International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:2682
Vol.3, No.12, December 2014 DOI:10.15693/ijaist/2014.v3i12.10-13

Luminous variability of GRB 110715A observed by SWIFT BAT mission

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Abstract: Study presents luminous variability of GRB 110715A detected with SWIFT BAT mission. In timing and spectral analysis we find two distinct pulses of GRB. Analysis provides two pulses for energy range 15-150 keV and then resolves each bands 15-25 keV, 25-50 keV, 50-100 keV and 100-150 keV. Using Cross Correlation Function (CCF) last three energy bands are cross correlated with first one and time delays are found. We establish relations of luminosity variables with energy and energy-lag. Luminosity increases for the energy bands (15-25 to 50-100 keV) but decreases for the higher band 100-150 keV. This may be attributed to convergence of bulk matter towards the core under its own gravity during impulsion for the formation of Compact body (black hole) in collapsar.

Key words: high energy astrophysics, gamma rays bursts (individuals: GRB 110725A), timing and spectral studies.

Introduction:

In several studies of GRBs (Boi et al. 2010, Bromberg et al. 2010, Cheng et al. 1995, Dermer et al. 2005, Fenimore et al.1999 etc.), it has been reported that extreme energetic explosions in most of the distant galaxies are associated with emission of gamma rays, which are known as gamma rays burst (GRB). GRBs are under continuous surveillance of extraterrestrial observatories which are equipped by Burst Alert telescopes (BAT). GRBs are always followed by its afterglow in space for quite long time and have been the central interest for the multiwavelength spectroscopy (Ford et al. 1995, Gao et al. 2010, Hakkila et al. 2008). GRBs happen to be the most luminous electromagnetic events known to occur in the universe. Bursts can last from ten milliseconds to several minutes. The short duration bursts are defined as those lasting less than 2 seconds, while long duration bursts last more than 2 seconds (Kouveliotou et al. 1993). The origin of GRBs is referred to collisions between black holes, neutron stars and galaxies. Also when a star with the mass at least 20 to 30 times of the sun, depletes its nuclear fuel, then it has as no outward radiation pressure to support its bulk. As a result, the gravitational implosion turns it into black holes with the emission of enormous GRB pulses (Hakkila et al. 2010, Golonetskii et al. 2011, and Guetta et al. 2005). The resolved bursts are most of the time made up of two or more peaks of energy range from few keV to several keV which show cross correlations. Despite of these suggestive correlations, GRB studies have focused on the measurement of bulk properties with pulses often regarded as nothing more than minor variability to the overall signal. First time Norris (1983) proposed the phenomenon related to the evolution of the observed the spectral of GRB pulses. Pulse peaks migrate to later times and become wider at lower energies are some distinct features observed in GB pulses. Further as the event progresses burst spectra tend to soften at each individual evolving pulses. Cheng et al. (1995) used cross correlation to demonstrate that soft emission had a time delay relative to high –energy emission. The higher resolution spectra of bright bursts confirmed the tendency of burst to soften as they progress (Ford et al. 1995).

Source and Observations:

We use the observations of long duration GRB 110715A detected with SWIFT BAT mission. BAT triggered on GRB 110715A on 2011 July 15 at 13:13:50:00 (trigger 457330) (Sonbas et al. 2011, GCN Circ. 12158). The BAT light curve shows a double peaked structure with a duration of 15 sec and red shift Z=0.82 (Nardini et al. 2010, Norris et al. 1996, Norris et al. 2000).

Data Reduction and Analysis:

We study timing properties of GRB 110715A detected with SWIFT BAT mission using appropriate software (HEAsoft6.11).Data reduction is done with available SWIFT software package. For spectral analysis we use XSPEC version 12.7 and CALDB version 1.0.1. We extract two different pulses separately for energy range 15-150 keV and then divide each pulse into four energy bands 15-25 keV, 25-50keV,50-100 keV and 100-150 keV. Last three energy band light curves are cross correlated with first one and found lag as described by Band (1997). Using Cross Correlation function (CCF) we establish relations between band energies and physical quantities like flux, lag, and luminosity. Within the limit of uncertainty, it appears that every pulse is characterized by its own lag. In some cases it is quiet difficult for overlapping pulses. Performing the analysis across above four different bands allow us to address the question of evolution of lag through CCF. The lag is measured by Gaussian fitting in the region near CCF main peak. The Gaussian is modeled as:

$$I(t) = I_0 \exp(-(t-t_0)^2 / 2\sigma^2)$$

Luminosity was obtained from the relation $L = 4\pi d_L^2 \times F$

Where F and d_L are flux and luminosity distance respectively.

Results and Discussions:

Gamma rays flux emitted during the collapse of compact objects in deep space are results of transformation of gravitational energy till both collapsars become one which is evident from the figure- 1. Out of two resolved peaks in single observed GRB pulse, first (data shown by red color) peak’s flux increases with energy of bands but cut down at higher band by the collapsing matter in the process of collapsing of collapsars. On contrary the second (data shown by blue color) peak of relatively very low flux does not show this feature but indicates linear increase. It supports the hot globular outburst of gamma rays (Norris J. P. 2002, Sari et al. 1999).

The lag between different energy bands in GRB is also synergized by the continuous transformation of gravitational energy of collapsing matter (Hakkila et al. 2010). The time delay between low energy bands (emitted from inner matter) is large i.e. low band will reach rather late than the higher energy band (as shown in figure-2 for both peaks of GRB).The second peak is relatively more delayed than the first peak. The reason is that the high energy band emitted close to the core where two compact objects got one degraded energy and delayed in time through multi absorption-emission processes with incoming matter (Piranomonte S. 2011).

In figure-3, the number of source emitting radiation of specific energy band per second is a measure of luminosity and in plot luminosity increases for the energy band (15-25 keV to 50-100 keV) but decreases for the higher band 100-150 keV. This may also be attributed to convergence of bulk matter towards the core under its own gravity during implosion for the formation of compact collapsar. It is evident that the luminosity would be low from low density peripheral matter having lost less gravitation energy as compared to converged matter close to core (Sonbas et al, 2011, Moti Dugair et al. 2014). The luminosity for higher band (100-150 keV) is low although emitted by high density inner matter, loosing large gravitational energy but must have stopped by incoming bulk matter as shown in figure-3. Collapsar exhibits the almost similar trend for the flux (as shown in figure-1 for both peaks) referred as the number of sources for the energy band emission per unit area available in the converging bulk matter (Bromberg et al.2010).

Spectral analysis of GRB 110715A has been done using power law fitting as shown in fig.-4. The nature of residual supports the fitting with the following parameters: Photon Index: 1.4-0.05; chi-square:1.185 for 78 degree of freedom (Wooseley, 1993).

Acknowledgement

This research has made use of obtained through obtained through the SWIFT BAT online service and computational facilities extended by IUCA, Pune, India.

References

1. Band D. L., 1997, Astro.ph. 121, 93B.
2. Boi S., Hafizi M., Mochkovitch R., 2010, A&A, 519, 76.
3. Bromberg Omer, Nakar Ehud, Piran T., Sari R., 2010. ApJ, 749, 110B.
4. Cheng L.X., Cheng K.S., 1995, AAS, 186,5905c.
5. Dermer C.D., 2005, ApJ, 121,64D.
6. Fenimore E.E., Ramirez-Ruiz E., 1999, ASPC, 190,67F.
7. Ford E., Kaaret P.,Tavani M., Tomsick J., Harmon B. A., Zhang S., Barret D., Grindlay J., Bloser P., 1995, AAS, 187, 2603F.
8. Gao H., L Sonbas u Y., Zhang S.N., 2010, ApJ, 717,268G.
9. Hakkila Jon, Giblin Timothy W., Norris Jay P., Fragile P. Chris, Bonnell Jerry T., 2008, ApJ, 677L, 81H
10. Hakkila Jon E., Adams J., Nettles C. J., 2010, AAS, 21540, 505H
11. Golonetskii S., Aptekar R., Frederiks D., Mazets E.,Pal'shin V.,Oleynik P., Ulanov M., Svinkin D., Cline T., 2011, GCN Circ., 12790.
12. Guetta D., Piran T., 2005, A&A, 435,421.
13. Kouveliotou Chryssa, Meegan Charles A., Fishman Gerald J., Bhat Narayana P., Briggs Michael S., Koshut Thomas M., Paciesa William S., Pendleton Geoffrey N., 1993, ApJ, 413L, 101K.
14. Moti R. Dugair, Sapna Sharma, D. Bhattacharya and S.N.A. Jaaffrey, New Astronomy Journal, 2012, 3, 31-34.
15. Nardini M., Giselle G., Ghirlanda G., Celotti A., 2010, MNRAS 403,1131N.
16. Norris, J. P., Bonnwell J. T., Nemiro_, R. J., Scargle J.D., Pendleton, G. N., Kouveliotou C., Pizzichini G, 1996, AAS, 189, 2803N.
17. Norris J. P., Marani G. F.; Bonnwell J. T., 2000, ApJ, 534, 284N.
18. Norris J. P., 2002, ApJ, 579, 386N.
19. Piranomonte S., 2011, GCN Circ. 12164.
20. Sari R., Piran T., 1999, A&AS, 138,537S.
21. Sonbas E., Barthelmy S. D., Baumagartner W. H., Beardmore A. P., Burrows D. N., D'Elia V., de Pasquale M., Evans, P.A., Gehrels N., Guidorzi C., 2011, GCN Circ., 121,58
22. Wooseley 1993, ApJ, 405, 273W.

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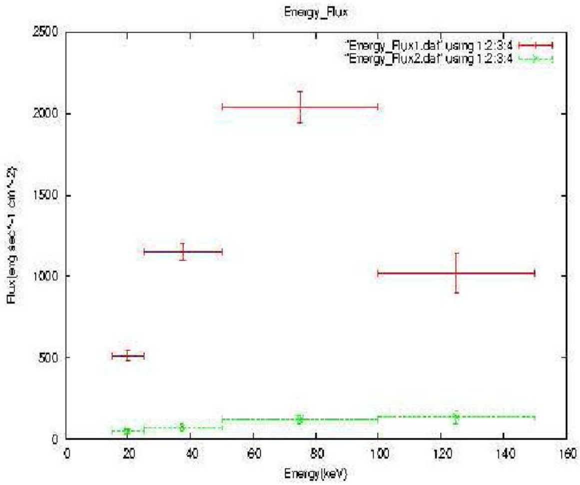

Fig. 1 Energy versus Flux for GRB110715A.

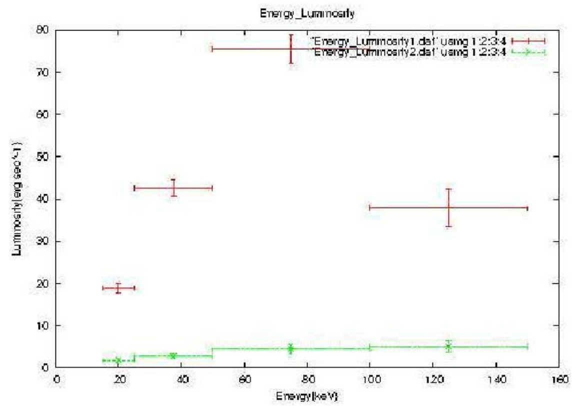

Fig. 3 Energy versus luminosity for GRB110715A.

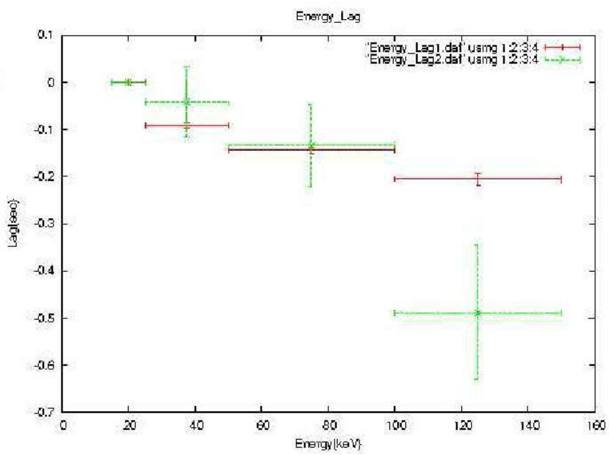

Fig. 2 Energy versus lag for GRB110715A.

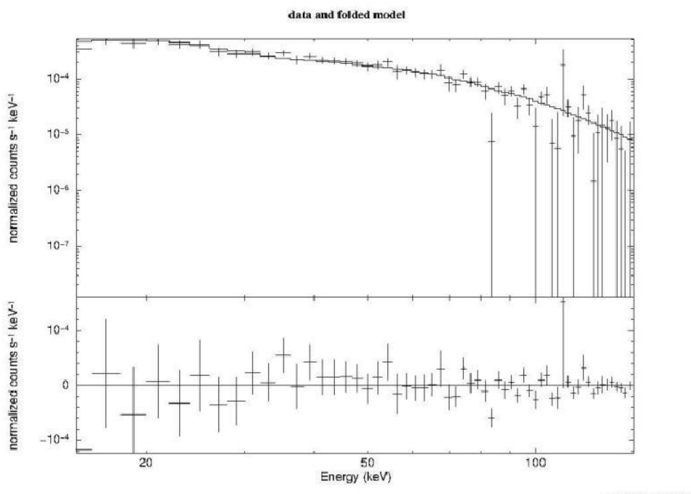

Fig. 4 Spectral analysis: power law with residuals.