 0.19	$1.03^{+0.51}_{-0.43}$	37^{+226}_{-34}	40^{+13}_{-10}	$1.13^{+0.46}_{-0.35}$	$10.2^{+1.5}_{-1.2}$	1.0 /28	9.2e−10	12e−10

Table 2. Spectral fitting results for the JEM-X soft state spectra of GRS 1724–308. The model used for the fitting procedure consists in a Comptonization model, COMPTT in XSPEC (Titarchuk 1994). Because of the data energy interval starting from 3.5 keV, the seed photon temperature has been freeze to its best value (0.8 keV). With the addiction of a DISKBB component the fit parameters cannot be constrained (see the text for details). The data corresponds to the blue and light blue points in the hardness–colour diagram (Fig. 6). All the errors and upper limits reported in the table correspond to the 90 per cent confidence level.

Spectrum	KTe	tau-p	*Norm*$_C$	$\chi^2_{\rm reduced}$/dof	Flux$_{2-10\,{\rm keV}}$	Flux$_{10-150\,{\rm keV}}$
–	keV	–	–	–	erg cm^{-2} s^{-1}	erg cm^{-2} s^{-1}
Light blue	$2.8^{+0.6}_{-0.4}$	5.5 ± 1	0.08 ± 0.01	0.40/13	8.4e−10	2.3e−10
Blue	$2.9^{+1.4}_{-0.6}$	$5.5^{+2.2}_{-1.9}$	$0.06^{+0.01}_{-0.02}$	0.30/11	6.5e−10	1.9e−10

or be very close to, the critical one, as, for example, Maccarone & Coppi (2006) report the 1999 HSS transition outbursts in the 1.6–2.2 × 10^{37} erg s^{-1} range. For the case of GRS 1724–308 the bolometric extrapolation of the relevant spectra (see the sections above) lead to $L \sim 2.8 \times 10^{37}$ erg s^{-1} for the hard 2008 flare, very similar to the case of Aql X–1. The typical (years 2003–2005) state transition flares of GRS 1724–308 peak at $L \sim 1.8 \times 10^{38}$ erg s^{-1} (Tarana et al. 2008), which is a relatively higher value. However, this value should be regarded only as an upper limit to the one of the critical luminosity for GRS 1724–308. One could reasonably deduce that the 2008 hard flare did not reach the critical luminosity for the LHS to HSS transition, so the flare should be regarded as the effect of an anomalous accretion event rather than a *classic* failed outburst episode. The 2008 perturbation, whose energy surplus has been likely almost completely dissipated via coronal emission, looks less powerful and acting on a much longer time-scale than the standard ones.

Such a rare, weak perturbation could be connected to the ∼12 yr super orbital modulation reported in Section 1.1, possibly related to a secular magnetic cycle of the donor star. In fact, the peculiar 2008 flare looks in coincidence with the minimum of the long term period, though we do not have enough data to establish a firm correlation.

Besides this possible long term coincidence, a rare variability episode of the donor, or the periastron of a third body in an eccentric orbit, or the transit of a nearby star could explain the anomalous 2008 hard flare. The last possibility could not be uncommon in a densely populated stellar system like a Globular cluster.

As recently reported in literature by various authors (for a review see, for example, Belloni 2010, and reference therein) the state transitions in X-ray binaries do not seem to be governed by the mass accretion rate only. A second parameter, which nature is still unclear, seems to be involved in the spectral transitions. This scenario is evident for BH binaries (Homan et al. 2001) that continuously shift the HID pattern, while for NS binaries this behaviour is less evident, even though the secular shifts observed in both ZETA and ATOLL sources (e.g. Di Salvo, Méndez & van der Klis 2003) could be related to the action of this unknown parameter. Therefore, one could speculate that also the 2008 peculiar flare of GRS 1724–308 could be an effect of the action of the second parameter and not directly related to an increase of the mass accretion rate.

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