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Letter to the Editor

BeppoSAX observations of a new X-ray burster in the Galactic Center region, possibly coincident with a recurrent transient

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Abstract. We report BeppoSAX NFI observations of the X-ray source SAX J1747.0–2853 recently discovered in the region of the Galactic Center. The presence of type I X-ray bursts indicates that this source, positionally coincident with the transient GX 0.2–0.2 observed in 1976, is a neutron star accreting from a low mass companion.

Key words: stars: neutron – individual: SAX J1747.0–2853 – X-rays: bursts

1. Introduction

In the last few years repeated observations of the galactic bulge region with coded mask hard X-ray telescopes have led to the discovery of many new sources.

The larger number of X-ray sources in the Galactic Center direction, compared to other parts of the galactic plane, indicates the presence of an enhanced concentration of accreting binaries in a region where the overall mass density is higher than at larger galactocentric distances. Though most of these sources are basically of the same kind of the accreting low mass and high mass binaries found elsewhere in the Galaxy, a few of them turned out to be particularly interesting and peculiar objects, like e.g. the "bursting pulsar" GRO J1744–28 (Lewin et al. 1996), the "microquasar" 1E 1740.9–2942 (Mirabel et al. 1992), and the 2 msec pulsar SAX J1808.4–3658 (in't Zand et al. 1998a, Wijnands & van der Klis 1998). Here we report on the BeppoSAX MECS observation of a recently discovered bursting X-ray source located at an angular distance of 19 arcmin from the Galactic Center direction. This source, named SAX J1747.0–2853, has been discovered with the Wide Field Camera instruments (WFC) on board BeppoSAX (in't Zand et al. 1998b) and has been later observed with both the Narrow Field Instruments (NFI) and the WFC instruments by Bazzano and collaborators (Bazzano et al. 1998). These authors also reported the presence of X-ray bursts from SAX J1747.0–2853. The data described here were obtained about 20 days after the discovery of SAX J1747.0–2853, as part of our survey of the Galactic Center region with the BeppoSAX NFI (Sidoli et al. 1998).

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2. Observations and data analysis

The region of sky containing SAX J1747.0–2853 was imaged with the MECS and LECS instruments during an observation performed from April 13 to April 15, 1998. The MECS instrument (Boella et al. 1997) is based on position-sensitive gas-scintillation proportional counters providing images in the 1.3–10 keV energy range within a field of view of 56 arcmin diameter. After standard data selection and cleaning, the resulting net exposure time in the MECS instrument is 72 ksec.

As 1E 1743.1-2843 was the main target of the observation, the new source SAX J1747.0–2853 was observed ~ 13 arcmin off axis, at coordinates $R.A. = 17h\ 47m\ 0.5s, Dec. = -28^\circ\ 52'\ 36''$, J2000 (with an uncertainty of ~ 1 arcmin). This position is consistent with that obtained in the discovery observation with the WFC instrument ($R.A. = 17h\ 47m\ 02s, Dec. = -28^\circ\ 52'.0$, J2000, $3'$ error radius, in't Zand et al. 1998) and subsequently refined with the NFI observations ($R.A. = 17h\ 47m\ 02s, Dec. = -28^\circ\ 52'.5$, J2000, $1'$ error radius) by Bazzano et al. (1998). in't Zand and coworkers noted that the source SAX J1747.0–2853 is positionally coincident, within errors, with the X-ray transient GX 0.2–0.2 observed in outburst in 1976 (Proctor et al., 1978).

Some variability on a timescale of hours, as well as a strong burst, starting at 1:40:03 UT of 1998 April 15 (see Sect. 3), are

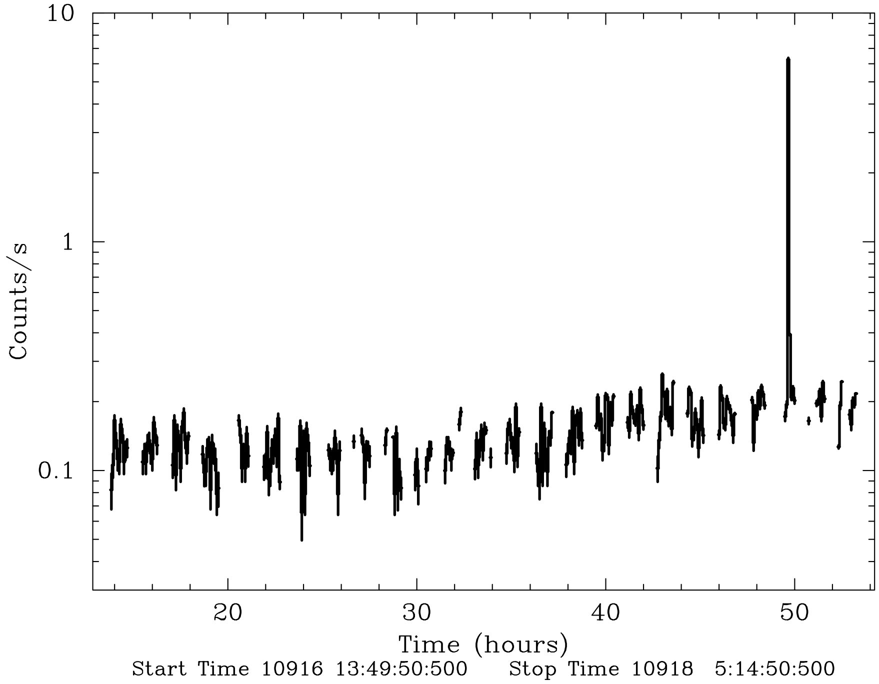

Fig. 1. SAX J1747.0–2853 MECS light curve. The bin size is 200 s.

clearly visible in the MECS background subtracted light curves presented in Fig. 1. After converting the arrival times to the Solar System barycenter, we searched for coherent signals in the X-ray flux of the source. We first removed the burst, then we accumulated a 0.3 s binned light curve and calculated a single power spectrum over the whole observation following the method outlined by Israel & Stella (1996). No significant periodicity was found with a corresponding 99% confidence level pulsed fraction upper limits between 25%–20% and 15%–17% for the 10^4 s–100 s and 100 s–1 s period intervals, respectively.

We also performed a period search during the 25s long burst time interval even in presence of poorer statistics. In this case we accumulated a 0.5 ms light curve and calculated the corresponding power spectrum. We found no significant peak. The 99% confidence level upper limits on the pulsed fraction are in the range 60%–40% and 35%–40% for the 1–500 ms and 500 ms–2 s period intervals, respectively.

To study the source spectrum we extracted the MECS counts within a radius of 2.5 arcmin from the source position and rebinned them in order to have at least 20 counts per bin. The time interval corresponding to the X-ray burst was excluded from the analysis. To properly fit the count spectrum, we derived the MECS response matrix appropriate to the source off-axis position and corrected for the adopted extraction radius. The latter was smaller than the usual 4 arcmin in order to avoid regions of the detector affected by the support strongback of the MECS window.

The standard MECS background spectrum obtained from blank field observations underestimates the actual background present in regions of low galactic latitude. We therefore estimated the background spectrum from the region surrounding SAX J1747.0–2853 observed in our data. The best fit with an absorbed power law gives a photon index $\alpha \sim 2.4$ and an absorbing column density of $\sim 10^{23}$ cm^{-2}. Though the formal uncertainties on these parameters are rather small, the results are somewhat dependent on the particular choice of the background region. Therefore, the errors indicated in Table 1, where the results of the fits are summarized, have been estimated taking the background uncertainty into account. The observed 2–10 keV flux is $\sim 2 \times 10^{-11}$ erg cm^{-2} s^{-1}. A slightly better fit of the MECS spectrum can be obtained with a ~ 6 keV thermal bremsstrahlung.

3. Analysis of the X-ray burst

The light curve of the X-ray burst is shown in Fig. 2; only the orbit containing the burst is displayed. At the burst peak the source reaches a count rate ~ 500 times stronger than the persistent emission. By fitting the burst light curves in two energy bands, we derived exponential decay constants of $\sim$15 s and $\sim$10 s at energies respectively below and above 4.5 keV. The average spectrum of the burst is harder than that of the persistent emission (power law photon index $\sim$1.7). In Fig. 3 we show the results obtained by fitting the burst emission in different time intervals with a blackbody spectrum. The contribution from the persistent emission has been subtracted. The spectral softening seen in the light curves is confirmed by the spectral analysis that shows a temperature variation from $\sim$2 to $\sim$0.5 keV. Assuming an Eddington luminosity at the burst peak, we obtain a distance of $\sim$10 kpc. Besides, assuming a spherical emitter at a distance of $\sim$10 kpc, we determine a blackbody radius consistent with the canonical radius for a neutron star. Moreover, this value remains constant during the burst.

Table 1. Persistent emission spectral analysis (errors are 90% c.l.).

Model	Column density (10^{22} cm^{-2})	parameter	Red. χ^2 (138 d.o.f.)	Unabsorbed Flux (2–10 keV) (10^{-11} ergs cm^{-2} s^{-1})
Power law	$9.9^{+0.8}_{-0.8}$	$\alpha_{ph} = 2.4^{+0.1}_{-0.1}$	1.09	$4.8^{+0.2}_{-0.3}$
Bremsstrahlung	$8.3^{+0.6}_{-0.3}$	$T = 6.1^{+0.9}_{-0.7}$ keV	1.01	$4.0^{+0.2}_{-0.3}$

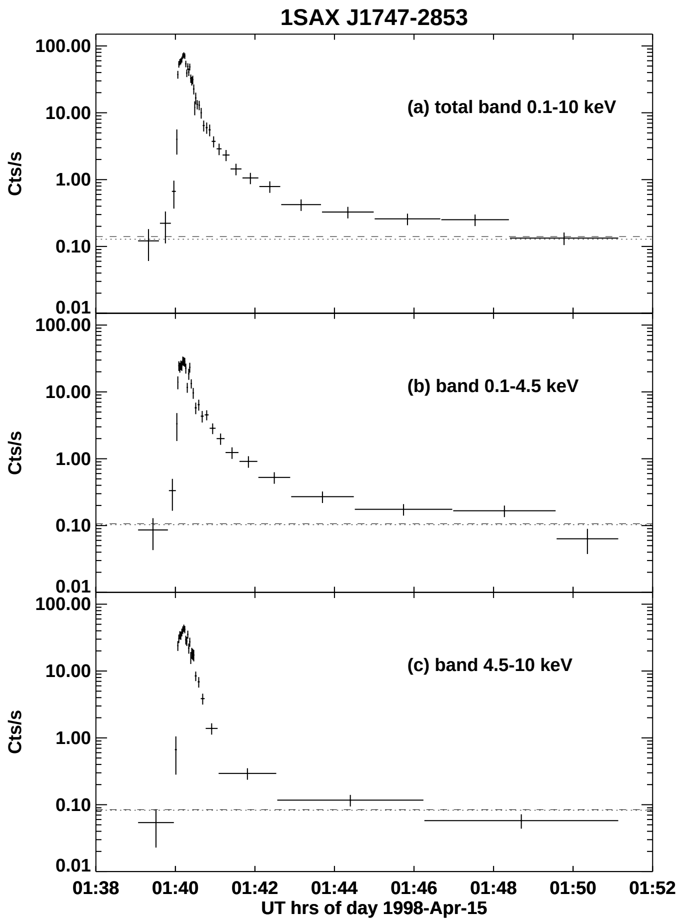

Fig. 2. Light curve of the burst in the total, soft and hard bands (panels a,b,c respectively). The minimum bin size is 1.5 s, but data have been rebinned for clarity in such a way that each bin has at least a statistics of 5 sigma during the burst decay (all bands), and a statistics of 2 σ (panels a,b) or 1.5 σ (panel c) during the burst onset. The dotted and dashed lines indicate the level of the persistent emission in the contiguous interval (uninterrupted by Earth occultation or SAGA passage) respectively before and after the burst.

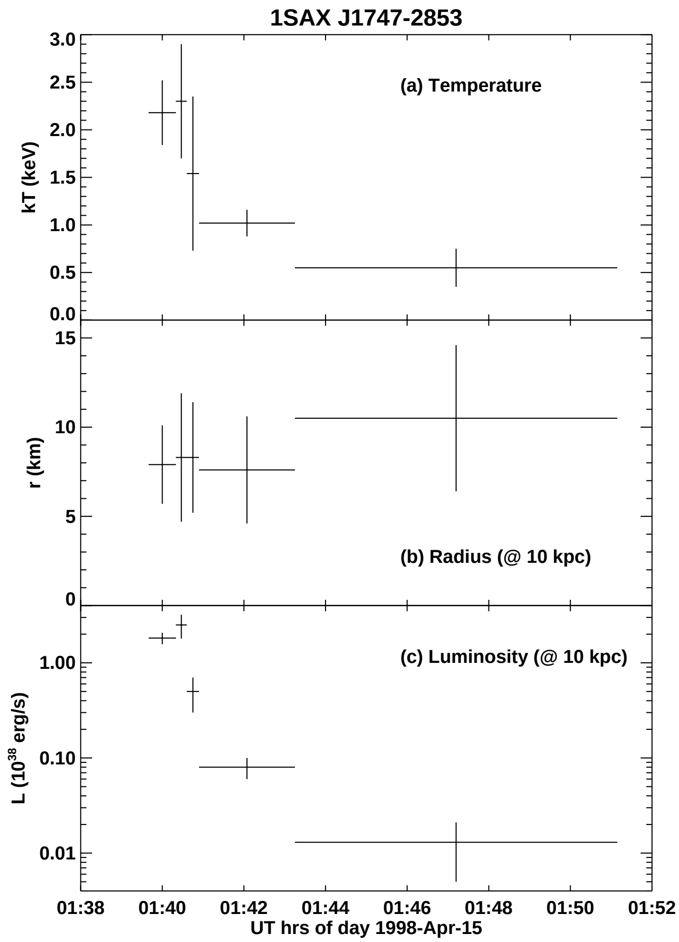

Fig. 3. Evolution of temperature, luminosity and blackbody radius during the SAX J1747.0–2853 burst. For luminosity and radius a distance of 10 kpc was assumed.

4. Discussion

The properties of the burst observed from SAX J1747.0–2853 are typical of type I X-ray bursts and allow to clearly classify this source as a neutron star in a Low Mass X-ray Binary. It is in fact widely believed that the type I X-ray bursts result from thermonuclear flashes on the surface of accreting neutron stars (see, e.g., Maraschi & Cavaliere 1977, Lewin et al. 1992).

Considering its galactic coordinates, the high absorption, and the properties of the burst, it is likely that SAX J1747.0–2853 be at a distance comparable to that of the galactic center. For a distance of ~ 10 kpc, also the flux of $\sim 5 \times 10^{-10}$ erg cm^{-2} s^{-1} observed during the previous BeppoSAX observations (Bazzano et al. 1998) is consistent with the typical luminosity of X-ray bursters (10^{36} –10^{37} erg s^{-1}).

At the time of the observation we present here, the flux had decreased by about a factor ten with respect to the first NFI observation by Bazzano et al.(1998), consistent with an exponential decay with e-folding time of ~ 8 days (Fig. 4). Unfortunately, the poor coverage of the light curve does not allow to determine the shape of the outburst.

No other X-ray sources at this position have been reported previously, with the exception of the transient GX 0.2–0.2,

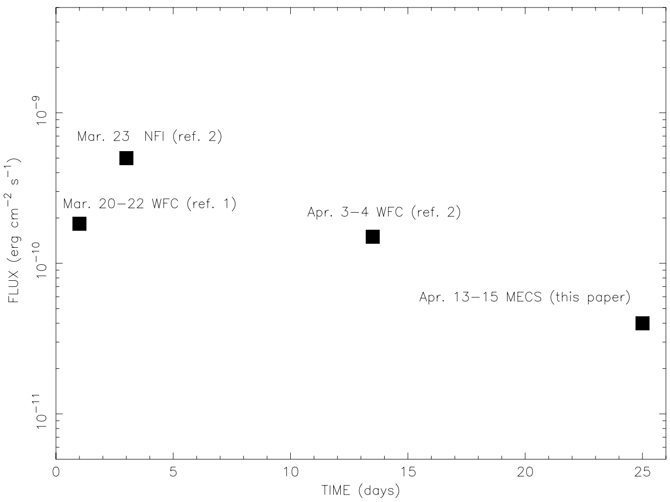

Fig. 4. SAX J1747.0–2853 recent BeppoSAX detections. The first three fluxes are taken from in't Zand (1998b, ref. 1) and Bazzano et al. (1998, Ref. 2.). In Ref. 1 and Ref. 2 flux uncertainties are not reported; our errors are smaller than the symbol used.

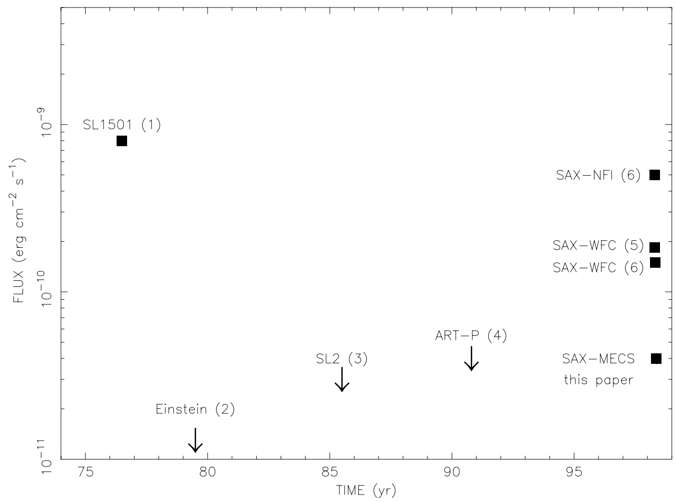

Fig. 5. SAX J1747.0–2853 detections and upper limits from 1975 to 1998. References are: (1) Proctor et al. 78; (2) Watson et al. 81; (3) Skinner et al. 87; (4) Pavlinsky et al. 94; (5) in't Zand et al. 98b; (6) Bazzano et al. 98.

that was active for a few months in 1976 (Proctor, Skinner & Willmore 1978, Cruddace et al. 1978). GX 0.2–0.2 was observed with rocket-borne instruments with limited angular resolution and more precisely located with the RMC instrument on the Ariel V satellite. The Ariel V position of GX 0.2–0.2 (90% confidence radius ~ 1.5 arcmin) is consistent with that of SAX J1747.0–2853. Although it cannot be excluded that different sources were observed, it is very likely that SAX J1747.0–2853 and GX 0.2–0.2 are the same object, as already pointed out by in't Zand et al. (1998b). No bursts were observed from GX 0.2–0.2 in 1976, but the peak luminosity, the duration of the ouburst and the relatively soft spectral shape (Proctor, Skinner & Willmore 1978) were similar to those observed in SAX J1747.0–2853.

In Fig. 5 the fluxes observed in 1976 and 1998 are compared with several upper limits that we have derived from published observations of the Galactic Center region. All the fluxes have been converted to the 2–10 keV band assuming the spectral parameters of our best fit. The SIGMA observations (Goldwurm et al. 1994) obtained at $\mathrm{E} > 40$ keV have not been reported since the corresponding upper limits ($\sim 0.6-3\times10^{-9}$ erg cm^{-2} s^{-1}) are not very constraining when extrapolated to lower energies with such a soft spectrum. For a different reason, i.e. the strong interstellar absorption, also the ROSAT data are not very useful to constrain the luminosity of SAX J1747.0–2853.

5. Conclusions

Using the MECS on–board BeppoSAX we detected a type I X-ray burst from the recently discovered source SAX J1747.0–2853. The estimated position supports the identification with the transient GX 0.2–0.2 observed in 1976. The X-ray burst is clearly indicative of the presence of a neutron star accreting matter from a low mass companion.

The analysis of the burst properties allow to estimate a distance to the source of ~ 10 kpc, that place SAX J1747.0–2853 close to the Galactic Center. The severe interstellar absorption in this region hampers the search for the optical counterpart. Applying the relation $N(HI+H_2)/A_V = 1.9\times10^{21}$ cm^{-2} mag^{-1} (Bohlin, Savage and Drake 1978), we estimate an extinction of ~ 50 mag, which means an apparent J magnitude > 30 for the low mass companion.

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References

Bazzano A. et al. 1998, IAU Circ. n.6873
Boella G., Butler R.C., Perola G.C., et al., 1997, A&AS 122, 299
Bohlin R.C., Savage B.D. & Drake J.F., 1998, ApJ, 224, 148
Cruddace R.G. et al., 1978, ApJ, 222, L95
Goldwurm A. et al. 1994, Nature 371, 589
Israel, G. L. & Stella, L. 1996, ApJ, 468, 369
Lewin W.H.G. et al. 1992, Sp.Sci.Rev. 61, 223
Lewin W.H.G. et al. 1996, ApJ 462, L39
Maraschi L. & Cavaliere A., 1977, in E.A. Muller (ed), Highlights in Astronomy, Reidel, Dordrecht, Vol. 4, Part I, 127
Mirabel I.F. et al. 1992, Nature 358, 215
Mitsuda K. et al. 1984, PASJ 36, 741
Makishima K. et al., 1986, ApJ 308, 635
Pavlinsky M.N. et al. 1994, ApJ 425, 110
Proctor R.J. et al., 1978, MNRAS 185, 745
Sidoli L. et al., proc. XTE/SAX Symp. "The Active X-ray Sky". Rome 1998, in press
Skinner G.K. et al. 1987, Nature 330, 544
Sunyaev R.A. et al. 1991, A&A 247, L29
Watson M.G. et al. 1981, ApJ 250,142
Wijnands R. & van der Klis M., 1998, Nature, in press
in't Zand J.J. et al. 1998a, A&A 331, L25
in't Zand J.J. et al. 1998b, IAU circ. n.6846