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Capture of Two GRBs: 050525 and 100621A by SWIFT Burst Alert Telescope

KEYWORDS: gamma ray bursts (individuals: GRB05052 and GRB100621A), collapsar: spectral studies.

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ABSTRACT *Timing and spectral data of two GRBs (050525 and 100621A) obtained by SWIFT BAT Mission are analyzed using cross-correlation function (CCF). We established relations between varying energy-flux, energy-lag and energy-luminosity. Different energy bands in GRBs showed lag between them. Luminosity is found to increase for the energy bands (15-25 keV to 50-100 keV) but decreased for the higher band, 100-150 keV. This may be attributed to convergence of bulk matter towards the core under its own gravity during implosion for the formation of black hole in collapsar. Both GRBs exhibited almost similar trends for the flux. The gradient of bulk matter is maximum near the high spinning of the core and as a result outer surface shows decrease in the flux for the high as well as low energy bands.*

1 Introduction

Gamma rays emission associated with extreme energetic explosions in space are known as Gamma Ray Burst (GRB) .These bursts have been observed in distant galaxies and happen to be the most ever fascinating and witnessed luminous electromagnetic events. 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 long-duration gamma-ray bursts are theorized as a result of a collapsar (Wooseley 1993). When a star, with the mass at least 20 to 30 times the sun, depletes its nuclear fuel, it has no outward radiation pressure to support its bulk, then core of the star containing the mass of several suns implodes into a black hole, while most of the star's bulk explodes into the surrounding interstellar medium. Short GRBs are believed to happen because of the collapse of either two black holes or two neutron stars or a black hole and a neutron star. Norris et al. (1996) observed first time the spectral evolution of GRB pulses. GRBs show distinct features in light curve and spectrum that pulse peak migrates to later times and become wider at lower energies. Further as the event progresses burst spectra tend to soften at each individual evolving pulses (Norris et al. 2000). Norris et al. (2002) provided evidence for two pulses in analysis of large BATSE burst samples.

Four channels data demonstrate the trends of spectral softening on the time scale of pulses in an integral sense (Band, 1997) in the cross-correlation analysis. Cheng et al., (1995) used cross correlation to demonstrate that soft emission had a time delay relative to high-energy emission. The tendency of bursts of softening as they progressed (Ford et al., 1995) is confirmed by higher resolution spectra of bright bursts. Later Norris et al. (1996) noticed that in pulse shape, the rise-to-decay ratio is unity or less; as this ratio decreased, pulses became wider, the pulse centroid shifted to later times at lower energies, and pulses turned spectrally softer while the correlation of pulse spectral hardness with pulse symmetry was less clear. Little variation in pulse width is observed within a given burst by the large number of studies (Dermer C.D. 2005, Sari & Piran 1999, Fenimore et al. 1999, Golonetskii et al. 2011). The constancy of pulse width provided conclusive proof that GRB pulses could be generated only by a small central engine otherwise, the deceleration expected in external shock models would be evidenced by widening of pulses as the burst progressed (Gao et al. 2010, Fenimore & Ramirez-Ruiz 1999).

The time delay is a lag between photons observed in high-energy band pass relative to a lower energy one and is primarily obtained through application of the Cross Correlation function (CCF) (Band 1997). In general, lag is referred as an indicator of both GRB peak luminosity (Norris et al. 2000, Norris et al. 2002) and time history morphology (Hakilla et al. 2008). The short-lag variable bursts have greater luminosities than long-lag smooth bursts but not clear as a function of different energy bands. Still lag information between different energy bands of a burst is inconclusive and requires further examinations of data. We attempted the present study to know time morphology and analyzed the GRBs (GRB 050525 & GRB 100621A) detected with SWIFT/BAT Mission.

2 Source and Observations

We downloaded archival data and analyzed the observations of bright and long duration GRBs (050525 & 100621A) captured by SWIFT/BAT Mission. On May 25, 2005, GRB 050525 was detected with the SWIFT/BAT (Trigger=130088). This is very bright burst, yielding about 1500 counts above background in 64 seconds over the range of 25 to 100 keV in BAT instruments (Sonbas et al. 2011). A long bright GRB050525 triggered konus-wind at 176.704 s UT with red shift z=0.606 (Guetta et al. 2005). This is the third closest long GRB discovered by swift.

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BAT of SWIFT pointed (Trigger 425151) upon GRB 100621A (Nardini et al.2010) on June 21, 2010. INTEGRAL/SPI-ACS also detected this burst. ESO VLT equipped with X-shooter spectrograph measured the spectrum of the afterglow of GRB 100621A and determined the red shift, z = 0.542 (Hakkila et al. 2010).

3 Data Reduction & Analysis

Data analysis for timing and spectral properties of GRB 050525 and GRB 100621A was carried out using appropriate software (HEAsoft6.11). 32 IDs for Timing and Spectral Studies of GRBs: GRB 050525 and GRB100621A were taken up.

Raw data obtained by SWIFT BAT Mission were processed first by data reduction technique. Data reduction was done with available SWIFT software package. For spectral analysis we used XSPEC version 12.7 and CALDB version 1.0.1. We found four different pulses for GRB050525 and three different pulses for GRB100621A in light curves (Piranomonte 2011). We extracted four different pulses separately for energy range 15-150 keV and then divided each pulse into four energy bands 15-25 keV, 25-50 keV, 50-100 keV and 100-150 keV. Last three energy band light curves were cross correlated with first one and found lag (time delay) as described by Band (1997). Using CCF we established relations between energy- flux, energy-lag and energy-luminosity variables. Light curves with time bin size 2 ms (for GRB 050525) and 64 ms (for GRB 100621A) were generated from BAT data for energy range 15-150 keV thereafter the light curve were extracted. Since the signal was strong enough that clear pulses could be unambiguously extracted with consistent characteristics across all energy bands. Within the limit of uncertainty, it appeared that every pulse was characterized by its own lag. This was not to say that all pulses were clearly identified from one energy band to another; there were fitting without ambiguities caused by pulse evolution, least pulse overlapping and adequate signal to noise ratio. Although it was little difficult to resolve few overlapping pulses. Performing the analysis across four different intervals allowed us to address the question of evolution of lag with CCF. The lag was measured by Gaussian fitting in the region near CCF Main peak. The Gaussian modeled as:

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

Luminosity was obtained from the relation L= 4 $\pi\pi$ dL2 x F

Where F=flux and dL = luminosity distance.

4 Results and Discussion

The dependence of flux, luminosity and lag as a function of the different energy bands were examined for GRB100621A and GRB 050525. We established relations between energy-flux, energy-lag and energy-luminosity variables (Hakkila et al. 2010) using cross-correlation function (CCF).The timing and spectral results of both GRBs: GRB 050525 and GRB100621A are shown in Figures 1(a, b, c, d) and 2(a, b, c, d) respectively.

The observed GRB peak of 10 sec (for GRB 050525) and 100 sec (for GRB 100621A) duration , made a point to believe that both GRBs were of long duration burst and the peripheral collapsing matter emitted low energy band as compared to matter close to the core. The measured lag between different energy bands in GRB could be explained on the basis of continuous transformation of gravitational energy of collapsing matter into radiation emission while the formation of a collapsar. The time delay between low energy and high energy bands (emitted from inner matter) would be large i.e. low band will reach early than the higher energy band.

For luminosity vs energy bands, the number of sources emitting radiation of specific energy band per second is a measure of luminosity and in plot these increase for the energy bands (15-25 keV to 50-100 keV) but decrease for the higher band, 100 to 150 keV (Boi et al. 2010). This could be attributed to convergence of bulk matter towards the core under its own gravity during implosion for the formation of black hole in 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. The luminosity for higher band (100- 150 keV) is low although emitted by high density inner matter, loosing large gravitational energy but must have been stopped by incoming bulk matter.

Collapsar exhibited the almost similar trend for the flux referred as the number of sources for the energy band emission per second per unit area available in the converging bulk matter (Bromberg et al. 2010). The gradient of bulk matter happen to be maximum near the high spinning of the core than at outer surface which would show decrease in the flux for high as well as low energy bands.

In the spectral power-law fitting we found photon index = 1.5 (0.04), reduced chi square = 0.9393 for 22 degrees of freedom for GRB 050525 and photon index = 1.8(0.05), reduced chi square = 0.6817 for 22 degrees of freedom for GRB 100621A. As shown in Figures: 1(d) and 2(d) both GRBs residuals are satisfactory minimum for spectral power-law fitting.

Fig-1 A

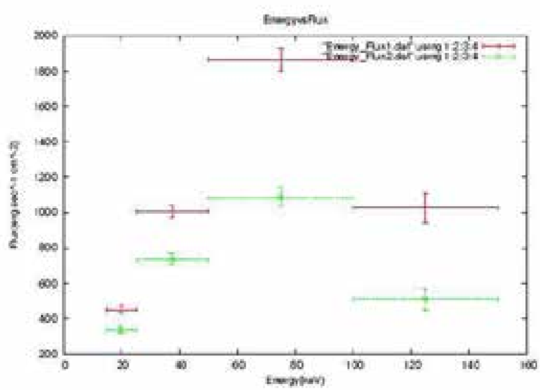
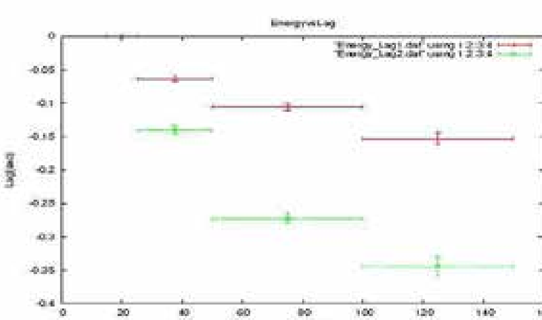


Fig-1 B and C



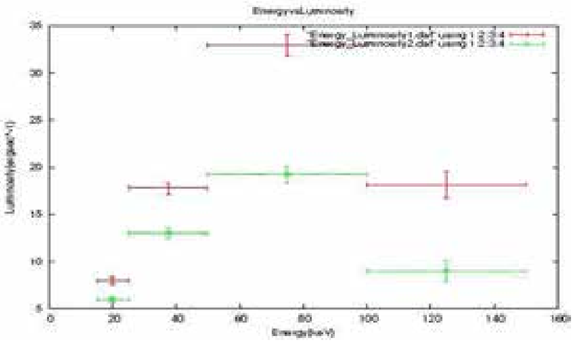


FIG-1 D

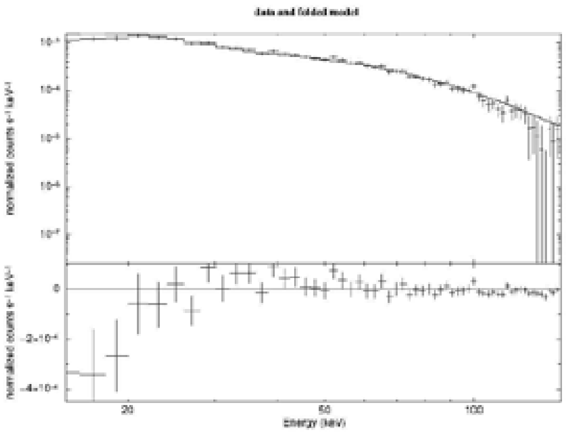
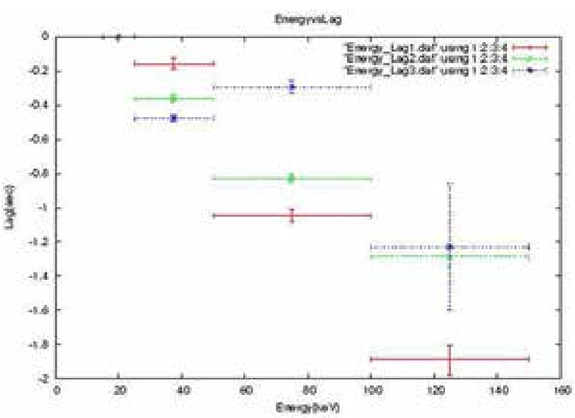


Fig. 1 (a) Energy versus flux (a), lag (b) and luminosity (c) for GRB050525. (d) Spectral fitting: power law with residuals for GRB050525. Fig. 1 (a) Energy versus flux (a), lag (b) and luminosity (c) for GRB050525. (d) Spectral fitting: power law with residuals for GRB050525

Fig-2 a.



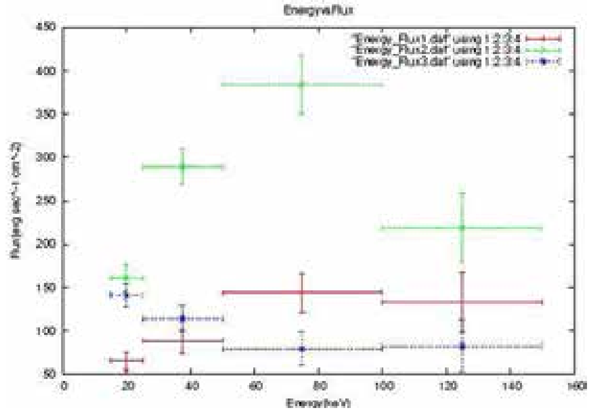
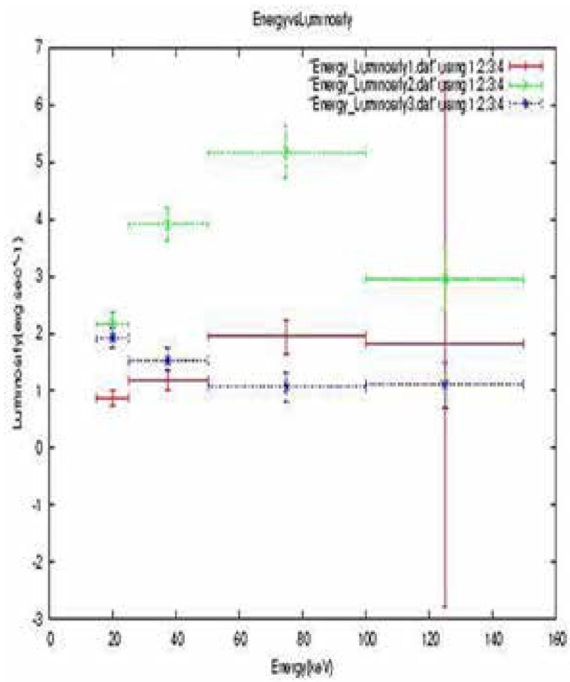


Fig-2 B and C



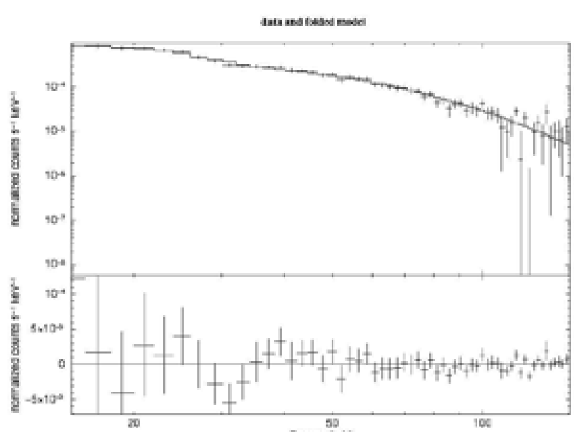


Fig-2 D

Fig. 2 Energy versus lag (a), flux (b) and luminosity (c) for GRB100621A. (d) Spectral fitting: power law with residuals for GRB100621A.

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