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Letter to the Editor

XMMU J174716.1–281048: a "quasi-persistent" very faint X-ray transient?

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ABSTRACT

The X-ray transient XMMU J174716.1–281048 was serendipitously discovered with *XMM-Newton* in 2003. It lies about 0.9 degrees off the Galactic Centre and its spectrum shows a high absorption ($\sim 8 \times 10^{22}$ cm^{-2}). Previous X-ray observations of the source field performed in 2000 and 2001 did not detect the source, indicative of a quiescent emission at least two orders of magnitude fainter. The low luminosity during the outburst ($\sim 5 \times 10^{34}$ erg s^{-1} at 8 kpc) indicates that the source is a member of the "very faint X-ray transients" class. On 2005 March 22nd the *INTEGRAL* satellite caught a possible type-I X-ray burst from the new *INTEGRAL* source IGR J17464–2811, classified as fast X-ray transient. This source was soon found to be positionally coincident, within the uncertainties, with XMMU J174716.1–281048. Here we report data analysis of the X-ray burst observed with the IBIS and JEM-X telescopes and confirm the type-I burst nature. We also re-analysed *XMM-Newton* and *Chandra* archival observations of the source field. We discuss the implications of these new findings, particularly related to the source distance as well as the source classification.

Key words. Galaxy: center – X-rays: binaries – stars: neutron – X-rays: bursts – X-ray: individuals: XMMU J174716.1–281048

1. Introduction

XMMU J174716.1–281048 is a faint X-ray transient serendipitously discovered in 2003 with *XMM-Newton* in the Galactic Centre (GC) region, during a pointed observation on the composite SNR G0.9+0.1 (Sidoli & Mereghetti 2003; Sidoli et al. 2004). The observed flux was 3.7×10^{-12} erg cm^{-2} s^{-1} (2–10 keV), and the spectrum was fit well with an absorbed power-law model with photon index ~2 and $N_{\rm H} \sim 9 \times 10^{22}$ cm^{-2}. The high interstellar absorption suggested a source location at the GC. The derived luminosity, assuming $d = 8$ kpc, is 5×10^{34} erg s^{-1}. The source position was also within the EPIC field of view during the *XMM-Newton* pointed observation of SAX J1748.2–2808 (Sidoli et al. 2006) performed in 2005. XMMU J174716.1–281048 was imaged at a large off-axis angle (~13′) with an observed 2–10 keV flux of $\sim 2 \times 10^{-12}$ erg cm^{-2} s^{-1} and a spectrum similar to that observed in 2003.

The discovery of a possible type-I X-ray burst at the coordinates RA(J2000) = 266.810°, Dec(J2000) = –28.185° (with a 90% error radius of 1 arcmin), has been recently reported by Brandt et al. (2006) with the JEM-X monitor (3–30 keV) on board *INTEGRAL* satellite. The new burster was initially designated as IGR J17464–2811. Taking into account both the spatial coincidence and the temporal closeness of the *INTEGRAL* (March 2005) and *XMM-Newton* observations (outburst observed on 2005, 26-27 February), Wijnands (2006) suggested that the X-ray burst is indeed associated with the transient XMMU J174716.1–281048.

Here we report results of the *INTEGRAL* observation of the type-I X-ray burst. We also discuss all archival X-ray observations of the source field, performed with *XMM-Newton* and *Chandra* satellites.

2. Observation and data analysis

We present *INTEGRAL* public data collected with the two coded mask telescopes JEM-X (Lund et al. 2003) and IBIS (Ubertini et al. 2003). In particular, we analysed data of the low energy detector layer of IBIS, ISGRI (Lebrun et al. 2003), and JEM-X1 camera with OSA 5.1. The X-ray burst occurred on March 22nd at 07:55:33 UT. Source light curves during the corresponding *INTEGRAL* pointing (lasting 1800 s) have been extracted in three energy ranges, 3–6, 6–10, 18–26 keV, with 3-second bin-size. In order to extract both JEM-X and IBIS/ISGRI burst spectra, as well as IBIS images, we selected the time interval $t_{\rm start}$ = 07:55:33 and $t_{\rm stop}$ = 07:56:52.

XMM-Newton (Jansen et al. 2001) observed the source field three times: on 2000, September 23 (as part of the GC monitoring), on 2003, March 12 (pointed on the SNR G0.9+0.1), and on 2005, February 26–27. EPIC data have been reprocessed with the version 6.5 of the Science Analysis Software (SAS) and known hot (or flickering) pixels and electronic noise, as well as proton flares, were rejected (details on the data reduction and analysis in Sidoli et al. 2004 and Sidoli et al. 2006).

The source field has also been observed with *Chandra*/ACIS on 2000, October 27 (pointed on the SNR G0.9+0.1) and on 2001, July 16 (Obs.ID 2271 and 2274; Wang et al. 2006). The events files (level 2) processed by the *Chandra* X-ray Centre and available from the public archive have been analysed by using CIAO tool v. 3.2.2.

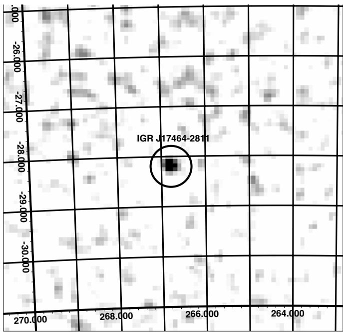

Fig. 1. XMMU J174716.1–281048/IGR J17464-2811 observed with IBIS/ISGRI between 20 and 25 keV. The image has been collected in 63 s during the X-ray burst.

3. Results

3.1. The X-ray burst caught with JEM-X and IBIS/ISGRI

We show in Fig. 1 the 20–25 keV IBIS/ISGRI image collected during the IGR J17464–2811 activity, namely during the X-ray burst. The persistent emission is below the detector level as can be inferred by the temporal profiles of IGR J17464–2811 shown in Fig. 2. A 2σ IBIS upper limit (1.5 Ms exposure time) of 3×10^{-12} erg cm^{-2} s^{-1} to the 20–40 keV persistent flux can be derived (Bird et al. 2006).

The decay times of the burst are 71.6 s and 7.3 s in the 3–6 kev and 20–25 keV energy bands respectively, clearly indicative of the spectral softening typical of type-I X-ray bursts. There is also evidence of a double-peaked burst profile, signature of Eddington limited bursts showing photospheric radius expansion.

Combining the JEM-X and IBIS burst averaged spectra, the best-fit (χ^2 = 80.9/79 d.o.f.) is achieved with an absorbed blackbody model with $kT = 1.8 \pm 0.1$ keV and $N_{\rm H} = 6.4^{+10.5}_{-2.7} \times 10^{22}$ cm^{-2} (Fig. 3, *left*). In the energy range 1–30 keV, the unabsorbed flux is $2.6^{+1.7}_{-1.0} \times 10^{-7}$ erg cm^{-2} s^{-1}. Following Kuulkers et al. (2003), we assume an Eddington luminosity corresponding to 3.8×10^{38} erg s^{-1}, thus deriving a source distance in the range of 2.8–4.6 kpc.

Moreover, Kuulkers et al. (2003) report on few type-I bursts showing higher peak luminosities, up to 7×10^{38} erg s^{-1}. If we assume such a high luminosity, we then obtain a distance ~6 kpc, which corresponds better to the observed high absorption. On the other hand, absorption intrinsic to the source can be invoked. Blackbody normalization parameter translates into an emitting sphere radius between 10 and 25 km for a source distance of 3 kpc, and 20–50 km at 6 kpc. We favour a lower value of the distance, 3 kpc, to be consistent with neutron star radii.

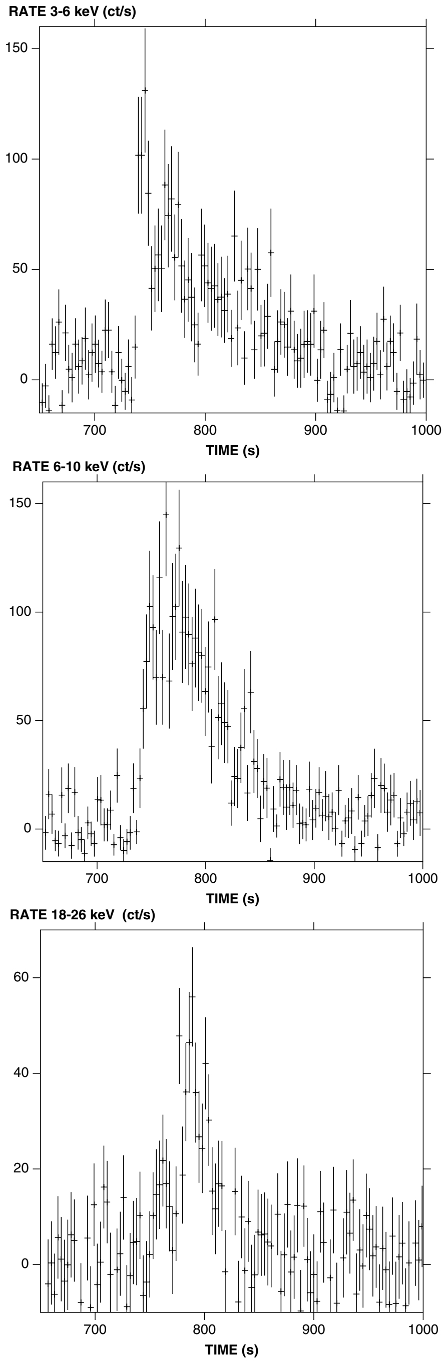

Fig. 2. From the top to bottom: JEM-X1 (3–6 keV), JEM-X1 (6–10 keV) and ISGRI (18–26 keV) lightcurves including the type-I X-ray burst from IGR J17464–2811(binsize = 3 s). The *INTEGRAL* persistent flux is consistent with zero.

3.2. XMM-Newton and Chandra

In order to show the transient nature of XMMU J174716.1–281048, a close-up view of the EPIC 0.5–10 keV images from the 2000 and 2003 observations is shown (Fig. 4). The solid circle marks the JEM-X error box of the burst (Brandt et al. 2006).

Detections and upper-limits estimated during *Chandra* and *XMM-Newton* observations are shown in Fig. 5. Our object displays a dynamic range of at least two orders of magnitude. *Chandra*'s upper limits to the unabsorbed fluxes (0.5–10 keV) have been obtained from estimated ACIS 3σ upper limits to the source count rate, assuming a power-law spectrum with $\Gamma = 2$ and an absorbing column density of 6×10^{22} cm^{-2}.

The best *XMM-Newton* spectrum was obtained during the 2003 observation (Fig. 3, *right*), because of a favourable position (almost on-axis) in the field of view, compared to the ~13′ off-axis distance during the 2005 pointing. The fit of the 2003 spectrum with an absorbed power-law already resulted in a good fit to the data (χ^2 = 205.9/201 d.o.f.): a photon index of 2.1 ± 0.1, a column density of $(8.9 \pm 0.5) \times 10^{22}$ cm^{-2}, and a 2–10 keV flux corrected for the absorption of $(6.8 \pm 0.4) \times 10^{-12}$ erg cm^{-2} s^{-1} have been obtained.

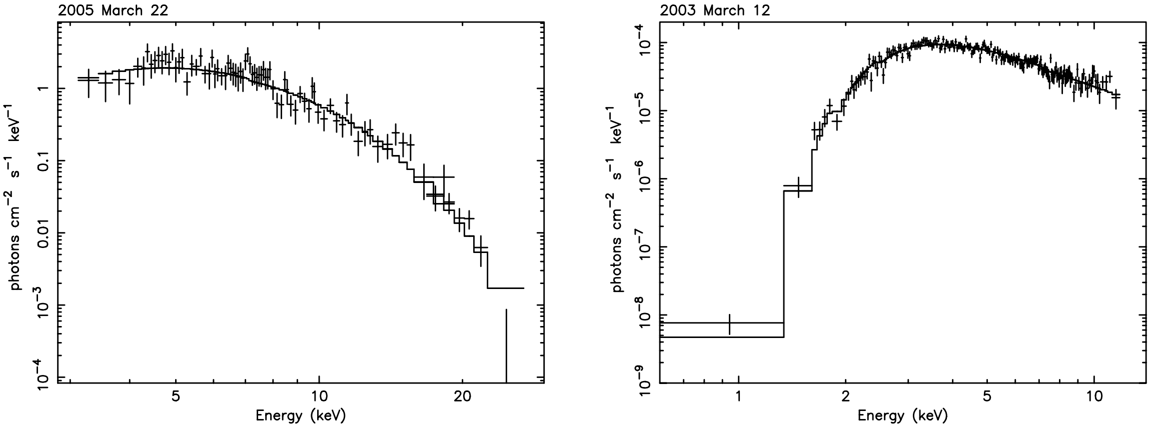

Fig. 3. Combined IBIS/ISGRI and JEM-X1 photons spectra and model (black-body) of the burst detected by *INTEGRAL* (*left*); spectrum of the persistent emission of XMMU J174716.1–281048 fitted with a simple absorbed power-law (EPIC/PN camera observation) is shown (*right*).

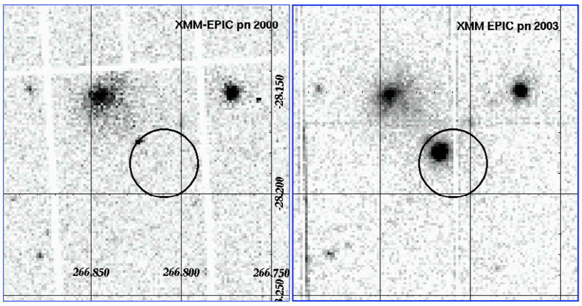

Fig. 4. X-ray images (0.5–10 keV) of the source field obtained with the EPIC-PN camera in 2000 (on the left) and in 2003 (on the right). The transient XMMU J174716.1–281048 is clearly evident in the centre of the 2003 image. The circle (1′ radius) marks the uncertainty region of the burst observed with JEM-X.

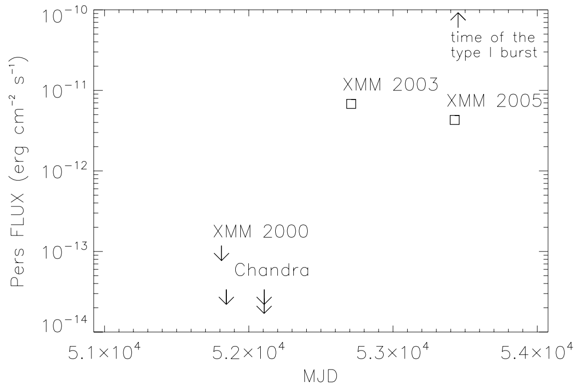

Fig. 5. Long term X-ray lightcurve of XMMU J174716.1–281048. The two observations performed with *XMM-Newton* in 2003 and 2005 are marked with squares, while meaningful upper limits are reported with arrows. The persistent flux (2–10 keV) is corrected for the absorption. Uncertainties on fluxes are smaller than symbols used.

The fit with an absorbed power-law to the 2005 spectrum resulted in similar parameters and in an unabsorbed flux of $4.3^{+0.4}_{-1.0} \times 10^{-12}$ erg cm^{-2} s^{-1} (2–10 keV). A proper timing analysis could not be performed because of several gaps in the light curves caused by the high background events rejection.

4. Discussion and conclusions

The discovery of a type-I X-ray burst with *INTEGRAL* from a source positionally coincident, within the errors, with XMMU J174716.1–281048, allow us to identify the nature of this faint transient as a Low Mass X-ray Binary containing a neutron star, and to determine the source distance (∼3 kpc). Furthermore, we can use the known properties of type-I bursters to derive some constraints on the accretion history of XMMU J174716.1–281048, as follows.

It is known that the quantity $\alpha = L_{\rm pers} \times t_{\rm rec} / E_{\rm burst}$ (where $L_{\rm pers}$ is the persistent luminosity, $t_{\rm rec}$ is the burst recurrence time and $E_{\rm burst}$ the energy emitted during the burst) is usually in the range 40–100 (see e.g. Strohmayer & Bildsten 2006). The XMMU J174716.1–281048 burst is Eddington limited and displays a decay time of 70 s, implying $E_{\rm burst} \sim 2.7 \times 10^{40}$ erg. Assuming for $L_{\rm pers}$ the value of 10^{34} erg s^{-1}, as observed in 2005 with *XMM-Newton*, we derive $t_{\rm rec} \sim 3 \times (\alpha/40)$ yr. This implies that the source luminosity between the two XMM-Newton observations remained at the same level, indicating that the two *XMM-Newton* observations performed in 2003 and 2005 caught the same outburst.

However, we are aware that the range for α as above was derived for much more luminous sources (see e.g. the sample in van Paradijs et al. 1988). Indeed, the burst properties for faint sources (such as XMMU J174716.1–281048), those showing in outburst accretion rates smaller than 10^{-12} $M_\odot$ yr^{-1}, are still unknown, and could be different. Moreover, we cannot be sure that 10^{34} erg s^{-1} was the maximum source luminosity reached by XMMU J174716.1–281048 in the years preceding the burst. On the other hand, if $L_{\rm pers}$ were much less than 10^{34} erg s^{-1}, the time needed to produce the type-I burst would have been much longer than that allowed by the upper limits placed by the 2000 observations.

XMMU J174716.1–281048 is a member of the class of the Very Faint X-ray Transients (VFXTs; King & Wijnands 2006; Wijnands et al. 2006), where the peak outburst luminosity is in the range 10^{34}–10^{36} erg s^{-1}, almost three order of magnitudes fainter than outbursts from "typical" Galactic X-ray transients. During the quiescent emission the XMMU J174716.1–281048 luminosity drops below $\sim 5 \times 10^{32}$ erg s^{-1}. These low luminosity transients have been mainly discovered with high sensitivity instruments, during *Chandra* and *XMM-Newton* surveys of the GC region (Wijnands et al. 2006, and references therein). XMMU J174716.1–281048 is not unique among VFXTs in displaying type-I X-ray bursts (Hands et al. 2004; Cornelisse et al. 2002b). These may likely be the same class of the "burst-only" sources observed in the GC region with the Wide Field Cameras on-board BeppoSAX satellite (Cocchi et al. 2001; Cornelisse et al. 2002a). However, the persistent flux was below the sensitivity threshold of the WFCs ($<10^{36}$ erg s^{-1}). XMMU J174716.1–281048 could be the first VFXT with "quasi-persistent" outbursts, similar to the brighter transient LMXRBs which displays outbursts lasting few years (e.g. MXB 1659-29 and KS 1731-260, Cackett et al. 2006). XMMU J174716.1–281048 might not be unique in this respect and other VFXTs could possibly display long-lived outbursts, but the available observations are probably too sparse to demonstrate it.

Previously, the *Chandra* and *XMM-Newton* surveys of the Galactic Centre region found that the VFXTs are mainly concentrated near the GC direction, suggesting that the high stellar density near Sgr A* could play a role in the formation of these faint transients (e.g. King 2000). The result of our analysis that the source distance is ~3 kpc casts some doubt on the distribution of the VFXTs in general, as already suggested by Wijnands et al. 2006, from the location of SAX J1828.5–1037 (another VFXT, see Hands et al. 2004).

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