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XTE J1807-294: Modulation of the pulsed flux with a refined spin period and orbit parameters

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Abstract. The accreting millisecond pulsar XTE J1807-294, discovered by RXTE on February 21, 2003 (Markwardt et al. , 2003ai), was observed as Target of Opportunity (ToO) by *XMM-Newton* on March 22, 2003. The source was detected in bright phase with an observed count rate of 33.3 cts s^{-1} in the EPIC pn-CCD camera in the 0.5–10 keV band (3.7 mCrab). Using the best-fit orbital period of 40.0741±0.0005 minutes reported by (Markwardt et al. , 2003c) and assuming a circular orbit as first approximation, we derived 4.8±0.1 light-ms for the projected orbital radius. The barycentric mean spin-period of the pulsar was derived as 5.2459427±0.0000004 ms. The modulation is seen over the entire energy band from 0.5 to 10 keV. The combined pulse profile in the 0.5–10 keV band shows a modulation of 6.0±0.1 % (90 % confidence).

Key words. stars: neutron star-pulsars: individual: XTE J1807-294 - super nova - X-rays: stars

1. Introduction

Accreting millisecond pulsars have been predicted to be the possible end state of low-mass X-ray binary (LMXB) evolution. In an LMXB a neutron star increases its spin frequency up to millisecond periods while decreasing its magnetic field due to the accretion of matter and torque from its stellar companion. At the end of the accretion phase, it may turn on as a radio millisecond pulsar (Bhattacharya & van den Heuvel , 1991). The discovery of accreting millisecond pulsar SAX J1808.4-3658 provided the first evidence of a neutron star spun-up by mass accretion in the LMXB with a 2.49 ms period (Wijnands & van der Klis , 1998).

XTE J1807-294, the fourth candidate accreting millisecond pulsar was discovered by RXTE (Markwardt et al. , 2003ai) on February 21, 2003. A coherent pulsation of 5.245902 ms

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was detected and subsequently the orbital period of 40.0741±0.0005 minutes was established (Markwardt et al. , 2003b) confirming it to be the shortest orbital period of the so far known four accreting millisecond pulsars. The spin-period of XTE J1807-294 was confirmed using XMM-Newton data (Kirsch & Kendziorra , 2003) and sinusoidal spin-profiles were established in three different energy bands covering 0.3–10 keV.

2. Data analysis

XTE J1807-294 was observed with *XMM-Newton* on March 22, 2003 under ObsId 01579601 in revolution number 601 with an exposure duration of 9293 s. The EPIC-pn Timing mode data were processed with *SAS 5.4.1*. Event times were corrected to the solar barycenter with the SAS tool *barycen*. The Timing mode of the EPIC pn-CCD camera provides only spatial resolution in one dimension and hence a point source is smeared out in the Y-direction. Therefore we used as extraction region for the source a 9 column wide window containing columns 33–41 (3–11 for the background respectively).

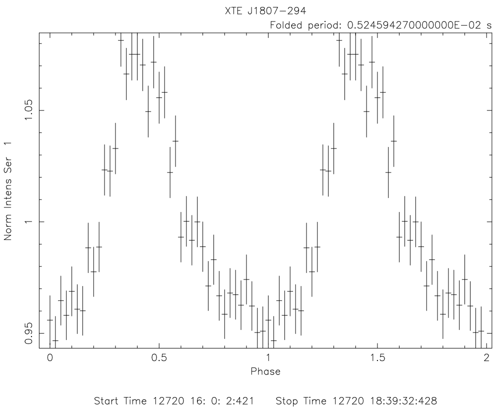

Fig. 1. Folded spin light curve in the energy range 0.5–10 keV

Using the best fit orbital period of 40.0741±0.0005 minutes (Markwardt et al. , 2003b) we grouped the events into 20 phase bins of the binary orbit. χ^2 maximum epoch folding on individual phase bins revealed a clear modulation of the spin period. Assuming, in first approximation, a circular orbit, we derived a value of 4.8 ± 0.1 light-ms for the projected orbital radius. The barycentric mean spin period of the pulsar was found to be 5.2459427±0.0000004 ms.

Epoch folding with that period at the epoch 52720.724 (MJD) shows a clear modulation of the flux over the entire energy band from 0.5 to 10 keV. The pulse profile shows a single peak (1.5 ms FWHM), its shape slightly varying with energy. The combined pulse profile in the 0.5–10 keV band shows a modulation of 6.0±0.1 % (90 % confidence) (see Figure 1).

Finer analysis of the pulse profile in different energy bands shows a higher pulsed fraction at the energy range 6–10 keV.

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