BEPPOSAX OBSERVATIONS OF THE GALACTIC SOURCE
GS 1826-238 IN A HARD X-RAY HIGH STATE

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ABSTRACT
The BeppoSAX Narrow Field Instruments observed the galactic source GS 1826-238 in October 1997, following a hard X-ray burst with a peak flux of about 100 mCrab detected by BATSE. Two short X-ray bursts (\textasciitilde 150 seconds) were detected up to 60 keV, with larger amplitude and duration at lower energies (up to a factor 20 times the persistent emission). This confirms the proposed identification of the source as a weakly magnetized neutron star in a LMXRB system. For both persistent and burst states, the spectrum in the 0.4-100 keV energy range is well fitted by an absorbed black body, plus a flat power-law ($\Gamma \sim 1.7$) with an exponential cutoff at 50 keV.

KEYWORDS: X-ray bursts, LMXRB

1. INTRODUCTION

GS 1826-238 was serendipitously discovered by the Ginga LAC in September 1988 \cite{1} with a flux of 26 mCrab and a hard power-law spectrum (photon index $\Gamma = 1.7$), and optically identified with a $V \approx 19.3$ star \cite{2}. Observations both a month before and after the discovery by the Ginga ASM, by TTM in 1989 and by ROSAT in 1990 and 1992 found comparable flux levels \cite{2,3}. In 1994 the source was detected at a $7\sigma$ level with OSSE above 50 keV \cite{4} with a steep power-law spectrum ($\Gamma = 3.1$).

Due to its flickering flux variability and hard X-ray spectrum, reminiscent of the behavior of Cyg X-1, the source was tentatively classified as a black hole candidate. Three X-ray bursts detected on 31 March 1997 with the WFC onboard BeppoSAX \cite{5}, and two optical bursts \cite{6} suggest instead that the system contains a lowly magnetized neutron star. We focus here on the spectral shape of the source during intense, hard X-ray states and on the spectral evolution exhibited in rapid X-ray bursts.
2. OBSERVATIONS, DATA ANALYSIS AND RESULTS

Observations with the BeppoSAX Narrow Field Instruments took place on 6-7, 17-18, and 25-26 October 1997 within a Target of Opportunity program for the monitoring of X-ray transients in active state in hard X-rays. The first pointing was triggered by the BATSE detection of a hard X-ray signal with a peak flux of about 100 mCrab. On source MECS exposures lasted typically for 25-30 ks, while LECS and PDS exposures were typically 30% and 50% shorter, respectively. The target was significantly detected with the PDS up to 100 keV. Data reduction was performed following standard methods (see, e.g., [7]). The MECS light curves exhibit two pronounced X-ray bursts of a factor 20 amplitude in the range 1.6-10 keV and ~150 seconds duration on October 18.12 (Fig. 1) and 26.19 UT. (Due to instrumental visibility constraints, the LECS only partially detected the first burst.) Both bursts were also detected, up to 60 keV, by the PDS. The flux exhibits a linear rise, which appears faster at higher energies, followed by an exponential decay. Burst amplitudes and durations decrease with increasing energy. Excluding the bursts, no significant variability is seen at any frequency within a same pointing, nor from epoch to epoch. For the spectral analysis, the LECS, MECS, HPGSPC and PDS data have been considered in the ranges 0.4-6 keV, 1.6-10 keV, 6-30 keV, and 15-100 keV (15-50 keV for the bursts), respectively. Both persistent and burst emission spectra cannot be fitted by an absorbed black body model only, but they exhibit a high energy tail which is accounted for by a power-law model plus a high energy cutoff (Fig. 2). For the October 17-18 observation, we obtain fitted temperatures of $T_{BB} = 0.94 \pm 0.05$ keV and $T_{BB} = 1.9 \pm 0.1$ keV for persistent and burst emission, respectively, power-law photon indices $\Gamma = 1.34 \pm 0.04$ and $\Gamma = 1.1 \pm 0.4$, and exponential cutoffs $E = 49 \pm 3$ keV and $E = 12 \pm 4$ keV. The last value is very
uncertain, due to the more limited energy range used for the fit. A fit to time-resolved spectra in the 2-10 keV range along the burst light curve indicates that the temperature decreases during the burst decay. The burst emission spectrum has been fitted without subtracting the underlying persistent signal, to avoid neglecting the possible influence of the burst on the accretion flow (see [8], and references therein).

3. DISCUSSION

The energy-dependent amplitude of the bursts detected by BeppoSAX and their shorter duration at higher energies strongly suggest a thermonuclear origin. This is confirmed by the good fit obtained with a thermal model up to 10 keV and by the decreasing black body temperature during the burst decay. The present and previous observations of burst activity in GS 1826-238 rule out the black hole nature of the central accretor and suggest the presence of a weakly magnetized neutron star in a LMXRB system. While the temperature of the black body doubles during the burst with respect to the persistent emission, the slope of the high energy power-law does not significantly vary, although its normalization is a factor of two larger in burst than in persistent state, indicating that the hard tail is intrinsically significant in the burst state too. A similar finding was previously reported for X1608–52 by Nakamura et al. [9], although the explored spectral range was more limited. Our fitted temperature of ~2 keV during the burst is consistent with the inverse correlation Nakamura et al. find between temperature and hard tail intensity (see their Table 2). This high energy component is tentatively interpreted in terms of inverse Compton scattering of soft black body photons off high energy electrons in a hot region surrounding the neutron star (see however Day & Done [10]). The break at 50 keV, reminiscent of that observed by BATSE in X1608–52 [11], indicates that, unlike in black hole candidates, the neutron star surface emission at soft energies tends to cool the hot Comptonization region. The temporal spacing of the two bursts detected by the present BeppoSAX observations is consistent, within the 40 minutes uncertainty, with the 5.67 hours period found by Ubertini et al. [12] during 2.5 years of WFC observations.

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FIGURE 2. Top panel: spectrum of the persistent emission measured on October 17 by the four Narrow Field Instruments along with the model which best fits the overall spectrum. The average flux level in the 2-10 keV band is $5.6 \times 10^{-10}$ erg s$^{-1}$ cm$^{-2}$. The best fit value for the neutral hydrogen column density, $N_{\text{H}} \simeq 4.7 \times 10^{21}$ cm$^{-2}$, is consistent with the Galactic one. The residuals with respect to $\chi^2 = 1$ are also shown. Bottom panel: spectrum of the burst+persistent emission measured by the MECS, HPGSPC and PDS during the October 18 event. Best fit model curve and residuals are also shown.