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Observation of the AXP 5U 0142+61 with XMM-Newton

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Abstract. We present results of a recent observation with the EPIC cameras on *XMM-Newton* of the anomalous X-ray pulsar 4U 0142+61 which was performed on 2003 January 24. The object belongs to a small class of pulsars with very soft spectra and spin periods around 10 seconds. These objects often were debated to be powered either by a decaying strong magnetic field or by accretion from a residual disk. Therefore, we tried to look for cyclotron lines in the X-ray band resulting from strong magnetic fields.
The observation was done in EPIC pn small window mode and for both MOS in timing mode. Data from all detectors can be well described by a black body plus power law spectral model, with $kT_{BB} = 0.398(7)$ keV and $\Gamma = 3.71(6)$. These results agree with the last observation by *Chandra*. No evidence for additional spectral features like cyclotron lines was found. The flux of $\approx 5.1 \cdot 10^{-11}$ erg sec^{-1}cm^{-2} $(2 - 10\,\text{keV})$ is consistent with previous observations. A period search for this object using the method of epoch folding resulted in a period of 8.6886(3) sec.

1. The Anomalous X-Ray Pulsar 4U 0142+61

Anomalous X-Ray pulsars are a small group of objects which have in common a spin period in the range of $6 - 12$ sec with long term spin down of $\dot{P}/P \approx 1 \times 10^{-13}$ [s^{-1}]. They also have a characteristic soft spectrum ($\Gamma \approx 3$) and low luminosity compared to High Mass X-ray Binaries (Israel et al. 2002). No evidence for a binary companion star is established. Searches for an optical counterpart rule out bright O/B stars.

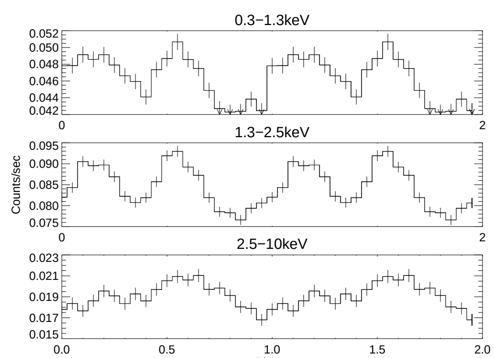

Fig. 1. Pulse profile in the energy range 0.3 – 10 keV

The brightest AXP is 4U 0142+61 for which an optical counterpart was proposed (Kern & Martin 2002).

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Table 1. Spectral fit of a black body plus powerlaw model (χ^2/DOF = 1341/1127) in comparison with *Chandra* (Patel et al. 2003). The result displays the hydrogen column density (N_H), the blackbody temperature (kT) and the Photon Index (Γ). Flux is given in 0.2 – 10 keV range.

	XMM-Newton	*Chandra* (ACIS)
N_H [cm^{-2}]	$0.94(2) \times 10^{22}$	$1.1(1) \times 10^{22}$
kT	0.398(7) keV	0.470(8) keV
Γ	3.71(6)	3.40(6)
Flux [erg cm^{-2} sec^{-1}]	5.1×10^{-11}	8.3×10^{-11}

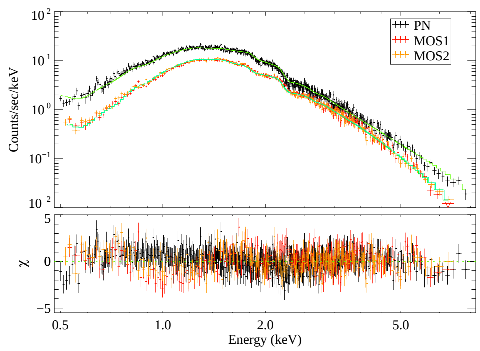

Fig. 2. Spectral result of a Blackbody plus Powerlaw model.

Here we present an observation taken on 2003 January 24 with *XMM-Newton*. The observation lasted 6 ksec; it was performed in pn small window mode while the MOS cameras were in the fast timing mode.

For position determination we fit a Gaussian curve at the pn point spread function. Within the 2.″2 absolute pointing error of *XMM-Newton* the object's location (α = $1^h46^m22^s.287$; δ = 61°45′02.″60(J2000)) is consistent with the position determined by *Chandra* (Patel et al. 2003).

2. Timing

Lightcurves for all EPIC instruments were extracted with a resolution of 0.01 s and barycenter corrected. A period determination for all lightcurves was done using epoch folding in the energy range 0.3 – 10 keV. The joint period was 8.6886(3) sec which agrees with the period of 8.6886(3) sec obtained by *Chandra* (Patel et al. 2003) and an estimated period of 8.68832888(3) extrapolated from a long term *RXTE* timing campaign (Gavriil & Kaspi 2002).

Errors are estimated using a Monte-Carlo approach. The given profile was used as a template for a sample of simulated lightcurves. The distribution of period determinations from these lightcurves are used as an estimator for the period uncertainty. Energy resolved profiles (Fig. 1) show a clear distinction between a double peak at low energies up to a sinusoidal behavior at higher energies.

3. Spectra

Spectral results were obtained for all three EPIC instruments with a joint fit. The best fit achieved with a was a black body plus powerlaw model (Table 1) and is shown in Fig. 2. There was no indication for cyclotron lines between 0.5 to 10 keV.

Finally we split the lightcurve into ten phase bins. The detailed analysis shows variation both of Γ and kT_{BB} with pulse phase, which will be presented elsewhere.

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