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PROCEEDINGS
SUPPLEMENTS

*Beppo*SAX observations of the binary pulsar PSR B1259−63

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The unique pulsar/Be star system PSR B1259−63/SS2883 [1] had their second "usable" periastron fly-by on May 29 ∼ 19:00 UT ($\mathcal{T}$). The original plan of observing the pulsar with the *Beppo*SAX NFIs some two months before and after periastron and to monitor it during the passage with five, one week interleaved observations, could not be accomplished.

PSR B1259−63 was instead observed five times by *Beppo*SAX during 1997: on March 22 ($\mathcal{T}$−68 days) and on September 2, 8, 17, 25 ($\mathcal{T}$+96, 102, 111, 118 days) for a total exposure time of 178.7 ks for each MECS and 36.1 ks for the LECS.

Here we present the preliminary results from the spectral and temporal analysis and compare them with previous ROSAT and ASCA observations.

1. OBSERVATIONS and DATA ANALYSIS

The first observation of PSR B1259−63 was performed on March 22 for a total exposure time of 28.6 ks in the MECS. It was $\mathcal{T}$−68 days before periastron and the true anomaly was ∼ 135°. The source was found in an unexpected low flux level; more than an order of magnitude fainter than the flux measured by ASCA 40 days after the 1994 periastron (true anomaly ∼ 127°) [2].

From these results and because *Beppo*SAX could not perform the planned periastron monitoring of PSR B1259−63 for solar angle constraints and gyroscopes failures, we decided to perform two 50 ks observations instead of the five 20 ksec planned and to perform the second 25 ks one soon after.

The first observation was scheduled for September 2, corresponding to $\mathcal{T}$+96, but a pointing failure resulted in a short, ∼ 17 ks exposure. The "proper" observations where then performed on September 8, 17, 25 ($\mathcal{T}$+102, 111, 118) with MECS exposure times of 53.4, 51.1, 28.7 ks. In all these observations the source flux level was about half that observed by ASCA (see Table 1 and Fig. 2).

The light curves of two of the four observations performed in September are shown in Fig. 1 for the full MECS energy bands and the 0.5 − 2 keV LECS band. The bins are 5 ks each. Because of the reduced LECS efficiency its coverage and statistics are unfortunately poor. Flux variations are quite evident on both intra- and inter-observations time scales (see also Table 1). In particular in the September 8 there is a sudden drop of a factor two in the flux level on 10 ks time scale.

We performed power law and thermal bremsstrahlung model fitting to the LECS + MECS spectra. The results from the power law fits were by far better than those from the thermal fit. The results, together with the obser-

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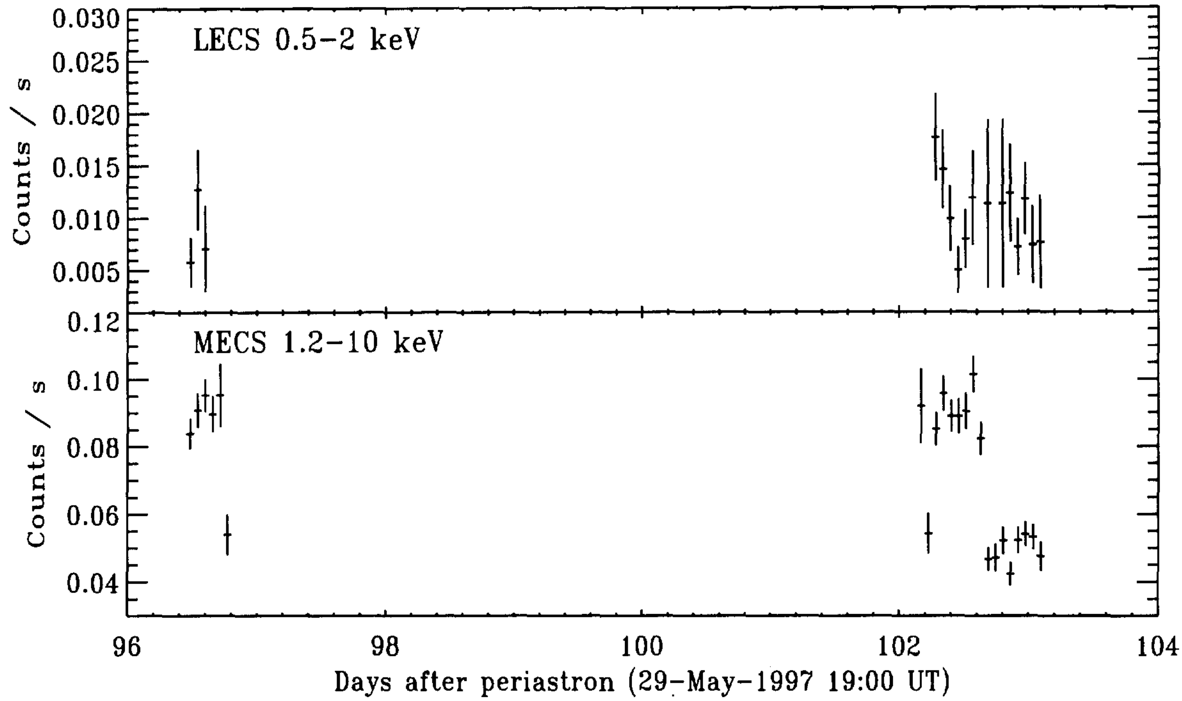

Figure 1. 5 ks rebinned light curve of PSR B1259−63 during the 2 and 8 September 1997 observations.

vations parameters, are shown in Table 1. Figures 2 and 3 show X-ray luminosity and spectral index as function of the true anomaly together with the ROSAT and ASCA results.

We were also able to detect a flux of $\sim$ 1 mCrab (6σ) in the 13–40 keV band of the PDS for the 8 and 17 September observations. This flux is the sum of that from PSR B1259−63 plus that from a serendipitous field object (FO), 9.5 arcmin away, that in the ROSAT PSPC is resolved in two components: 1RXP J130157−6358.1 and 1RXP J130159−6357.9. Accurate data analysis to desentangle the genuine pulsar flux in the PDS and HPGSPC is ongoing. Reanalysis of the old ROSAT and ASCA data of the FO will be performed to check its flux and spectral parameters stability.

2. RESULTS and DISCUSSION

The power law spectral fit of the March observation showed that while the spectral index was compatible with the ASCA results the column density was significantly lower than the typical 6×10^{21} cm^{-2}. The second ROSAT observation, even though at a low confidence level, gave a similar result [3].

In the September observations the N_H was compatible with the canonical value but with some indication of decreasing with time. On the other hand, the spectra were harder with $\alpha = 1.4 \div 1.5$ and with some indication of anticorrelation with the flux level (see Fig. 3).

The *Beppo*SAX results are in agreement with the trend of variable X-ray emission from the PSR B1259−63 system determined by previous

Table 1
PSR B1259−63: Observation and fit (Power Law + absorption model) parameters.

Obs. date	LECS–MECS Exp. (ks)	Orbital Phase†	True anom. (degrees)	Photon index	N_H (10^{21} cm^{-2})	0.1–2 keV flux*	2–10 keV flux*
22/03/97	11.5–28.6	0.945	−134.93	1.57 ± 0.15	1.8 ± 1.6	0.38 ± 0.01	1.23 ± 0.05
02/09/97	2.5–16.9	0.078	142.91	1.41 ± 0.12	5.0 ± 3.2	1.05 ± 0.19	6.93 ± 0.21
08/09/97	9.9–53.4	0.083	144.27	1.52 ± 0.07	7.6 ± 1.5	0.71 ± 0.08	5.42 ± 0.10
17/09/97	8.8–51.1	0.089	145.97	1.36 ± 0.05	4.2 ± 1.1	1.22 ± 0.16	7.81 ± 0.12
25/09/97	3.4–28.7	0.096	147.38	1.42 ± 0.08	2.9 ± 1.6	1.32 ± 0.24	6.48 ± 0.15

† periastron on 29 May 1997 (50597 MJD).
* In units of 10^{-12} erg cm^{-2} s^{-1}.

ROSAT and ASCA measurements. In general the level of X-ray intensity and the non-thermal spectrum agree with the theoretical expectation of a *non-accreting* and shock-powered pulsar system [4]. We also note that the low flux measured in March "before" periastron, is in some way specular to what was found around apastron when the pre-apastron observation had a flux twice weaker than that in the past-apastron observations [5]. This contradicts any hypothesis of asymmetry in flux emission for negative and positive true anomaly, in favor of a non-constant Be-star outflow rate leading to a non-constant value of X-ray flux and N_H also near apastron. Two features are particularly important:

(1) *Beppo*SAX detects for pre- and post-periastron 1997 a level of X-ray intensity which falls in between the previously detected X-ray fluxes for periastron and apastron passages in 1992–1994. These measurements agree qualitatively with expectations of a pulsar/Be star outflow interaction for a constant $\dot{M}$ and stable pulsar wind parameters. On the other hand rapid flux variations by a factor of ~ 2 are observed.

(2) The spectra detected by *Beppo*SAX are non-thermal, featureless, and particularly hard. They agree quantitatively very well with expectations for a pulsar/outflow shock interaction [4]. As the pulsar recedes from periastron, cooling by synchrotron and inverse Compton processes does not affect the shocked electron/positron pairs of the pulsar wind that radiate at a hydrodynamical shock with no appreciable radiative modifications. *Beppo*SAX measurements are very important and confirm that a very efficient mechanism is capable of accelerating particles in pulsar wind shocks with a (post-shock) distribution $N(\gamma) \sim \gamma^{-2}$.

(3) If the preliminary results from the PDS of a flux of $\simeq 1.3 \times 10^{-11}$ erg cm^{-2} s^{-1} in the 13–40 keV energy band (equivalent to an X-ray luminosity of $L_X \simeq 3.2 \times 10^{33}$ erg s^{-1}) will be confirmed and the FO flux and spectral parameters we measure in the 2–10 keV band are stable compared to the 1994 ASCA observations [2], then the reported OSSE flux in the 50–200 keV band [6] needs to be revised downward by a factor of ~ 2. This will have relevant implications on the efficiency of high energy photons production by the shock interaction.

3. CONCLUSIONS

*Beppo*SAX observed PSR B1259−63 in five occasions for a total of about 179 ks (MECS). In spite of the impossibility to perform the periastron passage monitoring, the orbital phase covered by these observations gave invaluable information to constrain emission models.

The preliminary results presented here are in agreement with the pulsar/Be, time-variable mass outflow, shock interaction leading to a time variation of the shock radius.

If the PDS detection of PSR B1259−63 will be confirmed, it will fill the gap left by the ASCA

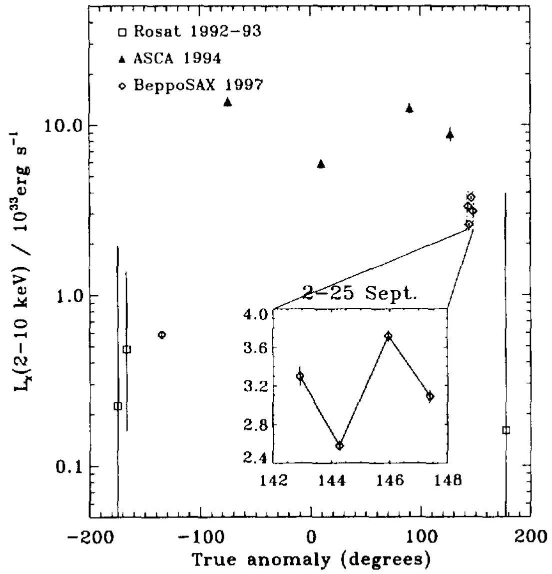

Figure 2. Luminosity history of PSR B1259−63 as function of the true anomaly.

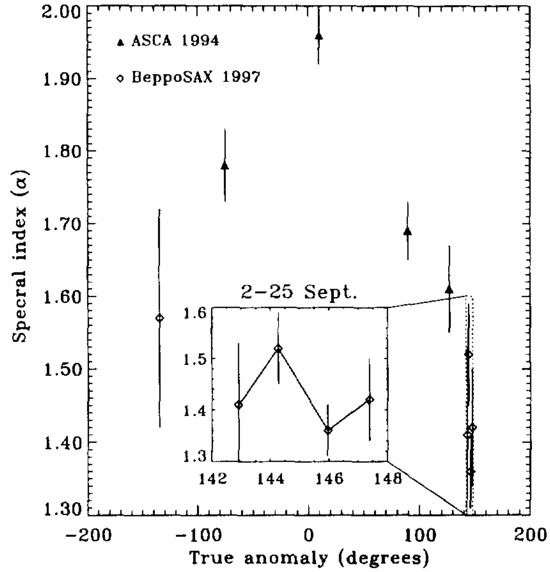

Figure 3. Power law spectral index of PSR B1259−63 as function of the true anomaly.

and OSSE observations [6] and will also allow to better evaluate the latter, taking into account the flux component from the FO.

Timing analysis to search for pulsed emission is ongoing. We will use the update radio ephemeris coming from the radio monitoring at Parkes [7] and the new geometry model parameters [8]. If the proposed detection of pulsation [9] is real, we should be able to detect it, though longer exposures by the LECS would be the best.

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