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Search for cyclotron lines in *INTEGRAL*/SPI spectra of Vela X-1

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Abstract

The wind-accreting X-ray binary pulsar Vela X-1 has been observed during the two *INTEGRAL* Core Program observations of the Vela region in June–July and November–December 2003.

Preliminary results on time averaged and time resolved spectra of *INTEGRAL*/SPI for the two observation epochs are presented. Time averages have been used in order to increase the signal to noise ratio, but cyclotron line features expected at ~20–25 and ~53 keV are without any doubt detected in the *INTEGRAL*/SPI spectra. This work shows that the detection of cyclotron feature as given in [Kretschmar, P., Staubert, R., Kreykenbohm, I., et al. In: Proceedings of 5th INTEGRAL Workshop, 2004.] should be taken with caution due to background modelling uncertainties. Further work using a better in-flight energy calibration and background monitoring is planed to improve the analysis.

Keywords: Vela X-1; *INTEGRAL*; Cyclotron lines

1. Introduction

Vela X-1 (4U 0900-40) is an eclipsing high mass X-ray binary with an orbital period of 8.96437 days (Barziv et al., 2001) at a distance of ~2.0 kpc (Nagase, 1989). This system is composed of a B0.5Ib supergiant (HD 77581) and an accreting magnetized neutron star. The accretion on the neutron star is provided by the wind of its companion emitting $4\times10^{-4}M_{\odot}$/yr (Nagase et al., 1986). The optical companion has a mass of $\sim23M_{\odot}$ and a radius of $\sim30R_{\odot}$ while the neutron star mass is estimated to be $\sim1.8M_{\odot}$ (Barziv et al., 2001) with a spin period of ~283 s (McClintock et al., 1976). Both spin period and period derivative vary erratically between two measurements as is expected for a wind accreting system.

The typical X-ray luminosity of Vela X-1 is $\sim4\times10^{36}$ erg/s, but both sudden flux reductions to less than 10% of its normal value (Inoue et al., 1984; Lapshov et al., 1992; Kreykenbohm et al., 1999) and flaring activity (Kendziorra et al., 1990; Haberl and White, 1990; Kreykenbohm et al., 1999) have been observed in the past. The broadband X-ray spectrum of Vela X-1 has the typical shape of accreting pulsar spectra with a power law continuum at low energy and an exponential cutoff at higher energies. A cyclotron resonant scattering feature (CRSF) at ~55 keV was first reported from observations with *Mir-HEXE* (Kendziorra et al., 1992). Makishima et al. (1992) and Choi et al. (1996) reported a weak absorption feature at ~25 keV from *Ginga*. This low energy feature has been disputed by *BeppoSAX*

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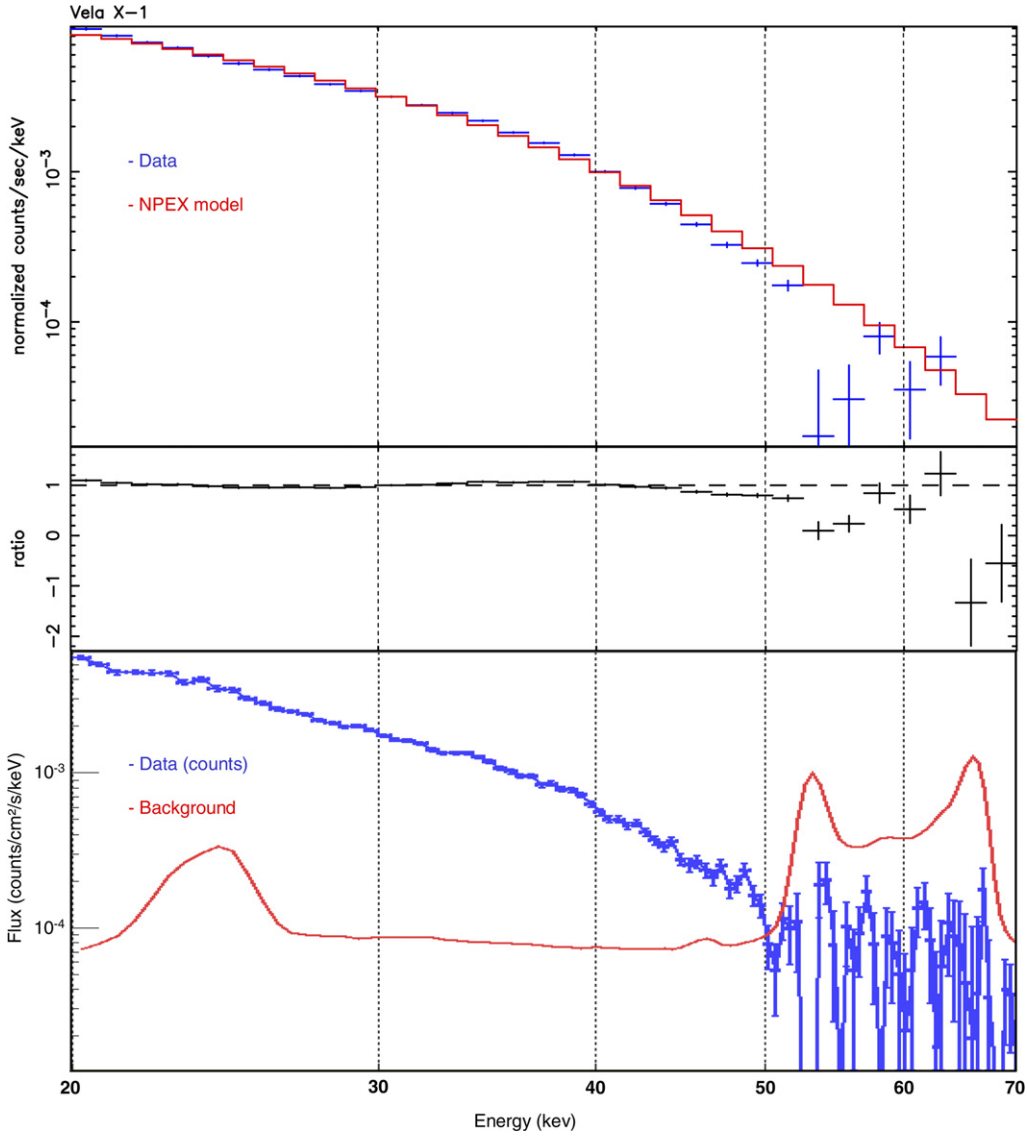

Fig. 1. SPI averaged spectrum of Vela X-1 [top] and spectrum in counts with the background associated [bottom].

observations (Orlandini et al., 1998) but supported by phase resolved analysis of *Mir-HEXE* (Kretschmar et al., 1997) and *RXTE* data (Kreykenbohm et al., 2002).

2. *INTEGRAL*/SPI observations of Vela X-1

The spectrometer SPI (Vedrenne et al., 2003) onboard *INTEGRAL* is the latest ESA's gamma-ray satellite launched in October 2002. According to Attié et al. (2003), at the CRSF expected energies of 25 and 50 keV, the corresponding effective areas are, respectively, 50 and 107 cm^2, while the energy resolution is 1.6 keV for both lines. The lines sensitivity for a total time of 10^6 s are 7×10^{-5} ph cm^2 s^{-1} and 5×10^{-5} ph cm^2 s^{-1} (Roques et al., 2003; Jean et al., 2003).

During the core program, the Vela region has been observed during two campaigns, in June–July 2003 (revolutions 81–88) and November–December 2003 (revolutions 137–141) which give us a total time of $\sim 2.44 \times 10^6$ s, where the dead time of 12.2% has been taken into account. The data during the periods of solar flares as well as the pointings just before or after the crossing of the radiation belts are excluded. This reduces the duration to ~1.96 Ms. During the observation, the pulsar was eclipsed by its companion during one third of the time. Altogether, the effective time available for the spectral analysis is finally ~780 ks (i.e., 30% of the life time). Then the line sensitivity at 25 keV decreases to 8.5×10^{-5} ph cm^2 s^{-1} and at 50 keV to 6×10^{-5} ph cm^2 s^{-1}.