HIGH-RESOLUTION SPECTROSCOPIC OBSERVATION OF VELA X-1 IN THE HARD X-RAY ENERGY RANGE

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ABSTRACT

We are reporting results of the first high-resolution (1.2 keV FWHM) hard X-ray (> 20 keV) observation of Vela X-1. Data were accumulated during a 5-hour balloon flight launched in Alice Springs, Australia on December 5, 1984. A summed-epoch analysis yields a light curve (Figure 1) and period (283 sec) consistent with previous measurements[1]. Significant pulsations were present to an energy of 60 keV. No statistically significant features were observed in the energy spectrum (Figure 3) and the spectrum (Figure 2) is well fit (χ^2 = 17.8 for 16 d.o.f.) by a simple exponential spectrum with an E-folding length of 10.8 ± 1.0 keV.

1. Introduction. Vela X-1 (4U 0900-40) is an eclipsing X-ray binary pulsar with a pulsar period of 283 sec and an orbital period of 8.96 days[1]. The hard X-ray spectrum is believed to reflect conditions near the surface of the neutron star, thus its measurement should provide constraints on the intrinsic emission processes active in this type of source. The observation of hard X-ray features in the spectrum of a similar source (Her X-1) has been interpreted as cyclotron emission in a 5×10^{12} gauss field near the pole of the neutron star. Although the hard X-ray spectrum has been measured by previous experiments (2,3,4,5,6), these experiments have had relatively poor energy resolution (> 10 keV) in this energy range. It was possible that a high resolution experiment might show features previously unresolved in this energy region.

2. Experiment. The Low Energy Gamma Ray Spectrometer (LEGS) experiment uses an array of three 5-cm diameter high-purity germanium detectors with an effective area of 47 cm^2 over the energy range 20 keV to 80 keV and a constant energy resolution of 1.2 keV. A combination of passive and active collimation is used to achieve a field-of-view of 3.3° x 6.7°. The background continuum is essentially flat over the relevant energy range at a level of 1.5×10^{-3} ph · cm^{-2} · sec^{-1} · keV^{-1}. Details of the experiment are given in Ref. 7.

3. Results. The source was observed for 4 hours divided into 20-minute intervals, alternating on-source and off-source by offsetting in azimuth. The source was not in eclipse. Pulsations were observed at a period of 283 seconds. The light curve (Figure 1) shows a simple double pulse structure previously observed at these energies (20 keV to 60 keV). No background subtraction has been performed in this summed epoch analysis. The background level determined from off-source pointings is

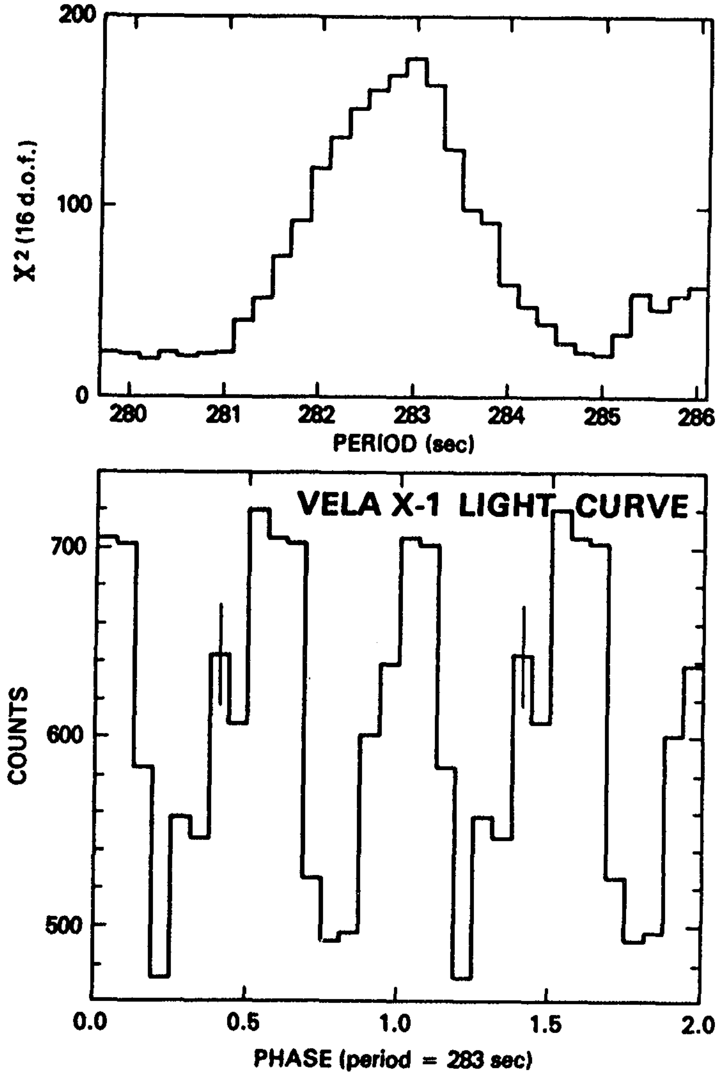

Figure 1

433 ± 6 cnts. No evidence for energy dependence of the light curve was observed in our data.

The phase averaged energy spectrum (Figure 2) was derived from source minus off-source spectra which were corrected for detector response and atmospheric absorption. The spectra were searched for narrow-line features by an automated routine. No features were observed at the 3 sigma level. Figure 3 gives the narrow-line upper limits derived. Since no narrow line features were observed, we are justified in binning the data in statistically significant energy bins. Figure 2 shows the resulting spectrum. The solid histogram is the count spectrum at the detector showing the effects of atmospheric absorption. The solid curve is a simple exponential ($I = (I_o/E) \cdot \exp(-E/E_{fold})$) which is a good fit to the data ($\chi^2 = 17.8$ for 16 d.o.f.). Fit parameters are given in Table I as well as comparison values from previous measurements.

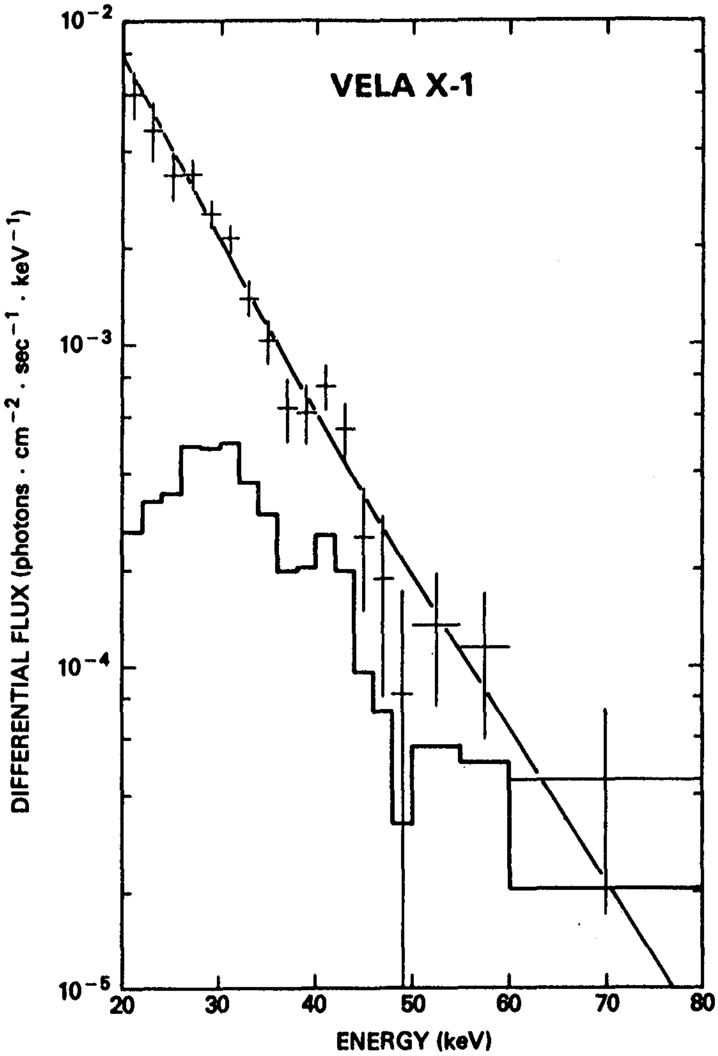

Figure 2

For comparison purposes, all normalizations have been converted to values at 30 keV where all the data sets overlap.

4. Conclusions. We have no statistically significant evidence for structure in the spectrum of Vela X-1. Our results are in reasonable agreement with previous measurements considering the known variability of the source.

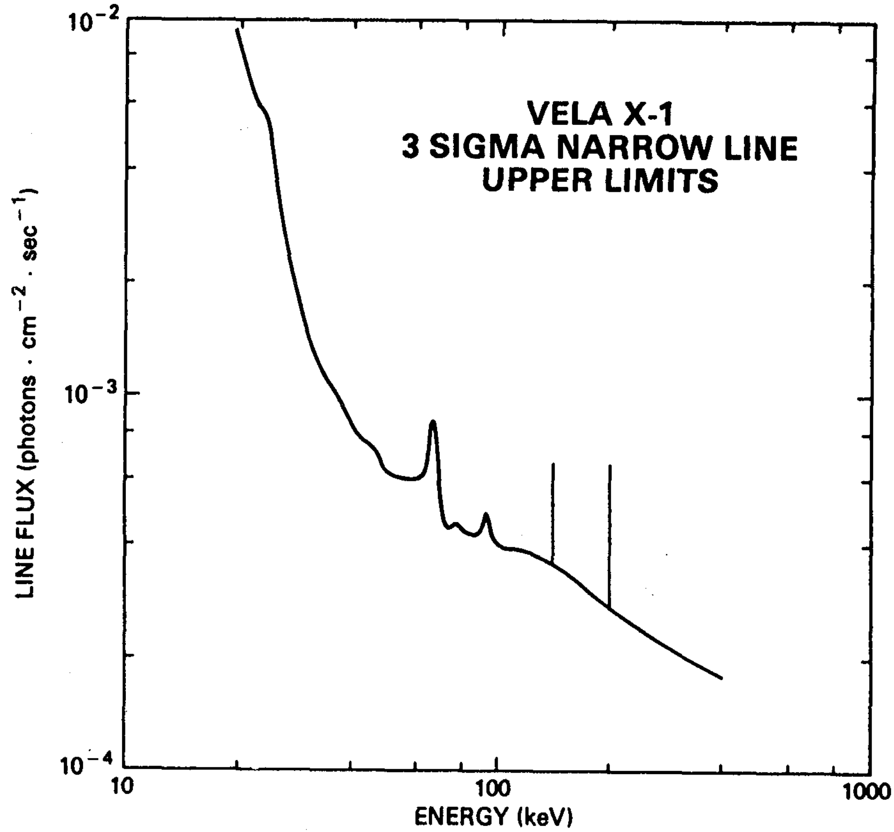

Figure 3

TABLE 1

Hard X-ray Spectral Fits

	Differential Flux (30 keV) ($\times 10^{-3}$ ph.cm^{-2}.sec^{-1}.keV^{-1})	E_{fold}
OSO 8(1976)[2]	~ 3	18 ± 2
OSO 8(1978)[3]	1.5 - 3.2	10.1 ± 1.4
MPI/AIT(1978)[4]	~ 5	10 ± 1
HEAO A-2(1978)[5]	~ 3	16 ± 2
HEAO A-4(1978)[6]	2.4 ± 0.2	14.0 ± 1.8
	2.5 ± 0.2	10.1 ± 1.2
This expt. (1984)	2.06 ± 0.14	10.8 ± 1.0

References

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