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ORIGINAL ARTICLE

GRB 090618: different pulse temporal and spectral characteristics within a burst

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Abstract GRB 090618 was simultaneously detected by Swift-BAT and Fermi-GBM. Its light curve shows two emission episodes consisting of four prominent pulses. The pulse in the first episode (episode A) has a smoother morphology than the three pulses in the second episode (episode B). Using the pulse peak-fit method, we have performed a detailed analysis of the temporal and spectral characteristics of these four pulses and found out that the first pulse (pulse A) exhibits distinctly different properties than the others in episode B (pulses B1, B2 and B3) in the following aspects. (i) Both the pulse width (w) and the rise-to-decay ratio of pulse (r/d, pulse asymmetry) in GRB 090618 are found to be energy-dependent. The indices of the power-law correlation between w and E for the pulses in episode B however are larger than that in episode A. Moreover the pulses B1, B2 and B3 tend to be more symmetric at the higher energy bands while the pulse A displays a reverse trend. (ii) Pulse A shows a hard-to-soft spectral evolution pattern, while the three pulses in the episode B follow the light curve trend. (iii) Pulse A has a longer lag than the pulses B1, B2 and B3. The mechanism which causes the different pulse characteristics within one single GRB is unclear.

Keywords Gamma-ray bursts · Statistical

1 Introduction

Gamma-ray bursts (GRB) have remained enigmatic since their discovery in the late 1960s (for reviews, see Piran 2004; Zhang 2007). Although in the last ten years our understanding of GRBs has been advanced significantly, due mainly to the study of GRB afterglows (e.g., Sari et al. 1998; Fan and Wei 2005; Zhang et al. 2006), the exact mechanism which produces the prompt gamma-ray emission has not been definitively established (e.g., Fan 2010; Ghisellini 2010). The temporal structures of the prompt emission are very complicated, consisting of many overlapping pulses. Pulses are the basic, central building blocks of the prompt emission, and their correlative properties imply that the pulses are responsible for many luminosity-related characteristics. Recent studies showed that the lag vs. luminosity relation (Norris et al. 2000), the variability vs. luminosity relation (Reichart et al. 2001), the $E_{\rm peak}$ vs. $E_{\rm iso}$ relation (Amati et al. 2002) and the $E_{\rm peak}$ vs. $L_{\rm iso}$ relation (Wei and Gao 2003; Yonetoku et al. 2004) all seem to be better explained by pulse rather than bulk emission properties (see Hakkila et al. 2008; Hakkila and Cumbee 2009; Krimm et al. 2009; Firmani et al. 2009; Ohno et al. 2009; Ghirlanda et al. 2010; Arimoto et al. 2010). In principle, the bulk characteristics of the prompt emission can be derived from our knowledge of the decomposition of the burst in pulses and their individual properties. Therefore, it is essential to our understanding of the physics of the bulk prompt emission of GRBs, that we properly measure and understand the properties of the individual pulses.

Hakkila et al. (2008) isolated and delineated pulse spectral properties of GRBs detected by BATSE with known redshifts, and found that pulse lag, pulse luminosity, and pulse duration are strongly correlated. They also found that pulse peak lag, pulse asymmetry, and pulse hardness are correlated for a large number of pulses of long GRBs (Hakkila and Cumbee 2009). These results indicate that most pulses of long GRBs within a given burst as well as when comparing different bursts might have similar physical origins.

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