EXOSAT MEDIUM ENERGY OBSERVATIONS OF CYG X-2.

Spectra and QPOs.

L. CHIAPPETTI[1], A.L. CIAPI[2], L. MARASCHI[2], L. STELLA[3],
E.G. TANZI[1] and A. TREVES[2]

[1]Istituto di Fisica Cosmica, CNR, Milano, Italy

[2]Departimento di Fisica dell'Universita', Milano, Italy

[3]EXOSAT Observatory, ESOC, Darmstadt, F.R.G.

ABSTRACT

We report on a series of observations of Cyg X-2 obtained with EXOSAT in September 1983 at five phases in a single orbital cycle (P = 9.8 days, see Cowley et al. 1979). Here we present spectral data obtained with the Argon counters of the Medium Energy experiment (ME) (see Turner et al. 1981), together with the search of Quasi Periodic Oscillations (QPOs) in high time resolution data.

1. OBSERVATIONS

A journal of observations is given in Table I. The usual procedure of having half detector on the source and half offset for background monitoring was adopted for the ME experiment.

The light curves of the five observations after background correction are reported in Fig. 1. Most of the spectral data in observation 2 (after 19:52 UT), including a 25 minute dip and a shorter dip of nearly equal depth, are corrupted because of mixing of the telemetered data of the two experiment halves. However, after examination of the Housekeeping data, no doubt can be thrown on the reality of the dips.

It is apparent that observation 3 corresponds to an intensity state of the source ~30% lower than the level during observations 1 and 2. An examination of the light curves indicates also a number of minor "dips" of small duration (typically few minutes) and amplitude (10%).

Spectral data have been accumulated and combined over the whole duration of each observation. Best fits were performed with the usual minimum chi-square method. Single component spectral forms being clearly ruled out, we considered the superposition of a thermal Bremsstrahlung and a blackbody component. This choice appears to adequately account for the spectra of various low mass X-ray binaries (e.g. White and Mason 1985). and enables a direct comparison with the results of previous authors.

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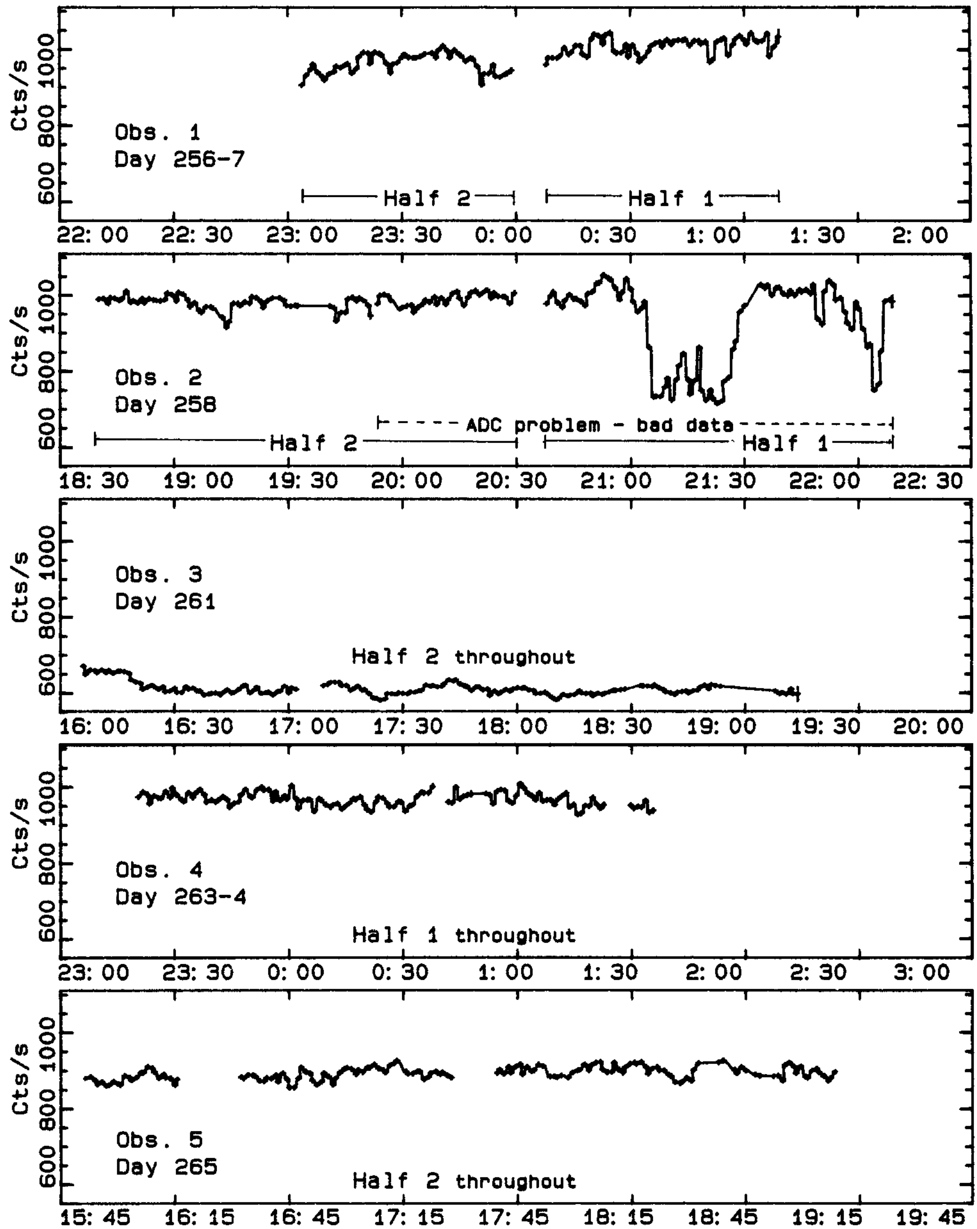

Figure 1. Medium Energy (1-16 keV) light curves of Cyg X-2. The on-source ME half experiment is indicated. X-axis is in UT hours of the given day(s) of 1983. The data labelled "ADC problem - bad data" have not been used for spectral analysis.

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Table I

1 N	2 Epoch (days of 1983)	3 Phase	4a NH (10^{21} cm^{-2})	4b min max	5a TTh (keV)	5b min max	6a Tbb (keV)	6b min max	7a LTh (10^{37} erg/s)	7b Lbb	8 Chi	9a Low freq. Slope	9b noise RMS %
1	256 23:03-01:08 257	0.86	1.4	0.3 2.9	5.2	4.9 5.6	1.12	1.09 1.15	8.2	3.8	17.5	-1.2±.3	1.6±.2
2	258 18:40-22:09	0.05	1.2	0.0 2.3	4.9	4.7 5.4	1.12	1.09 1.15	8.2	3.7	44.9	-.55±.15	2.5±.5
3	261 16:05-19:13	0.33	2.0	1.2 2.9	7.6	6.8 8.1	1.40	1.27 1.49	7.8	0.8	14.8	-.52±.03	5.5±.2
4	263 23:22-01:36 264	0.55	0.0	0.0 1.2	8.1	7.4 8.3	1.28	1.26 1.32	8.4	3.5	15.9	-.75±.03	4.3±.2
5	265 15:51-19:09	0.75	4.0	2.7 4.8	7.3	7.0 8.0	1.36	1.28 1.42	10.	2.5	16.4	-.75±.03	4.2±.1

Table I. Journal of observations and summary of spectral and temporal analysis.

Col. 1 : Observation sequence number used in text.
Col. 2 : Epoch of the observation
Col. 3 : Phase of the observation, according to the ephemeris of Cowley et al. (1979)
Col. 4 : Best fit values of the hydrogen column density for a thermal Bremsstrahlung + blackbody model (col. 4a) and extremes of the 90% confidence interval (col. 4b)
Col. 5 : Best fit values of the temperature of the Bremsstrahlung component (col. 5a) and minimum and extremes of the 90% confidence interval (col. 5b)
Col. 6 : Best fit values of the temperature of the blackbody component (col. 6a) and extremes of the 90% confidence interval (col. 6b)
Col. 7 : Luminosities at the source for the Bremsstrahlung (col. 7a) and blackbody (col. 7b) components, calculated in the band 1 to 16 keV.
Col. 8 : Chi-square (for 24 degrees of freedom) of the best fit spectrum.
Col. 9 : Parameters of the low frequency noise (high time resolution data): power law slope (col. 9a) and RMS variability (col. 9b)

Notes: The high time resolution data for observation 1 include both Argon and Xenon data. All other observations include Argon only. The intensity dip in observation 2 has been excluded from the temporal analysis. Valid spectral data in observation 2 cover only the period 18:40-19:52.

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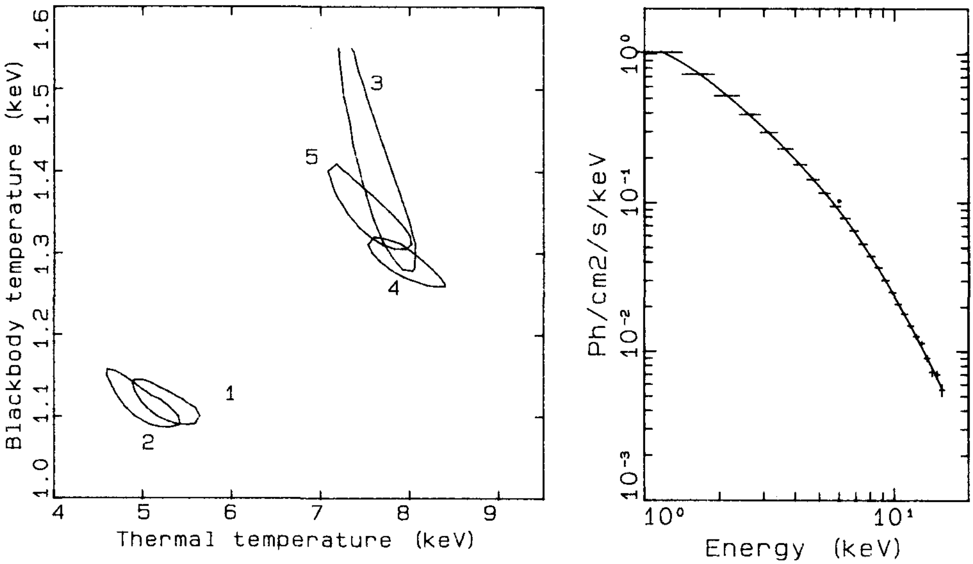

Figure 2. Left: The 90% confidence contours in the two temperature plane for a thermal+blackbody fit of the five observations of Cyg X-2. The contour for each observation is the envelope of several confidence contours with the hydrogen column density fixed at a number of values within the 90% confidence interval of the best fit. The relevant confidence intervals are reported in Table I. Right: The reconstructed photon spectrum and the thermal+blackbody best fit for observation 3 (1983 day 261).

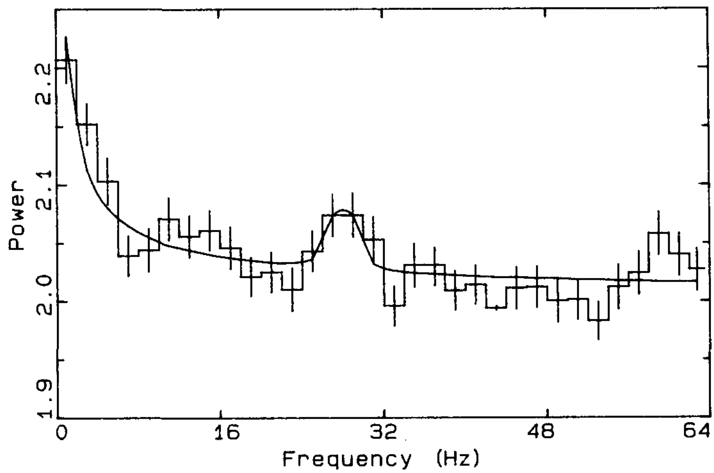

Figure 3. Power spectrum for observation 3 (1983 day 261). The counting statistics noise corresponds to a level of 2.

The best fit parameters, with uncertainties from chi-square grids corresponding to the 90% confidence level, are reported in Table I. The grids themselves and an example of reconstructed spectrum are given in Fig. 2. A comparison of the spectra indicates the occurrence of rather complex changes. The indication of variation of the hydrogen column density appears strong, in particular comparing observation 4 with observation 5.

The chi-square contours show that the spectral parameters of observations 1 and 2 do not differ significantly. Observations 4 and 5, though similar in intensity to the first two, show a significant increase of the temperature of the thermal Bremsstrahlung component. The lower state detected in observation 3 corresponds to a value of the Bremsstrahlung temperature close to that of observations 4 and 5, and is characterized by a drop of the flux of the blackbody component.

2. SHORT TERM VARIABILITY

During the 5 EXOSAT observations of Cyg X-2 described here a fast timing program (HTR3) was also run in the on-board computer to obtain a 7.8 ms resolution without any spectral information. Following the recent discovery of 20-50 Hz QPOs in the X-ray flux of Cyg X-2 (Hasinger et al. 1986), these data have been analyzed to further investigate the very short term activity of this source. The source power spectrum for each observation was calculated by summing the power spectra obtained for each 256 s interval. The frequency range which can be explored extends to 64 Hz. In all the five observations a very significant excess with respect to the counting statistics noise was observed. The power increased towards the low frequency end of the power spectra (low frequency noise) and was modelled with a simple power law. The power law slopes obtained in the 5 observations are given in Table I, together with a direct evaluation of the source RMS variability in the frequency range 0.25-20 Hz.

Only in one case (observation 3) a broad peak revealing the presence of QPOs was detected (see Fig. 3). The frequency, FWHM and RMS variability obtained by fitting a Lorentzian to the peak were respectively 28.3±0.4 Hz, 2.7±0.2 Hz and 2.0±0.5 %. The QPO frequency is consistent with the one found by Hasinger et al. (1986) for their lowest intensity interval, although in the present observation the RMS variability associated to the QPOs is a factor of 2 lower. A second peak is also visible in Fig. 3 at a frequency of 60±3 Hz (with a chance probability of 0.01), which could be interpreted as the first harmonic of the 28 Hz QPO.

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