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Study of pulse structure and radiative mechanisms associations of long GRBs at $z \sim 1$

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Abstract. In this work, we have studied five different GRBs detected by *Swift*: GRB 071010B ($z = 0.94$), GRB 080411 ($z = 1.03$), GRB 080413B ($z = 1.10$), GRB 091208B ($z = 1.06$) and GRB 110715A ($z = 0.82$); Those GRBs, with similar z and have well defined pulses. To obtain spectral lag, we fit the light curves with a model having exponential rise and decay parts. In addition, we performed spectral analysis using three spectral models for different GRBs' regions: *power law*, *cutoff power law* and *band model*. Additionaly, we releated spectral parameters such as photon index and luminosity with spectral lag. The analysis suggests that there are two types of pulses associated to specific radiation mechanisms which would reveal the radiation process of long gamma-ray bursts.

Keywords. gamma rays: bursts

1. Introduction

Gamma Ray-Burst (GRBs) are considered the most energetic phenomena after the Big Bang with an average luminosity of 10^{51} erg/s (Zhang 2014; Zhang & Mészáros 2004; Piran 2004). GRBs emission mechanisms are an open question in Astrophysics due to the poor knowledge of their nature. The literature has established more than one non-thermal emission mechanisms associated with GRBs' emission (Resmi & Zhang 2011). Furthermore, these mechanisms are candidates to explain radiative processes that depend on jets of particles proposed by fireball model. The emission is believed to be originated from relativistic jets of electrons and positrons accelerated in strong magnetic fields, and the natural emission mechanism should be synchrotron and others such as inverse Compton and synchrotron self-Compton (Piran 2004). The fireball model consider that internal shocks are created by collisions between relativistic shells with different Lorentz factors ejected by a central engine, and external shocks by collisions between shells and interstellar medium. We propose the analysis of a sample of five long GRBs with regular pulses and similar redshifts because spectral parameters such as energy, luminosity must be influenced by the expansion of the Universe. Moreover, we searched for relations between spectral parameters and a characterization of pulses in high temporal resolution analysis.

2. Data selection and analysis

We selected five long canonical GRBs ($t > 2$ seconds) with well defined pulses and similar redshift ($z \sim 1$) in order to keep constant the effect of Universe's cosmological expansion in the sample (Jacob & Piran 2008). For this reason, we could compare spectral parameters between different GRBs. We chose this sample due to the fact that we

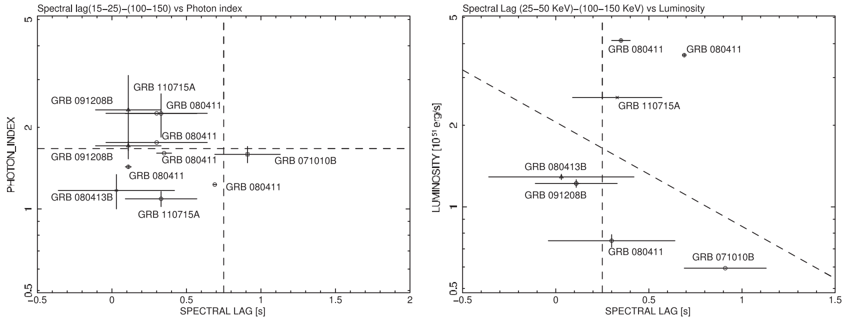

Figure 1. (*left*) t_{lag3} vs photon index and (*right*) t_{lag5} vs luminosity [10^{51} erg/s].

proposed a high temporal resolution analysis, and these GRBs have high fluence (more than 30×10^{-7} erg/s cm^2). The spectral lag is defined as a temporal delay between high energy photons and low energy photons emitted at the same time (Jacob & Piran 2008). We determined spectral lag using a exponential model proposed by Norris (Norris *et al.* 2005), where spectral lag is the difference between the maximum amplitudes in low and high energy bands: $\tau_{lag} = t_{peak,low} - t_{peak,high}$ (Arimoto *et al.* 2010). We applied three different spectral models such as *power law*, *Band model* and *cutoff power law model* normalized to 50 keV in rise/decay regions where light curves have high resolution and the noise is neglected.

3. Conclusions

The analysis suggest two different kind of pulses. One group of pulses (type I) have short spectral lag while other group of pulses (type II) have long spectral lags. Moreover, we proposed that short lags are related with efficient generation radiation energy and long lags are related to inefficient processes. In Figure 1, we observed a clustering of pulses that are associated with two or more different radiation mechanisms, which are occurring within the fireball expansion. Type I are characterized by short lags and low luminosities, and these are associated with short lags due to the collision between gamma-rays and particle jets or interstellar medium. Also, type I pulses are related with photon indeces close to 2. In the other hand, type II are characterized by long lags and high luminosities. In conclusion, long GRBs could be associated to two groups of pulses depending of their temporal delay. Maybe these two groups might be related to core collapse massive stars according to physical classification proposed by Zhang *et al.* (2007). We suggest that gamma radiation should originate from pulses with low photon index and short spectral lag, while X-ray radiation should originate from high photon index and long lag. To confirm this proposal a more detailed analysis is already in progress.

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