X-ray bursts from *XTE J1709-267*

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We report evidence of bursting activity from *XTE 1709-267*, following a series of deep observations of the Galactic Centre region performed with the *WFC*'s on board *BeppoSAX*. The long exposure and the imaging capability of the instruments allowed for a better position determination for this source, tentatively classified as an X-ray nova by Marshall et al. *(IAUC 6543)* on the basis of the data collected by *RXTE-PCA*.

1. INTRODUCTION

XTE 1709-267 has been observed for the first time in the hard X-rays band by the *Proportional Counter Array (PCA)* on board the *Rossi X-ray Timing Explorer (RXTE)* [7]. The source was detected for about 20s during two different satellite manoeuvres, on Jan.16.016 and Jan.18.147 respectively.

Due to the limited amount of observing time, the X-ray characteristics of *XTE 1709-267* are not known in detail. The spectrum obtained by the *PCA* could be fitted both by a power law with a 3.06 photon spectral index and by a thermal bremsstrahlung model with kT=4.7 keV. In both cases the column density was found in excess of 2x$10^{22} cm^{-2}$, thus collocating the source close to the Galactic Centre. The uncertainty of the source position was estimated to be 6 arcminutes, suggesting a possible association of *XTE 1709-267* with the soft X-ray source *RX J1709.5-266* included in the *ROSAT All-Sky Survey* catalogue [9] , whose position is only 5' apart. During both the observations with the *PCA* the source accounted for a 2-10 keV flux of 140 mCrab, while the 1-2.4 keV flux of *RX J1709.5-266* at its detection time was only 13 mCrab.

Taking into account its spectral characteristics, *XTE 1709-267* has been tentatively classified as an X-ray nova. A possible radio counterpart of the source was found in the 1.42 and 4.9 GHz bands [3]. The radio position, given with less than 1" uncertainty, was 2'8 apart from the *PCA* position and 6' from the *ROSAT* position. One deduces that the hard X-ray source could only be associated either with *RX J1709.5-266* or with the proposed radio counterpart, but not with both.

After its discovery, *XTE 1709-267* was monitored by *RXTE-ASM* in the 2-10 keV range (*ASM Announcements*). The source was still bright (140-200 mCrab) up to Feb.20, then declined to 80-120 mCrab (Mar.12-18) and to 25-65 mCrab since Mar.19. The source was no longer in outburst since Apr.7, its flux being below 13 mCrab.

2. OBSERVATION AND DATA ANALYSIS

The *Wide Field Cameras (WFC)* on board *BeppoSAX* satellite consist in two identical coded mask proportional counters [5]. The two cameras point at opposite directions to ensure an excellent sky coverage due to the largest FOV (40°x40°) ever designed for a coded mask telescope. With its source location accuracy better than 0'.6 (68% confidence level), a time resolution of 0.5 ms, and an energy resolution of 18% at 6 keV, the *WFC*'s are very effective in studying hard X-ray (2-28 keV) transient phenomena. The imaging capability, combined with the good instrument sensitivity (a few mCrab in 10^4 s), allows for accurate monitoring of complex sky regions, like the Galac-

Table 1
Summary of the *XTE 1709-267* bursts characteristics

	burst 1	burst 2	burst 3
Observation date	Mar 18.04	Apr 13.16	Apr 13.16
Observation total duration	102.6 ks	97.8 ks	97.8 ks
Burst time	Mar 18.21058	Apr 13.52963	Apr 14.59554
Max counting rate (1s time bin)	65 ct/s	75 ct/s	60 ct/s
Max burst intensity flux (2-11 keV)	530 mCrab	600 mCrab	480 mCrab
Steady intensity flux (2-10 keV)	26 mCrab	< 3 mCrab (*)	< 3 mCrab (*)
Burst Duration	13 s	20 s	12 s

(*) 3σ upper limit

tic Centre [1].

The data of the two cameras are systematically searched for time signatures, like bursts or flares, analysing the time profiles of the detectors in the 2-11 keV energy range, integrated on a 1s time bin. Reconstructed sky images are generated in coincidence with any statistically meaningful enhancement, to identify possible bursters. This analysis method, described in detail elsewhere [4], allowed for the identification of over 300 X-ray bursts in a total of about 530 ks *WFC* observing time [2].

During a 102.6 ks observation started on 1997 Mar.18.04, a burst was detected at a position consistent with that of *XTE 1709-267* at Mar.18.21058 *UT*. The event occurred during the egress from the Earth's occultation, and its 2-11 keV time profile is shown in fig.1.

Two more bursts were detected from the same position in a different observation shift, started on Apr.13.16 and lasted for 97.8 ks. The 2^{nd} burst time profile is plotted in fig.2. Details on the three observed bursts are summarised in table 1.

3. DISCUSSION

Up to date, transient phenomena like X-ray bursts having typical duration less than a few minutes are classified in two main types (see [6] for a review).

Type-I bursts are the most common in X-ray astronomy, originating from thermonuclear flashes onto a neutron star surface. The time profiles of type-I bursts show fast rise times, ranging from less than 1s up to 10s, and longer decay times, ranging from seconds to minutes. They strongly depend on photon energy, decays being shorter at higher energies, so that bursts appear to soften during the decay. This softening has been suggested to originate from the cooling of the neutron star photosphere.

Type-II bursts have been observed only in two

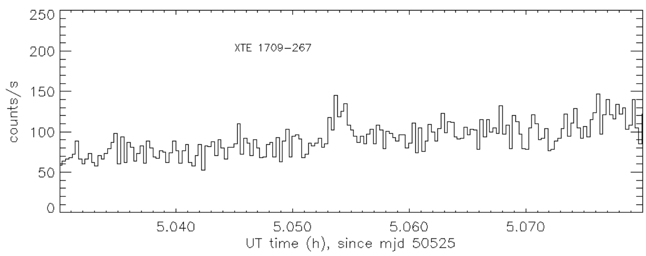

Figure 1. The 1997 Mar.18^{th} burst

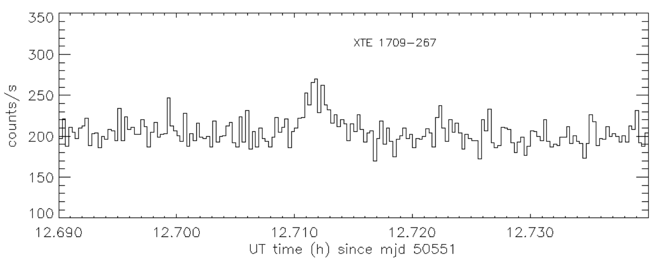

Figure 2. The 1997 Apr.13^{th} burst

peculiar cases, namely the Rapid Burster and the Bursting Pulsar *GRO 1744-28*. They show no spectral softening and are frequently repeated in time, intervals ranging from a few seconds to hours. These phenomena are thought to originate from not well understood accretion instabilities.

On the basis of their time profiles, we interpreted the three bursts detected from *XTE 1709-267* as type-I bursts. Even though the statistics is limited, the decay time appears shorter in the high energy band. Type-I bursts strongly suggest a neutron star nature for the binary system. This indicates *XTE 1709-267* as a neutron star X-ray nova.

In fig.3 the profile of the Apr.13 burst, integrated on a 2s time bin in two different energy bands, is reported. Besides the longer decay time of the low energy profile, it is apparent that the high energy emission had a 2s time lag with respect to the low energy one. Moreover, hints of a precursor event are present in both profiles, even though at a low statistical significance level.

Bursts detection from *XTE 1709-267* allowed also for an improvement of the position determination of the source. In fig.4 a sky map is reported showing the error circles of the position we calculated for the Mar.18 persistent emission and for the first two bursts. In the figure is also reported the given 6' *ASM/XTE* error circle as well as the position of the *ROSAT* source and the proposed radio counterpart. The *WFC* position is almost coincident with the *ROSAT* one, ruling out a possible association of the hard X-ray source with the proposed radio counterpart, which lies more than 5' apart. We then conclude that *XTE 1709-267* and *RX J1709.5-266* are the same source, as already suggested in the *XTE-ASM Announcements*. This implies that during January 1997 the source had an increase in intensity by about a factor of ten, as it was detected by the *XTE-PCA* at a 140 mCrab intensity flux level.

It's interesting to notice that the reported

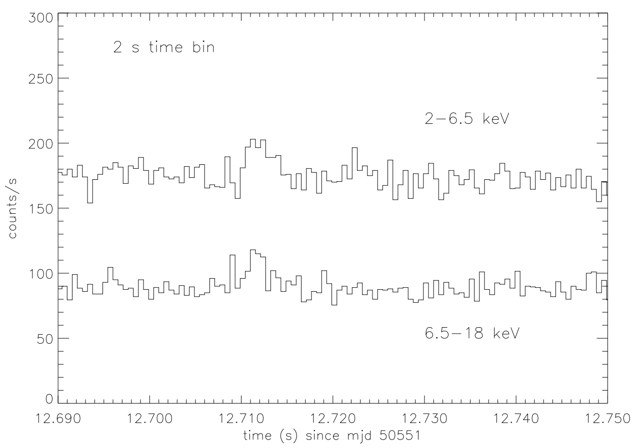

Figure 3. Time profile of burst 2 in two different energy bands

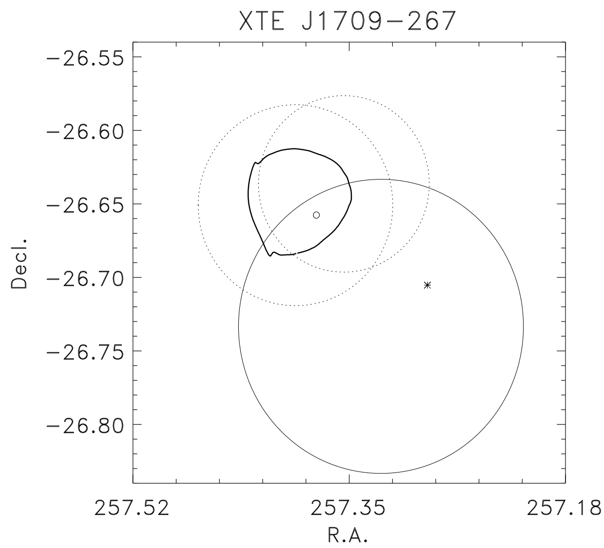

Figure 4. *WFC* error boxes for *XTE 1709-267* (99% confidence level)
Irregular error box: *WFC-SAX* steady source (Mar.18)
Dashed circles: burst 1 (right) and burst 2 (left)
Large circle: (6' radius) *XTE/PCA* [7]
Small circle: (8" radius) *RX J1709.5-266* [9]
$*$: the proposed radio counterpart [3]

bursts, which had roughly the same intensity, occurred regardless the persistent flux of *XTE 1709-267.* In fact at the epoch of the first burst detected, Mar.18, the source was reported in outburst, even though declining (about 70 mCrab intensity in the 2-10 keV band). On the contrary on Apr.13-14, when the other two bursts were observed, the source was no longer in outburst, being the flux below 13 mCrab (*ASM Announcements).* Actually, we measured a steady flux of 26 mCrab in the 2-10 keV band on March 18, while both on Apr.13 and on Apr.14 *XTE 1709-267* was undetectable in the same band with upper limit of 3 mCrab on a 3σ confidence level (see table 1).

Burst activity from neutron star X-ray novae have already been reported in a number of cases during the declining phase (e.g. *Cen X-4, 1658-298*, see [8]). Actually the Mar.18 burst of *RX J1709.5-266* occurred while the source was declining, as we measured intensities of 26, 24 and 19 mCrab on Mar.18^{th}, 19^{th} and 20^{th} respectively. Conversely, the two observed bursts on Apr.13^{th} and $Apr.14^{th}$ occurred just after the source entered in a quiescent state.

In principle, it is possible that *RX J1709.5-266* had bursting behaviour even before last January's outburst, as the bursts don't seem to be related to the persistent flux. On the other hand, it is possible that the outburst triggered the type-I burst mechanism, due to an increased accretion rate from the companion star, and the physical conditions that activated the bursts persisted even after the ingress in the quiescent phase.

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