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Spectral Lag Evolution among γ-Ray Burst Pulses

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Abstract. We analyse the spectral lag evolution of γ-ray burst (GRB) pulses with observations by CGRO/BATSE. No universal spectral lag evolution feature and pulse luminosity-lag relation within a GRB is observed. Our results suggest that the spectral lag would be due to radiation physics and dynamics of a given emission episode, possibly due to the longer lasting emission in a lower energy band, and the spectral lag may not be an intrinsic parameter to discriminate the long and short GRBs.

Key words. γ-rays: bursts—spectral lag—GRB pulse.

1. Introduction

It is found that soft photons lag behind the hard photons and is usually seen in long GRBs (e.g., Norris *et al.* 2000; Chen *et al.* 2005; Yi *et al.* 2006), but it is not the case in short γ-ray bursts (Yi *et al.* 2006). The evolution of the spectral lag for pulses in a given GRB may shed light on the physical origin of the lag. We present a systematical analysis of the spectral lag evolution of GRB pulses with observations by CGRO/BATSE.

2. Results

Our sample was taken from the catalogue established by CGRO/BATSE. We obtain a sample for 64 GRBs based on the selection criteria: (1) Their light curves are bright enough (with signal-to-noise ratio being $>6\sigma$); (2) Having at least three well-identified pulses. We identify a pulse from the light curves in 25–2000 keV band with the same algorithm proposed by Liang *et al.* (2002), and then calculate the spectral lag between the light curves in 25–50 keV and 100–300 keV bands with cross correlation function.

The distribution of τ for all the pulses selected from our sample is shown in Fig. 1(a). The lag ranges from 0.01$\sim$1 s. We investigate the evolution of τ burst in detail. Among 64 bright GRBs one-third of them show long-to-short lag, one-third show short-to-long lag, and the other one-third have no clear evolution trend.

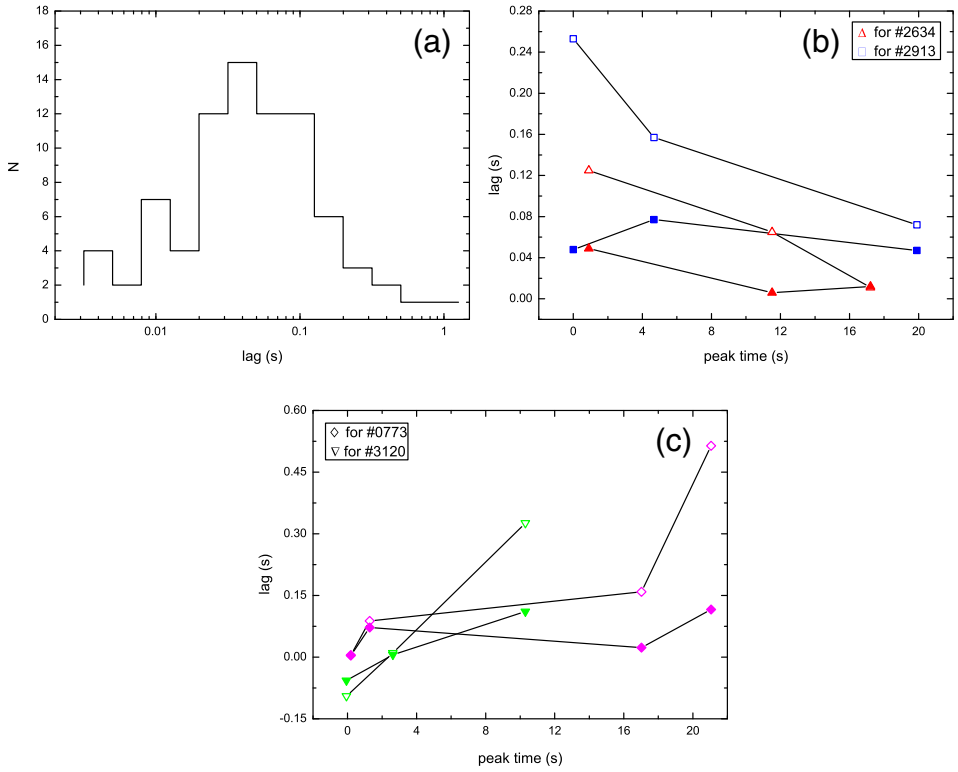

Figure 1. (**a**) Distribution of the lag for the pulses from our sample. (**b**) Examples of GRBs with long-to-short lag evolution (open symbols). (**c**) Examples of GRBs with short-to-long lag (open symbols). The corresponding specified lag (solid symbols) are also displayed.

Figures 1(b) and 1(c) show some typical cases of the spectral lag evolutions. Defining the specified lag with the ratio of the spectral lag and the pulse duration in 25–50 keV band, we find that no prominent case that the specified lag shows clear evolution feature. Hakkila & Giblin (2004) found that the late pulses in GRB 960530 and GRB 980125 have a much longer spectral lag than previous pulses. Our analysis results indicate that this is not a universal trend among bursts.

Tentative relations of the spectral lag to the peak luminosity and the jet break time were proposed by some authors (Norris *et al.* 2000). The spectral lag of a burst is derived from its global light curves. Note that GRB light curves are generally composed of some pulses. They may have different spectral lag, as shown here. We do not find correlation between the lag and the peak flux of each pulse, thus not favouring the lag-luminosity relation.

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