Discovery of SAX J1753.5-2349 and SAX J1806.5-2215: two X-ray bursters without detectable steady emission

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We report the discovery with BeppoSAX-WFC of two new X-ray sources that were only seen during bursts: SAX J1753.5-2349 and SAX J1806.5-2215. For both sources, no steady emission was detected above an upper limit of 5 mCrab (2 to 8 keV) for 3 10^5 s around the burst events. The single burst detected from SAX J1753.5-2349 shows spectral softening and a black body color temperature of 2.0 keV. Following the analogy with bursts in other sources the burst very likely originates in a thermonuclear flash on a neutron star. The first of two burst detected from SAX J1806.5-2215 does not show spectral softening and cannot be confirmed as a thermonuclear flash.

1. Introduction

The Wide Field Camera instrument (WFC, Jager et al. 1997) on board the BeppoSAX satellite (e.g., Boella et al. 1997) has the largest field of view (FOV) of any astrophysical X-ray imaging device flown so far. This implies an exceptional capability in finding short unexpected transient sources with durations between seconds and one hour, such as gamma and X-ray bursts. Only instruments that cover relevant portions of the sky with an appropriate time coverage can be efficient in finding such events. The relevant sky portion for gamma-ray bursts is the whole sky, for X-ray bursts this is the galactic bulge. According to a recent count of X-ray bursters before the launch of BeppoSAX (Van Paradijs 1995), about 80% of all known X-ray bursters are within 20 degrees from the direction to the galactic center. WFC can cover all of this region with a single pointing and it is obvious it can contribute a lot to the knowledge of sources of X-ray bursts.

The galactic bulge region is regularly monitored with WFC as part of an ongoing program. So far, there have been campaigns in the spring of 1997 and the falls of 1996 and 1997. In the first operational year of BeppoSAX over 10^6 s has been accumulated on the region and has turned up a number of new X-ray bursters (In 't Zand et al., 1998a, In 't Zand et al. 1998b, Heise et al. 1997, Cocchi et al. 1997a). Four of these were first detected as X-ray sources. This paper presents two of those. They are set apart by the fact that they were only detected during bursts, no steady emission was detected. A general review of the bulge observations with WFC may be found in Heise et al. 1997.

The WFC instrument consists of two identical coded aperture cameras. Each has a FOV of 40 by 40 square degrees and covers 3.7% of the sky. The angular resolution is 5' full width at half maximum. The cameras are pointed in opposite directions. Because of the low-earth orbit of BeppoSAX the FOV of either camera is at any time usually blocked by the earth. The other X-ray instruments, the so called narrow field instruments, view the sky perpendicular to the WFC. Most of the galactic bulge observations with WFC are performed with WFC as prime instrument and the center of the FOV of either camera is pointed as close as possible to the galactic center. The very bright and, therefore, disturbing source Sco X-1 is usually kept outside the FOV.

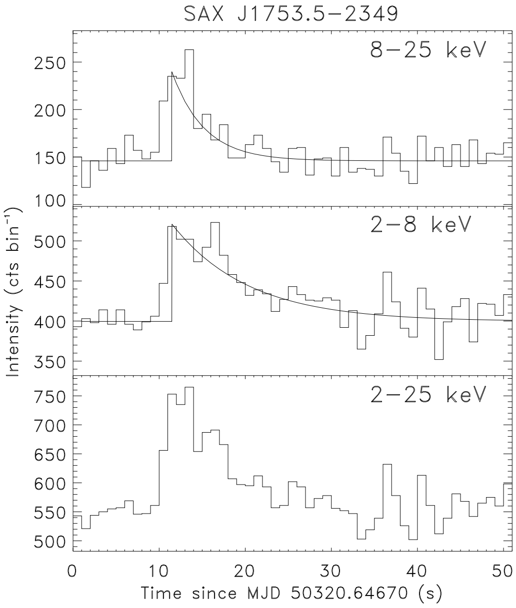

Figure 1. Time history of SAX J1753.5-2349 in two bandpasses and in the total bandpass. The photons have been counted in the portion of the detector illuminated by the source. No background subtraction was performed. The bin time is 1 s.

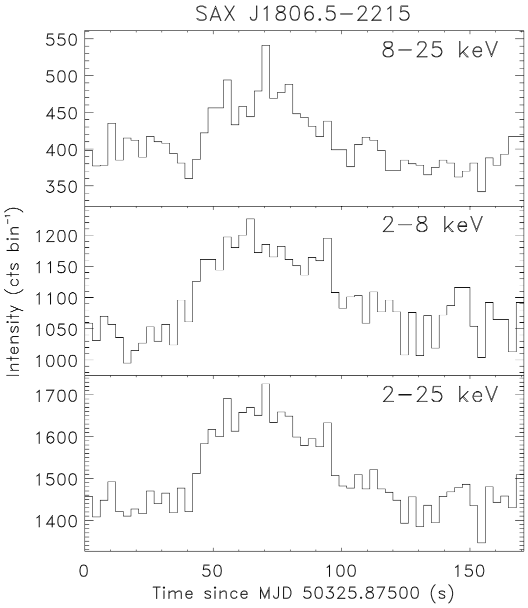

Figure 2. Time history of SAX J1806.5-2213 in two bandpasses and in the total bandpass. See caption to Figure 1 for explanation. The bin time is 3 s.

2. SAX J1753.5-2349

SAX J1753.5-2349 was detected during a single burst on August 24, 1996. The time profile of this burst is shown in Figure 1 in two bandpasses and the error region is depicted in Figure 3. The best fit position is at R.A. = $17^{\mathrm{h}}53^{\mathrm{m}}34^{\mathrm{s}}$, Decl. = $-23^{\mathrm{o}}49.4'$ (J2000.0). No identification could be made with any other known object in any wavelength band within the error box using the Simbad database in December 1997. The peak intensity of the burst is 0.9 Crab units in 2 to 8 keV.

There is strong proof of spectral softening. We fitted an exponential function to the decaying part of the burst in 2 to 8 and 8 to 25 keV, see Figure 1, and find 1/e decay times of 8.9±1.9 s and 3.8±0.7 s respectively.

The spectral model could not be constrained. However, if one assumes a black body spectrum, like is common among X-ray burst spectra, the color temperature is 2.0 ± 0.2 keV.

Not correcting for color nor gravitational redshift and assuming isotropic radiation, the black body emission region can be characterized by a sphere with a radius of 11 ± 2 km$/d_{10\mathrm{kpc}}$ where $d_{10\mathrm{kpc}}$ is the distance to earth in units of 10 kpc.

The spectral softening and the black body color temperature, together with the time and size scale identifies SAX J1753.5-2349 with great certainty as a low-mass X-ray binary with a neutron star as compact object (see Lewin, Van Paradijs

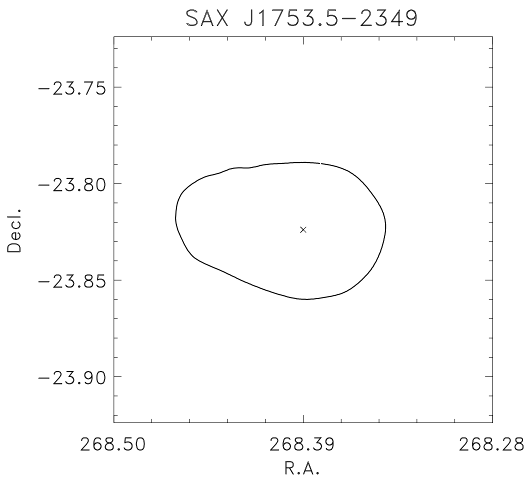

Figure 3. Error region of SAX J1753.5-2349 for a confidence level of 99%. The cross indicates the best fit position

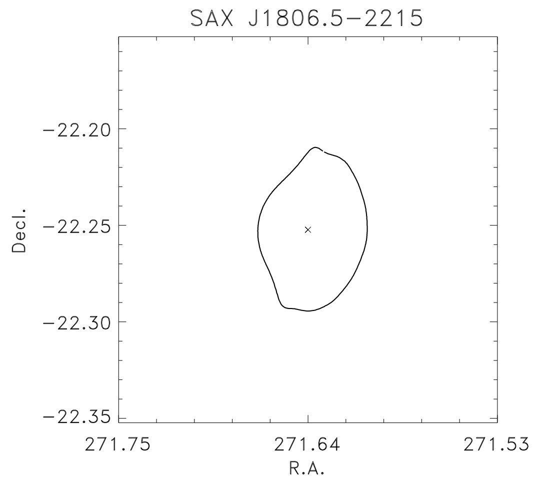

Figure 4. Error region of SAX J1806.5-2215 for a confidence level of 99%, based on the first burst. The cross indicates the best fit position

& Taam, 1995, for these diagnostics).

3. SAX J1806.5-2215

SAX J1806.5-2213 was detected during two bursts on August 30, 1996, and March 30, 1997. We here discuss the first burst which enables easier analysis than the second one. The second burst is presented by Cocchi et al. (1997a). The time profile of the first burst is presented in Figure 2 and the error region in Figure 4. The burst is relatively long, about one minute, and has a peak intensity of 1.9 Crab in 2 to 8 keV which is also relatively bright. The best fit position of the burst is R.A. = $18^{\rm h}06^{\rm m}34^{\rm s}$, Decl. = $-22^{\rm o}15.1'$ (J2000.0). The error box does not contain a known object in any wavelength band according to the Simbad database in December 1997.

The time profile in Figure 2 shows that there is no noticeable spectral softening in the burst. This sets it apart from typical X-ray bursts due to thermonuclear flashes and hampers easy characterization of this X-ray source. Nevertheless, if we fit a black body model to the observed spectrum, we find a color temperature common for such X-ray bursts: 1.7 ± 0.2 keV. The radius of the isotropically emitting sphere would be $14{\pm}3$ km$/d_{\rm 10kpc}$.

4. Steady emission

No steady emission was detected from both sources. For all observations of the month August 1996 with a total exposure time of 3 10^5 s the upper limit is 5 mCrab in 2 to 8 keV for both sources. SAX J1753.5-2349 and SAX J1806.5-2215 are the only sources in the complete WFC data set of over 10^6 s exposure time on the galactic bulge that have been seen only during bursts brighter than $\sim$0.3 Crab. Probably it is coincidence that no steady emission was detected. WFC is not an all-sky monitor and, therefore, has a far from complete coverage of the two sources. They might have exhibited steady emission above the WFC detection limit but just before WFC observed the bursts. WFC observations of XTE J1709-267 (Cocchi et al. 1997b) exemplify this: X-ray bursts were seen from this object even when the steady emission dropped below the detection limit of WFC. If bright steady emission from SAX J1753.5-2349 or SAX J1806.5-2215 would have existed before the WFC observations it could not have been above roughly 0.1 Crab units, though, because then it would very probably have been detected with the all-sky monitor ASM onboard the Rossi X-ray Timing Experiment (Levine et al. 1996) which is not the case.

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