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LETTER

Letter to the Editor

Discovery of a 0.08 Hz QPO in the power spectrum of black hole candidate XTE J1118+480

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Abstract. We found a strong QPO feature at 0.085 ± 0.002 Hz in the power spectrum of an X-ray transient XTE J1118+480. The QPO was detected in PCA/RXTE data with an amplitude close to 10% rms, and width 0.034 ± 0.006 Hz. The shape of the power spectrum is typical for black hole candidates: almost flat at frequencies lower than 0.03 Hz, roughly a power law with slope $\sim$1.2 from 0.03 to 1 Hz, with steepening to $\sim$1.6 at higher frequencies. The hard energy spectrum detected up to $\sim$150 keV and the absence of significant X-ray variability at the high frequencies above 100 Hz strongly support the identification of XTE J1118+480 as black hole transient.

Key words: stars: binaries: general – stars: flare – stars: neutron – stars: individual: XTE J1806–246 – X-rays: stars

1. Introduction

The transient X-ray source XTE J1118+480 was discovered with the RXTE All-Sky Monitor on March 29th, 2000. Subsequent RXTE pointed observations revealed a power law energy spectrum with a photon index of about 1.8 up to at least 30 keV. No X-Ray pulsations were detected (Remillard et al., 2000) In hard X-rays the source was observed by BATSE up to 120 keV (Wilson&McCollough 2000). Uemura, Kato & Yamaoka(2000) reported the optical counterpart of 12.9 magnitude in unfiltered CCD. The optical spectrum was found typical for the spectrum of an X-Ray Nova in outburst (Garcia et al. 2000). Pooley & Waldram (2000) using the Ryle Telescope detected a noisy radio source with flux density of 6.2 mJy at 15 GHz.

All existing observations show that XTE J1118+480 is similar to the black hole transients in close binaries with a low mass companion.

In this Letter we report on the detection of quasi-periodical oscillations (QPO) in the power spectrum of this source.

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Table 1. RXTE target-of-opportunity (TOO) observations of XTE J1118+480 used in our analysis.

ObsID	Date 2000	TimeStart UT	Exp. ksec
50503-01-01-00	Mar.29	22:51	0.7
50407-01-01-00	Apr.13	09:28	5.0
50407-01-01-01	Apr.13	14:18	3.1
50407-01-02-00	Apr.15	07:51	1.1
50407-01-02-01	Apr.17	04:44	4.1
50407-01-02-02	Apr.18	19:21	1.0
50407-01-02-03	Apr.18	21:27	1.8
50407-01-03-01	Apr.24	20:35	0.7
50407-01-03-02	Apr.27	01:57	0.9
50407-01-04-02	May 1	11:25	1.8
50407-01-04-01	May 4	05:15	1.0

2. Observations and data analysis

In our analysis we used public domain target-of-opportunity observations of XTE J1118+480 performed by the Rossi X-ray Timing Explorer (RXTE) observatory in the period Mar 29 – May 4, 2000. The total usable exposure time of 11 observations was approximately 22 ksec. The source was weak during all analyzed RXTE observations ($\sim$40 mCrab in 2-12 keV spectral band). The source count rate was about 90–100 cnt/s/PCU. In Fig. 1 we present a light curve of the recent outburst of XTE J1118+480 accoring to data of All Sky Monitor (ASM) aboard RXTE as it is provided by MIT ASM/RXTE team.

All data reduction was performed using the latest HEAsoft/FTOOLS 5.0 package. The correction for counting statistics noise in the power spectra was done according to the procedure described in Sunyaev & Revnivtsev 2000 (see also Zhang et al. 1996).

3. Results

The power spectrum of XTE J1118+480 with a strong QPO feature is shown in Fig. 2. The simplest Lorentz approxima-

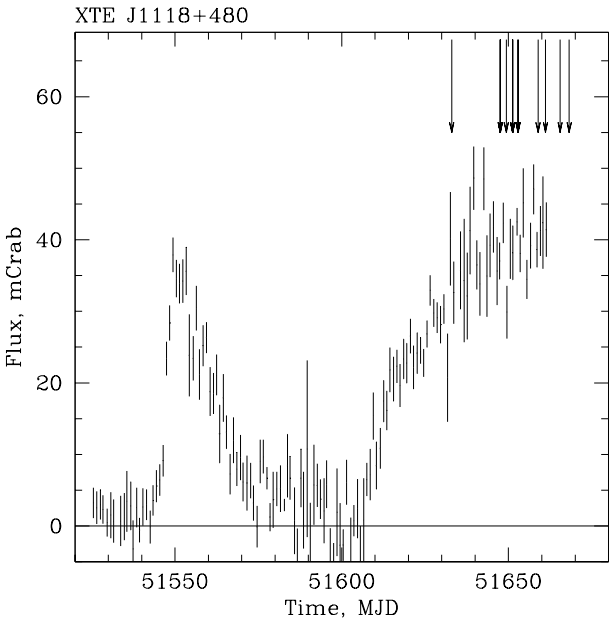

Fig. 1. The RXTE/ASM light curve (1.3-12.2 keV) of the transient XTE J1118+480. Arrows show the dates of RXTE pointed observations, used in our analysis.

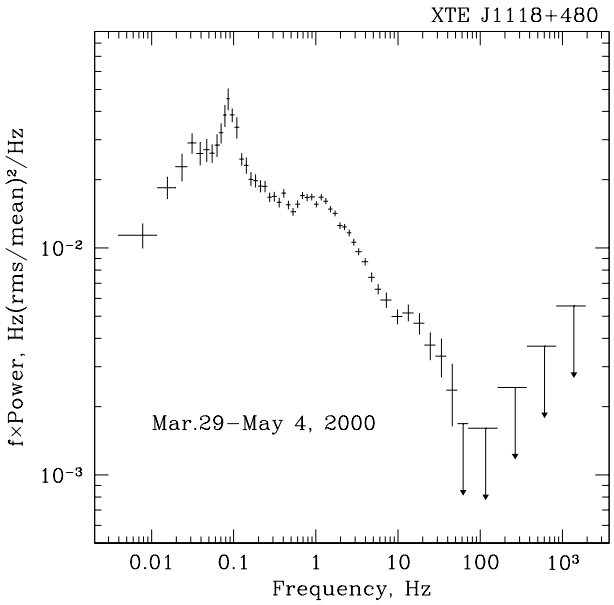

Fig. 2. Power spectrum of XTE J1118+480

tion of the detected QPO peak gives the centroid frequency 0.085 ± 0.002 Hz and the width 0.034 ± 0.006 Hz (Q parameter ∼2–3). The amplitude of the QPO is ≈10% rms. The power density spectrum (PDS) of the source is typical for a black hole candidates in the low/hard spectral state. The power spectrum is almost flat at frequencies below ∼0.03 Hz, roughly a power law with slope ∼1.2 from 0.03 to 1 Hz with steepening to slope ∼1.6 at higher frequencies. The total amplitude of detected variability of the source is close to 40% rms. We did not detect any X-ray variability of the source flux at the frequencies higher than ∼70 Hz. The 2σ upper limits on the kHz QPOs in the frequency band 300–1000 Hz are of the order of 5–6% for QPO with quality $Q \sim 10$, this is in 1.5–3 times lower than typical amplitudes of observed kHz QPOs in the neutron star PDSs (e.g. van der Klis 2000).

Our preliminary analysis of the XTE J1118+480 energy spectrum confirms that it is very hard: it was detected by High Energy Timing Experiment (HEXTE) up to energies of ∼130–150 keV with the power law slope $\alpha \sim 1.8$ with possible cutoff at the highest energies (≳130 keV) The spectrum of XTE J1118+480 is very similar to that of the transient source GRS 1737–37 (Sunyaev et al. 1997, Trudolyubov et al. 1999a, Cui et al. 1997). A detailed spectral analysis of XTE J1118+480 will be presented elsewhere.

4. Discussion

Low frequency QPO peaks were reported earlier in the power spectra of several black hole candidates in their low/hard state – at ∼0.03–0.07 Hz with $Q \sim 1$ for Cyg X-1 (Vikhlinin et al. 1992, 1994, Kouveliotou et al. 1992a), at ∼0.3 Hz for GRO J0422+32 (Kouveliotou et al. 1992b, Vikhlinin et al. 1995), ∼0.8 Hz for GX 339-4 (e.g. Grebenev et al, 1991, Nowak, Wilms & Dove 1999), ∼0.08–4 Hz for XTE J1550-564 (Cui et al. 1999) and in the high/soft state of LMC X-1 (Ebisawa, Mitsuda & Inoue 1989) and XTE J1748–288 (Revnivtsev, Trudolyubov & Borozdin 2000). Impressive QPOs with harmonics were observed e.g. in the power spectra of GRS 1915+105 (e.g. Greiner et al. 1996, Trudolyubov et al. 1999b). The detection of low frequency QPO in the power spectrum of XTE J1118+480 allows us to add another black hole candidate to this sample. In all these cases the QPO peak lies close to the first (low frequency) break in the power spectrum (see also Wijnands & van der Klis 1999).

It is interesting to note that the brightness of the optical counterpart of XTE J1118+480 allowed to detect a similar QPO feature in optics – there was found a QPO with $f \sim 0.1$ Hz (Scillman 2000).

The power spectra of black hole candidates are drastically different from those of neutron stars in LMXBs in similar low/hard spectral state. Sunyaev and Revnivtsev (2000) presented a comparison of power spectra for 9 black hole candidates and 9 neutron stars. None of the black hole candidates from this sample show a significant variability above ∼100 Hz, while all 9 neutron stars were noisy well above 500 Hz, with the significant contribution of high-frequency noise $f > 150$ Hz to the total variability of the source. The power spectrum of the newly discovered X-ray transient XTE J1118+480 (see Fig. 2) looks very similar to other black hole PDSs (see Fig. 1 of Sunyaev and Revnivtsev, 2000).

The detection of low frequency QPO, lack of high-frequency noise and a hard energy spectrum detected up to ∼150 keV in X-rays are supportive arguments for the earlier identification of XTE J1118+480 as a black hole candidate.

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