Gamma-ray burst observation for eight and half year by Akeno MITSuME telescope

Taichi Fujiwara,[1] Yoshihiko Saito,[1] Ryosuke Itoh,[1]
Yutaro Tachibana,[1] Yuki Ono,[1] Kotaro Morita,[1] Kouta Saisho[1] and Nobuyuki Kawai[1]

[1] Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro, Tokyo, Japan
E-mail(TF): fujiwara@hp.phys.titech.ac.jp

Abstract

We report the observations of early Gamma-Ray Burst (GRB) afterglows carried out with Akeno 50 cm Telescope from 2008 to 2016. In this period, fourteen GRB afterglows were detected within 1000 seconds after the detections of the prompt emission. We show the optical light curves of the GRB afterglows to discuss timing properties of the external shock. Then, we compare the light curves with the forward/reverse shock models. We discuss the number ratios of the different light-curve types based on the simulation by Gao et al. (2015). Finally, the ratio of magnetic equipartition parameters in the reverse and forward shocks are evaluated as 10–100.

Key words: gamma-ray burst: general

1. Introduction

The gamma-ray burst (GRB) afterglows are usually described well with forward shock emission. As the counterparts of the afterglows, reverse shock emission was also predicted. However, the typical frequency of the reverse shock emission is lower than that of the forward shock (Kobayashi et al. 2003).

Depending on the spectral peak frequency and the intensity ratio of the forward shock emission to that of the reverse shock, the early optical afterglows are classified into four types (Gao et al. 2015):
Type 1: **Rebrightening.** The forward shock peak is beneath the reverse shock component. A sign of rebrightening emerges due to forward shock emission later.
Type 2: **Flattening.** The forward shock peak is beneath the reverse shock component. The forward shock emission only shows its decaying part in the late stage.
Type 3: **Forward shock-dominated emission without ν_m crossing.** No reverse shock component is visible. The observed optical peak is the deceleration peak.
Type 4: **Forward shock-dominated emission with ν_m crossing.** No reverse shock component is visible. The observed optical peak is the crossing peak of ν_m.

It is necessary to observe GRB afterglows immediately to analyze their morphology. Akeno 50 cm Telescope automatically observes GRBs detected by Swift and MAXI to obtain the light curves of early afterglows.

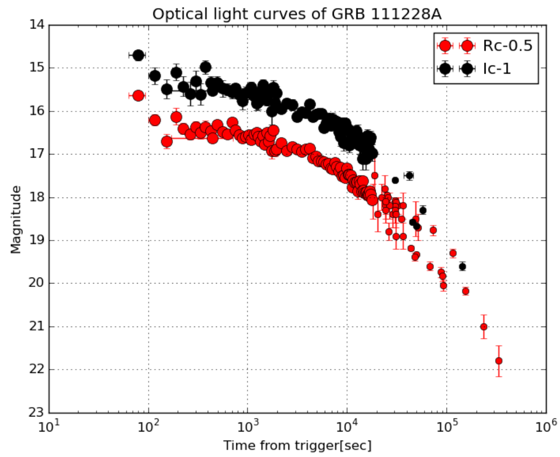

Fig. 1. Optical light curves of GRB 111228A.

2. Observation and Results

From 2008 January to 2016 June, we observed 14 GRB afterglows with Akeno Telescope within 1000 seconds after the detections of the prompt emission. Fig. 1 and Fig. 2 show the examples of the light curves obtained with Akeno Telescope.

GRB 111228A showed a steep decay for < 200 seconds followed by flattening. This light curve cannot be fit with a simple smooth broken power-law function but with a combination of a single power-law component and

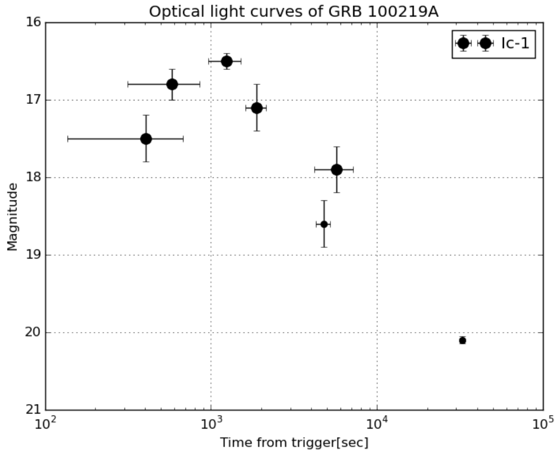

Fig. 2. Optical light curve of GRB 100219A.

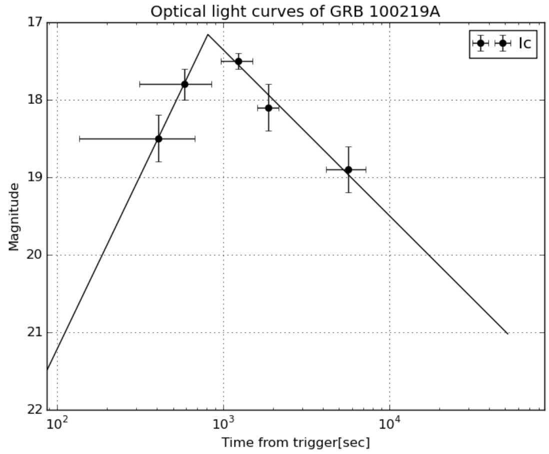

Fig. 4. Fitting result of the GRB 100219A data.

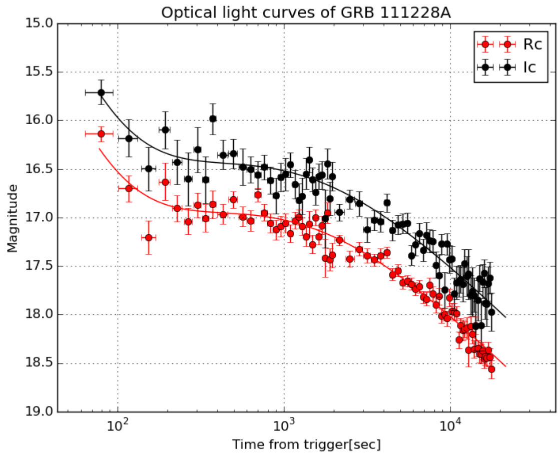

Fig. 3. Fitting result of the GRB 111228A data.

a smooth broken power-law component. The model light curve obtained in this fitting is shown in Fig. 3. Thus, we classify this afterglow as Type 1.

We detect an initial rise in the afterglow of GRB 100219A. We fitted the light curve with a broken power-law function. The power-law index of the decaying slope is smaller than 1.5, so we consider that a forward shock is dominant in this GRB. We classify this GRB as a Type 3/4 candidate. The power-law index of the rising slope is larger than 0.6, suggesting that the optical peak is the deceleration peak. We therefore classify it into Type 3. The result of this fitting is shown in Fig. 4.

Applying a similar analysis to the early optical light curves of the 14 GRBs, we eventually find one burst of Type 1, another burst of Type 2, four bursts of Type 3 and eight bursts that cannot be uniquely classified.

3. Discussion

Some GRBs cannot be classified, because the start of their observations were not early enough to detect their rising phases if they exist.

We discuss number ratios of the different light-curve types by the simulation done by Gao et al. (2015). First, if the reverse-to-forward shock ratio (R_B) of magnetic equipartition parameters is generated through a Gaussian distribution with mean values ($\overline{R_B}$) of 10, the cases where the reverse shock dominates (Type 1 and 2) become less than 2%. We found 2 such bursts out of 14. Therefore, $\overline{R_B}$ needs to be larger than 10. If we assume $\overline{R_B} = 100$, then the "reverse-shock dominant" cases become 20–30%, consistent with our results.

Thus, we find that the reverse-to-forward shock ratio of magnetic equipartition parameters is likely $10 < \overline{R_B} \leq 100$.

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