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EXO 2030+375: Analysis of Pulse Profile for different Energy range during Outburst of 2011

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Abstract: In this paper we present result of systematic study of timing properties of transient high mass X-ray binary (HMXBs) EXO 2030+375 using RXTE observations. In this study we plot energy dependent pulse profile of energy range 2-30 Kev. We analyze 30 observations of 2011 outburst from January 2011 to June 2011. In these profiles we see sinusoidal variations.

Index Terms **- RXTE, Pulse Profile, HMXBs.**

I. INTRODUCTION:

Be/X-ray binaries are high mass X-ray binary which consisting a neutron star as compact object and B or O type star as companion star. In this type of X-ray binary matter is accreted by neutron star when it passes through the circumstellar disk of the companion star. Strong outburst of X-ray takes place at that time (Okazaki et al, 2001). In the Be/X-ray binary system most of the neutron stars are accretion powered X-ray pulsars (Massi et al, 2004). Accretion powered pulsars are the X-ray binary pulsars whose pulses are generated by the accretion flow striking the neutron star. Most of the accretion powered pulsars have periods 1second to 1000 second. Mostly the Be/X-ray binaries are transient systems. Outbursts of this type of system have been classified into two classes: type I and type II outbursts. Type I outburst also known as normal outburst. They define X-ray variability of transient Be XRD. Type II outbursts are quasi-periodic outburst and regular (Bildsten et al, 1997), (Frank et al, 2002). Giant outbursts have no consistently preferred orbital phase (Wilson et al, 2008). Luminosity peak during Type II is 1030 erg s-1 high. Be X-ray binaries consist neutron star and non-supergiant star which shows Blamer lines in the emission spectrum .The X-ray spectrum of these type of pulsars is hard.

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II. ABOUT THE SOURCE:

EXO 2030+375 is a transient high mass X-ray binary system in which a neutron star orbiting a be companion. It was discovered by EXOSAT in 1985 (Parmar et al, 1989a &1989b). Different satellites are used to study the pulsar. These are RXTE (Wilson et al, 2008), INTEGRAL, SWIFT (Gehrels et al, 2004), CGRO/BATSE, and EXOSAT (Stollberg , 1997). The estimated spin and orbital periods is 42 second and 44.3-48.6 days. B0 Ve star was found as the counterpart of the pulsar in the infrared and optical bands (Janot-Pacheco et al, 1988), (Motch et al, 1987; Coe et al, 1988). EXO 2030+375 show QPO phenomenon during the gaint outburst of frequency 0.2 Hz (Angelini et al, 1989). This source showed normal outburst for every periastron passage for 13.5 years (Wilson et al, 2002). Some important orbital parameters of binary system are derived by Stollberg (Stollberg, 1997), such as orbital period Porb = 46.02±0.01 days, e = 0.36±0.02, ax sin i = 261±14 lt-sec, $\omega = 223^\circ .5 \pm 1^\circ .8$, and time of periastron passage τ = 2448936.8 ± 0.3 days

III. OBSERVATIONS AND DATA ANALYSIS:

RXTE was launched on 31 December 1995. The main objective of launching of RXTE is to study the timing properties of celestial objects. RXTE has three sets of instruments.

a) ASM (all sky monitor)
b) PCA (Proportional Counter Array)
c) HEXTE (High Timing Experiment)

ASM was sensitive in energy range 1.5-12keV.PCA was sensitive in energy range 2-60 Kev. It consist five Xenon filled detectors (Jodha et al, 1996). HEXTE was operating in energy range 15-250 Kev.

In this paper we analyze data of EXO 2030+375 during 2011 data. We analyze 30 observations. In present analysis standard 1 mode data with time resolution of 0.125 second was used. PDS power density spectrum was generated by using the FTOOLs. The pulsation of this pulsar was found 42 second, shown in figure 1.

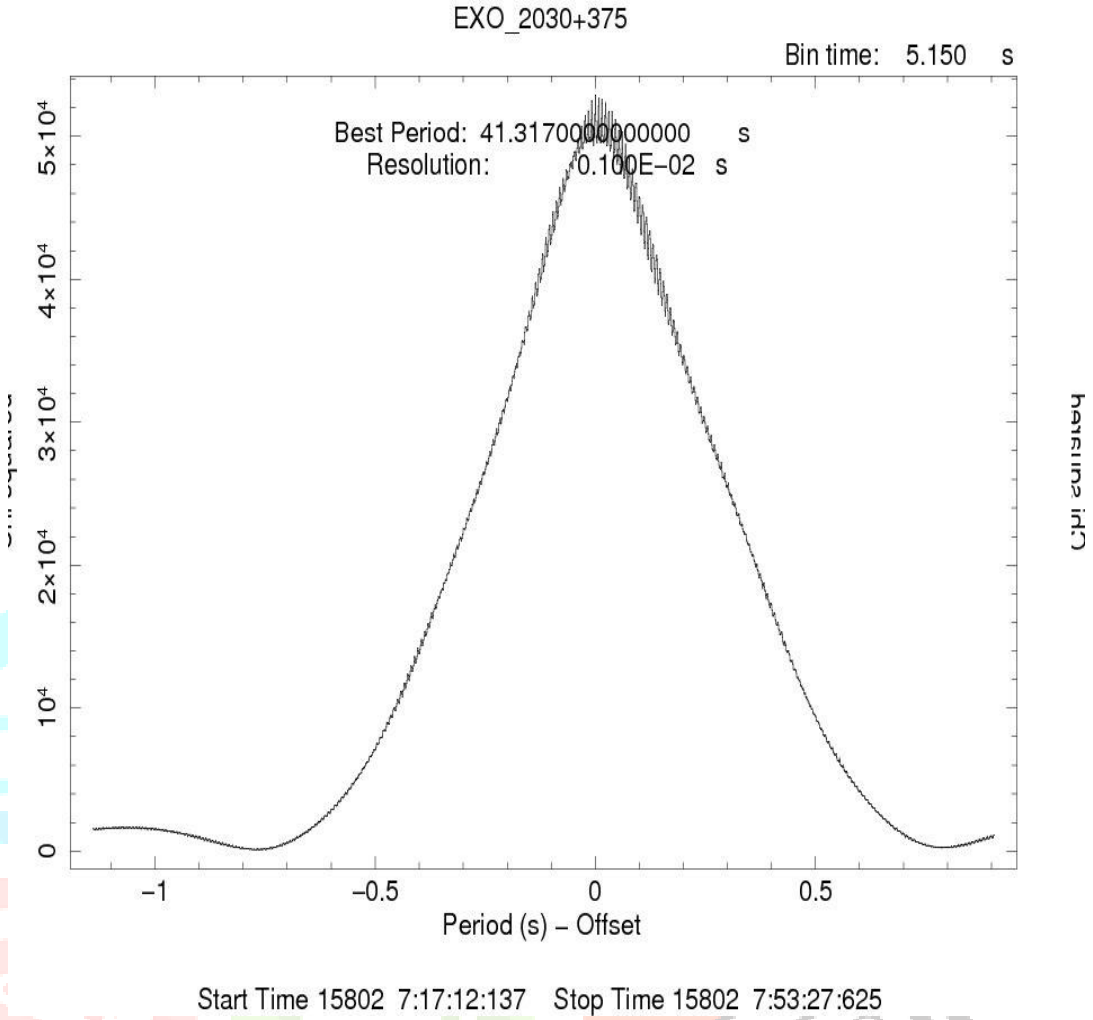

Figure 1: Pulse Period of EXO 2030+375

IV. PULSE PROFILE FOR DIFFERENT ENERGY RANGE:

Pulse Profile is a graphical representation of normalized intensity verses pulse phase. All the energy resolved background subtracted light curve were folded with the above mentioned pulse period and the resultant pulse profiles in different energy ranges 2-6 Kev, 6-12 Kev, 12-16 Kev, 16-22 Kev, 22-30 Kev, are shown in figure 2. In plotting pulse profiles we use standard 2f data and bin size used is 16. Pulse height variation for the mono-energetic incident radiation of the energy arises due to the excitation of the gas molecules instead of ionization in the proportional counter due to this the Pulse height is proportional to the square root of the energy whereas the energy resolution is inversely proportional to the square root of energy (Ramsey et al., 1988). The pulse fraction is defined as (maximum – minimum)/ maximum or the ratio of pulse flux to the total flux.

Table: Observations of 2011 (January-February-April-May-June)

Observation ID	Date	MJD	Pulse Period
96098-01-01-00	05/01/11	55566	41.3
96098-01-01-01	06/01/11	55567	41.32
96098-01-01-02	05/01/11	55566	41.3
96098-01-01-10	07/01/11	55568	41.31
96098-01-01-11	08/01/11	55569	41.34
96098-01-01-12	10/01/11	55571	41.32
96098-01-01-13	11/01/11	55572	41.32
96098-01-01-14	12/01/11	55573	41.32
96098-01-01-15	13/01/11	55574	41.32
96098-01-01-20	14/01/11	55575	41.33
96098-01-02-05	22/02/11	55673	41.37
96098-01-02-20	07/04/11	55658	41.3
96098-01-02-10	08/04/11	55659	41.3
96098-01-02-11	09/04/11	55660	41.3
96098-01-02-12	10/04/11	55661	41.34
96098-01-02-13	10/04/11	55661	41.31
96098-01-02-14	12/04/11	55663	41.32
96098-01-02-15	12/04/11	55663	41.33
96098-01-02-04	14/05/11	55665	41.31
96098-01-03-00	22/05/11	55703	41.29
96098-01-03-01	23/05/11	55704	41.3
96098-01-03-02	24/05/11	55705	41.31
96098-01-03-03	25/05/11	55706	41.31
96098-01-03-04	26/05/11	55707	41.3
96098-01-03-10	27/05/11	55708	41.39
96098-01-03-11	28/05/11	55709	41.33
96098-01-03-12	29/05/11	55710	41.33
96098-01-03-13	30/05/11	55711	41.32
96098-01-03-14	31/05/11	55712	41.34
96098-01-03-15	01/06/11	55713	41.31

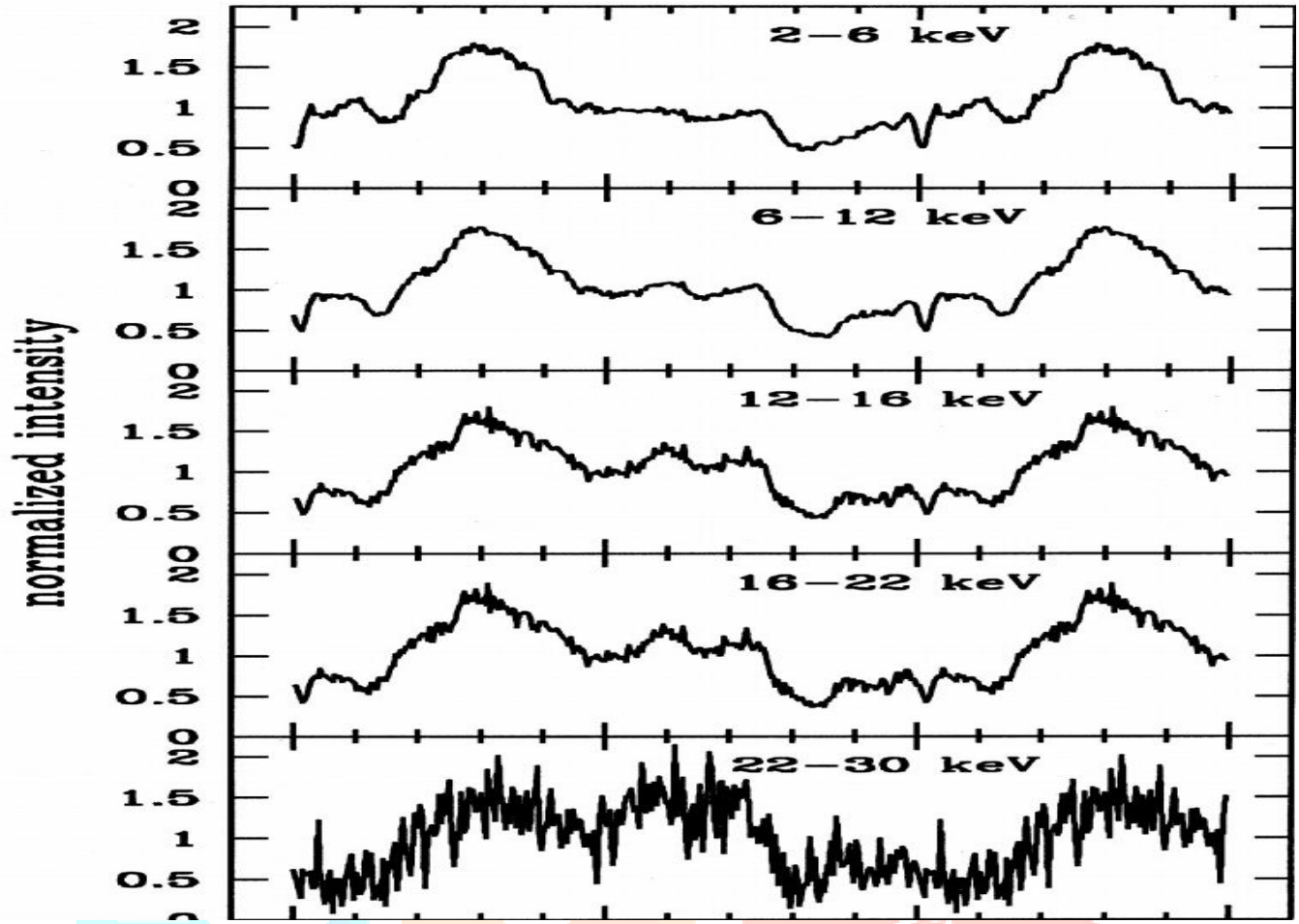

Figure 2: Pulse Profile for energy range 2-30 Kev for observation Id 96098-01-02-05

V. CONCLUSION:

In this paper, we performed timing analysis using the RXTE observation of the Be/X- ray transient pulsar EXO 2030+375 during the outbursts 2011. Temporal analysis performed with RXTE/PCA observations showed X-ray pulsations. The 42 s pulsations were detected in the light curves. The pulse curves are sinusoidal.

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