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# Is GRB 100418A a Cosmic Twin of GRB 060614?

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**Abstract.** GRB 100418A is a long burst at $z = 0.624$ without detection of associated supernova (SN). We present a detailed analysis on this event and discuss possible origins of its multi-wavelength emission. The temporal features of this event is similar to GRB 060614, a well-known nearby long GRB without SN association (possibly a Type I GRB), indicating that the two events may be cosmic twins. However, both the circumburst medium density and the GRB classification based on the gamma-ray energy and spectrum suggest that GRB 100418A would be a Type II GRB. These results make a great puzzle on the progenitors of this kind of events, if they belong to the same population.

*Key words.* Gamma-rays: bursts—X-rays: X-ray—individual: GRB 100418A.

## 1. Introduction

Recent progress made by Swift mission presents several lines of evidence that burst duration is no longer a reliable indicator for gamma-ray burst (GRB) classification (Zhang 2006; Zhang *et al*. 2007, 2009; Lü *et al*. 2010). The most prominent case is GRB 060614, which is a long GRB at $z = 0.125$ without detection of associated supernovae. It leads to the debate on the physical origin of this event, i.e., collapse of massive stars (Type II) or merger of compact stars (Type I) (e.g., Zhang 2006 and references therein). It is interesting that Swift/BAT triggered GRB 100418A, which is quite similar to GRB 060614. We present a detailed analysis on this event and compare it with GRB 060614.

## 2. Analysis

The $T_{90}$ of GRB 100418A is $7\pm1$ s in the 15–350 keV band, with weak extended emission up to roughly 40 s post the BAT trigger. The joint light curve in 1 keV derived from Swift/BAT and XRT observations and the optical light curve in the R band are shown in Fig. 1(a), with comparison to GRB 060614. It is composed of two distinguished components, but the optical emission was detected only for the second component. The optical light curve traces the X-ray one. It is interesting that GRB 100418A is almost a mimic of GRB 060614.

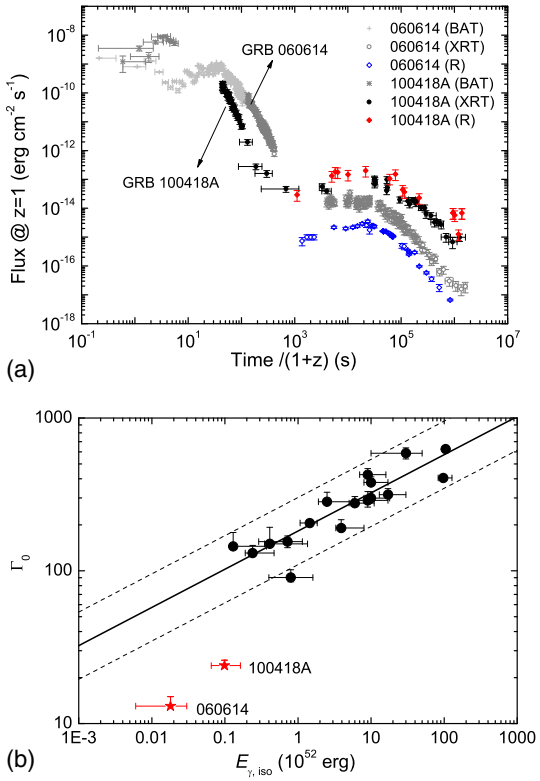


**Figure 1.** (**a**) Joint light curves in 1 keV derived from the BAT and XRT observations and the R band light curve of GRB 100418A in comparison with GRB 060614 (stars). (**b**) Initial Lorentz factor ($\Gamma_0$) as a function of $E_{\rm iso}$ (Liang *et al*. 2010).

The X-ray light curve can be fit with a two-component broken power-law model. The steep decay post the peak time ($\alpha_2 = 4.18 \pm 0.18$) and extremely soft X-ray spectrum ($\Gamma = 4.32^{+0.28}_{-0.24}$) of the first component indicates that this component may not have originated from external shocks. The early steep decay segment observed in the XRT band would be contributed by the tail emission of the prompt gamma-rays due to the time-delay of the photons at high latitude of the GRB fireball as is usually seen in some typical GRBs (Liang *et al*. 2006; Zhang *et al*. 2007, 2009). The second component slowly rises and peaks at $\sim 10^5$ s post the GRB trigger. This component is also detected in the optical bands. The extremely late peak time is not consistent with the scenario of the deceleration of the GRB fireball as usually seen in some typical GRBs (Fig. 1b). In the refreshed external shock cases, we find that the behavior of the energy injection is roughly consistent with the continued energy injection from spin-down energy release of a magnetar ($q \sim 0$). However, the extremely large injected energy raises an issue on this scenario. We propose that the external shocks from a sub-energetic jet component or from a late, sub-energetic fireball may be responsible for this component.

## 3. Discussion and conclusions

It is interesting that the temporal features of this event is similar to GRB 060614. Deep optical monitoring did not find any signature of SN in the late optical light curves as seen for most GRBs at $z < 1$. Therefore, both GRBs 060614 and 100418A possibly are of the same population of long GRBs without an accompanied SN.

It was suggested that GRB 060614 would be a Type I GRB from merger of compact stars. The circum burst environment may also present signature of progenitor of a GRB. A low-density medium is evidence for a burst from merger of compact stars. With the X-ray and optical afterglow emission, it is found that $n \geq 0.1$ cm$^{-3}$ for GRB 100418A (Marshall *et al*. 2011). This disfavors the scenario of mergers of compact stars as the progenitors of this event. Lü *et al*. (2010) proposed a new GRB classification with both the burst energy and spectrum. With this method, GRB100418A is also classified into the Type II group. These results make a great puzzle on the progenitors of this kind of events, if GRBs 060614 and 100418A belong to the same population. We would like to point out that one cannot confidently exclude the possibility that the two bursts may essentially have different physical origins from both Type I and Type II, such as a stellar object disrupted by a median-mass black hole (Lu *et al*. 2008).

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