

INTEGRAL observations of PSR B0540-69

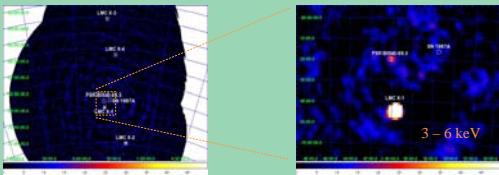
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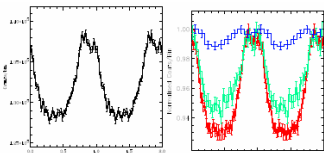
PSR B0540-69 is often called an extragalactic 'twin' of the Crab pulsar in the Large Magellanic Cloud. The pulsar is embedded in a synchrotron nebula in the center of SNR 0540-69.3. PSR B0540-69 was discovered with the Einstein satellite (Seward, Harnden and Helfand, 1984) with P~50 ms, spin-down age of ~1500 years and a spin-down luminosity of $\sim 10^{38}$ erg/s. It has since been detected with all major X-ray telescopes. At X-ray energies up to ~40 keV the latest observations were reported from RXTE (de Plaa et al., 2003) and from INTEGRAL (only spectrum) in the context of a survey of the LMC (Götz et al., 2006). Optical pulsed emission (Middleditch and Pennypacker, 1985) and faint radio emission (Manchester et al., 1993) have also been found from PSR B0540-69.

The INTEGRAL analysis presented here is based on observations of the LMC obtained in Jan. 2003 and Jan. 2004 with a total exposure of ~1.5 Ms. In the mosaic maps from the total exposure (JEM-X and IBIS/ISGRI) a source at the location of PSR B0540-69 is clearly visible up to energies of ~200 keV. After barycentric correction and determination of the pulsar phases, based on the ephemeris available from contemporaneous RXTE data, the lightcurves show the characteristic shape of a broad pulse up into the 40-100 keV band. At higher energies no significant pulsation is detectable. We derive the spectrum of the total source from the ISGRI data (judging the calibration of JEM-X to be not applicable to such a weak source). The photon spectrum can be fitted with a power law of index 2.22, which is compatible with the result found by Götz et al., 2006.

PSR B0540-69 and its surroundings mapped with JEM-X



PSR B0540-69 Ephemeris 2003/2004 Derived from RXTE/PCA observations



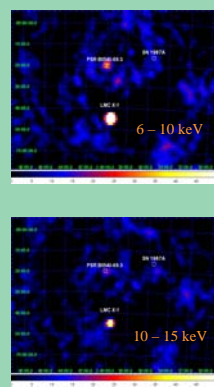
RXTE/PCA lightcurves for 2003 (left) and 2004 (right, for 2-10 (r), 10-20 (g), and 20-30 (b) keV respectively)

Parameter & Value	Value
α_{2000}^*	05 ^h 40 ^m 11 ^s .221
δ_{2000}^*	-69 [°] 19'54".98

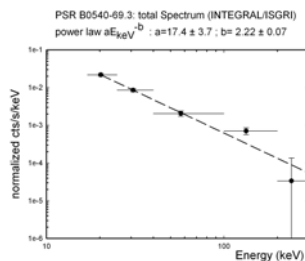
Rev. 27, 28, 29, 33, 34 and 35	
Val. range (MJD)	52620-52670
t_0 (TDB MJD)	52625.000000000
ν_0 (Hz)	19.779296587915
$\dot{\nu}_0$ (10^{-10} Hz s ⁻¹)	-1.87410
$\ddot{\nu}_0$ (10^{-20} Hz s ⁻²)	2.51

Rev. 150, 151, 152	
Val. range (MJD)	53007-53062
t_0 (TDB MJD)	53007.000000000
ν_0 (Hz)	19.773116586988(11189)
$\dot{\nu}_0$ (10^{-10} Hz s ⁻¹)	-1.87256(11)
$\ddot{\nu}_0$ (10^{-21} Hz s ⁻²)	3.413(4.92)

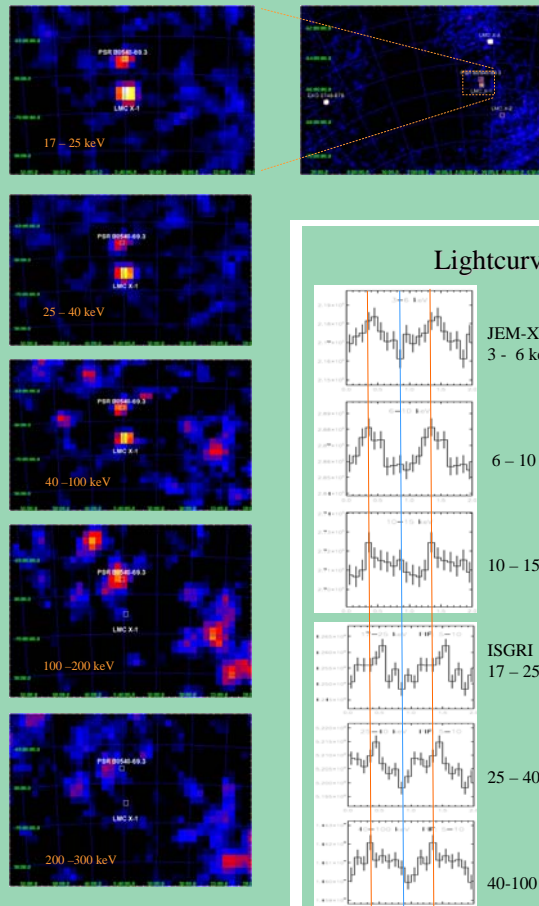
General parameters of the pulsar	
Age	1.67 kyr
Magnetic field ^b	4.97×10^{12} G
Distance ^c	49.40 kpc
Spin-down luminosity ^d	1.5×10^{38} ergs s ⁻¹



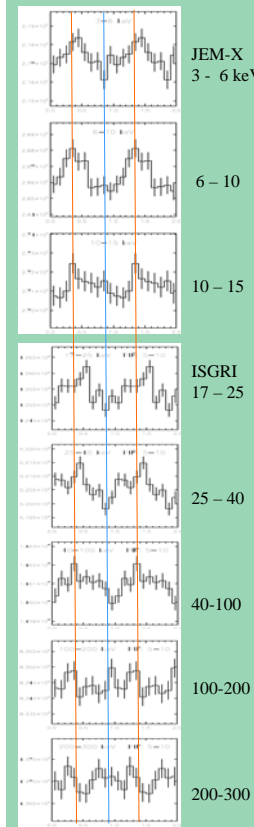
ISGRI Spectrum



PSR B0540-69 with ISGRI



Lightcurves



Summary: PSR B0540-69 has been detected up to ~200 keV with pulsations visible up to 100 keV. The total source photon spectrum can be fitted with a $E^{-2.22}$ power law and the flux in the range 17-300 keV is about 6×10^{-11} erg s⁻¹ cm⁻². The pulsed fraction of the total emission decreases with energy and only upper limits could be derived above 100 keV assuming a lightcurve profile from lower energies. Cheng and Wei, 1995 predict in an outer gap emission model for the parameters of PSR B0540-69 a significant downturn of the synchrotron spectrum around 50 keV, which we seem to confirm. Above 100 keV the Cheng & Wei model predicts an inverse Compton spectrum to dominate, but its intensity is lower by about a factor of 10 with respect to the extrapolation from soft X-rays.

Acknowledgement: We thank Lucien Kuiper for his help with the RXTE pulsar ephemeris

References:
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