Bull. Astr. Soc. India (2001) **29**, 365–367

Timing and spectral studies of the 1999 Outburst of 4U 1630-47

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1. Introduction

4U 1630 is a soft x-ray black hole transient with the shortest known outburst recurrence interval of ~ 600 days and whose optical counterpart is yet to be identified. Absorption dips lasting 50-150s and reaching 8%-30% of the nondip flux have been observed. QPO signals were found between 0.06 and 14 Hz during the 1998 outbursts and early part of the 1999 outburst (McCollough et al. IAUC 7165), in contrast to the earlier outbursts. Kuulkers et al. (1997, 1998) have pointed out similarities in the x-ray behaviour between 4U 1630-47 and the two galactic superluminal jet sources GRS 1915+105 and GRO 1655-40. As predicted, during the 1998 outburst, radio emission was detected for the first time, the optically thin emission suggesting the presence of a radio jet.

2. Observations

The IXAE onboard the IRS P-3 satellite observed 4U 1630-47 between the 19th and 30th of June 1999 (6 days of good data) while in outburst. This experiment consists of three gas-filled proportional counters with a field of view of 2.3^{o} x 2.3^{o} (Agrawal et al. 1997) and an effective area of 1200 cm^2, sensitive to x-rays in the energy range 2-18 keV. To investigate the detailed properties of the long term burst of interest, we analysed data from the ASM public data archive of the RXTE mission. We also compared the 1999 burst with 2 earlier bursts of 1996 and 1998 with data obtained from the same archive.

3. Data analysis and results

3.1 IXAE

The light curves show a lot of variation, with the counts varying by a factor of three within 90 minutes on one of the days of observation (Figure 1). We observed a hardness ratio (6-18)/(2-6) keV of 2.3 ± 0.3 on 19th June 1999, which decreased to 1.12 ± 0.2 on the 23rd, (hardness ratio for Crab = 0.85, Mukerjee 1999) indicating a softening of the spectrum. This spectrum is harder than that of the Crab assuming a power law spectrum for the source. The power density spectrum was generated by concatenating three data segments of June 29 1999, being the only fast mode data available with a time resolution of 0.1s. As

shown in Figure 2, it is clear that there is no QPO feature in the frequency range of 0.001 Hz to 5 Hz. Interestingly, McCollough et al. observed a QPO signal at 0.855 ± 0.005 Hz from the same source on the 8th of May 1999, highlighting the extreme temporal variations of this source.

3.2 RXTE

The ASM data for the 1996, 1998 and 1999 outbursts of 4U 1630-47 were analysed in order to study their long term properties, a summary of which is given in table1.

In the broad band (2-12) keV, we see that all the three bursts have an *e*-folding time of ~ 15 days. As suggested by Tomsick and Karet (Tomsick et al. 2000) this timescale is probably governed by some physical property of the system like the mass of the compact object (Cannizo et al. 1995), or the radius of the accretion disk (King & Ritter 1998) that does not change between the outbursts. However, in the (1.5-5) keV band, the 1998 burst shows a very large *e*-folding time implying a slower decay of the soft photons compared to the hard photons. Detailed observations of a few more bursts may be needed to address the energy dependence of the *e*-folding time.

Table 1. Summary of burst properties.

Properties		1996	1998	1999
Start Day (TJD) Start time (hr:min:sec)		10152 06:27:11.973	10849 18:40:47.946	11307 06:49:04.026
Decay time (d) (exponential)	1.5-5 keV 5-12 keV	18.7 12.2	33.0 17.0	13.7 14.5
Rise time (d) (linear)	1.5-5 keV 5-12 keV	2.6 12.7	17.6 13.8	4.3 6.6
Maximum counts/(s)	1.5-5 keV 5-12 keV	12.8 11.7	9.3 13.9	7.7 8.1
Burst duration (d)		125.7	49.7	69.2

We carried out (a preliminary) spectral analysis for the 20th of June 1999 using the STD 2 mode PCA data. A zeroth order spectral model (disk black body + power law, similar to that used by Cui, Chen & Zhang (1999) is shown in Figure 3a & 3b (reduced χ^2 of 2.6). The 1996, 1998 and 1999 bursts have each been fitted with spectral models consisting of a disk black body component plus a power law component. The 1999 burst shows the hardest power spectrum during the peak with α ~ 1.7 unlike that in 1996 α ~ 4.5 (Cui et al. 1999) and 1998 α ~ 2.6 (T.Oosterbroek et al. 1998). Thus, the spectrum during the peak of the burst appears to get harder with time.

Fig. 1

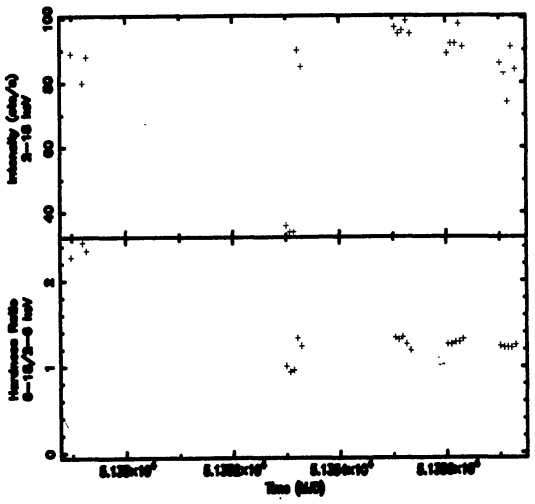


Fig. 3a

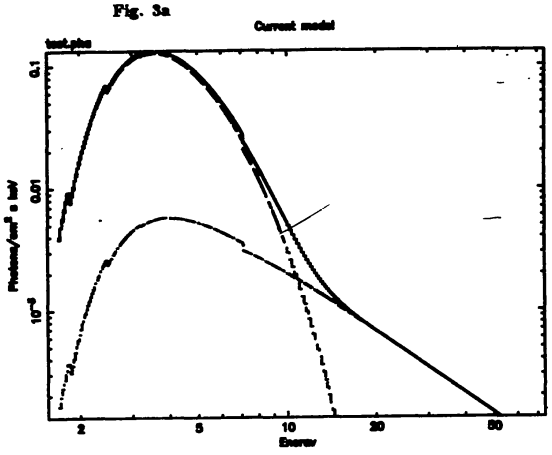


Fig. 2

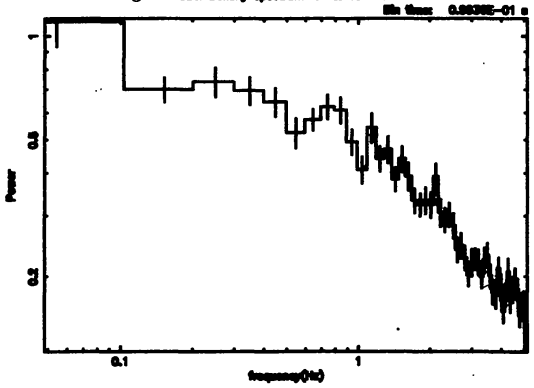
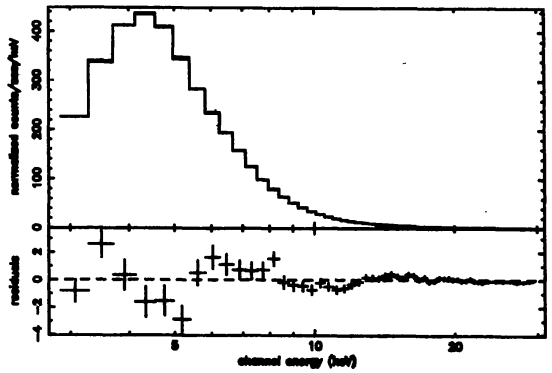


Fig. 3b Data and folded model



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