Early optical afterglow spectra of GRB021004 by Kiso observatory

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Abstract

We have operated TOO system for prompt GRB follow-up observations at Kiso observatory since 2001. The Kiso observatory is located in Nagano prefecture, Japan, and has 105 cm schmidt telescope and three instruments. We carried out 14 follow-up observations using this system. In the GRB021004, we could obtain the very early afterglow spectrum with low dispersion slitless spectrograph using objective prism, well before a position of optical transient was reported. We carried out spectrophotometry, and obtained B-, V-, R-, and I-band light curve. The brightness re-increased at ∼2 hours after the burst. From our results, it is suggested that the light curve have two components. One of the interpretations it that one is a prompt optical emission, and the other is typical afterglow. Here we report the optical follow-up observations of GRB021004.

1. Introduction

GRB021004 was detected by the FREGATE, WXM, and SXC instruments aboard HETE-2 at 12:06:13 UT on 2002 October 4. The flight localization was reported in a GCN Position Notice at 12:07:02 UT, 53 sec after the burst trigger. The prompt localization by HETE-2 allowed the follow-up of the afterglow at a very early time. Fox et al. reported their discovery of a bright, fading optical transient within the SXC error circle 186 min after the burst. The rapid identification allowed for near-continuous monitoring of this afterglow. The redshift $z = 2.335$ is measured by the Lyα emission line. The Kiso observatory has established the capability of multi-band and slitless spectroscopic follow-up observations of GRB. In this burst, we could obtain the very early (80∼ min after the burst) afterglow spectrum before the accurate optical transient position reported.

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2. Observation and Analysis

We carried out follow-up observations of the optical afterglow of GRB021004 with the 1.05 m Schmidt telescope starting at 12:06:13 UT on 2002 October 4 (80 min after the burst) before the optical transient position reported. We performed low-resolution spectroscopy with eighteen 300 sec exposure using a 2k×2k CCD Camera with 2 deg objective prism spectrometer. Figure 1 shows images obtained on the nights of October 4 and 5. The dispersion is 1.9 nm/pixel at Hγ and 9.1 nm/pixel at A-band of atmosphere absorption. This spectrometer is able to obtain spectra in 50'×50' field.

We used NOAO IRAF, and purpose-written software to reduce the data. This entailed bias subtraction, flat-fielding using the flat frame which was constructed from the median of the dithered science and calibration frames. Wavelength calibration was accomplished with absorption of hydrogen balmer series lines of A-type star ("HD216999 "). To look the temporal behavior compare with other site results, we performed spectroscopic photometry. The flux calibration was performed by compared with photometric standard stars located in the same field calibrated by Henden (GCN1583).

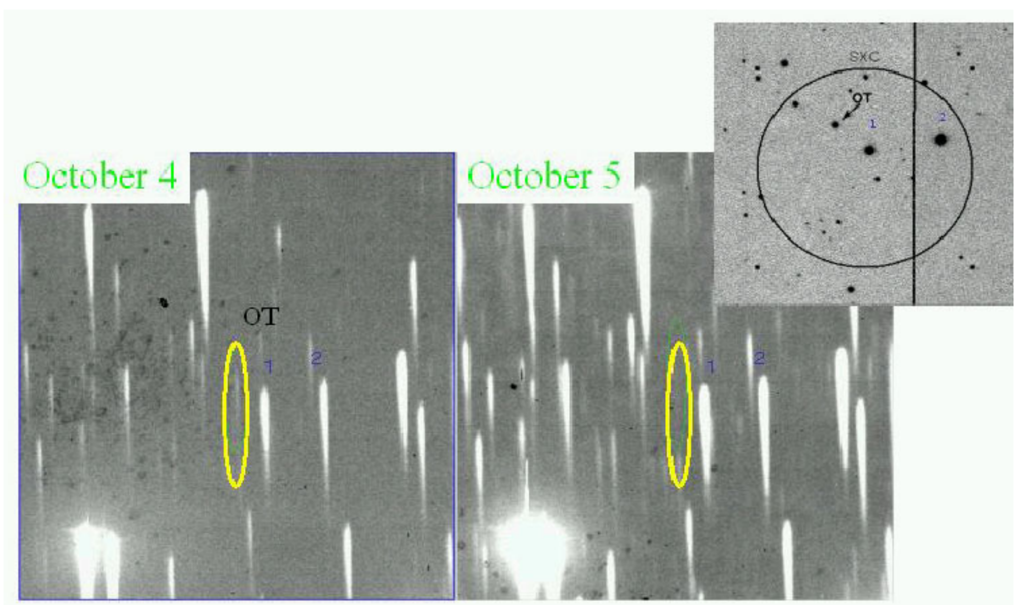

Fig. 1. The raw spectrum image of GRB021004 field.

3. Result

Figure 2 shows four-band light curves of the optical afterglow. We can see the re-increasing the brightness in V-, R-, and I-band light curve around 0.073

day after the burst. In this phase, it is well fitted with power law whose index is 1.6 ± 0.1 (V-band), 1.7 ± 0.3 (R-band), and 1.2 ± 0.3(I-band). The decay index after the peak is -0.2 ± 0.1 obtained from R-band light curve. Around 0.2 day after the burst, it has a temporal break whose decay index of after the break is -0.7 ± 0.1.

The spectrum after the peak is well fitted with power law whose index of β at 0.142 after the burst is 1.01 ± 0.10. This value close to 0.94 ± 0.03 of X-ray afterglow spectra obtained by Chandra and 0.98 ± 0.03 from the optical afterglow 550∼885nm range spectra obtained by MMT telescope (Matheson et al. 2003).

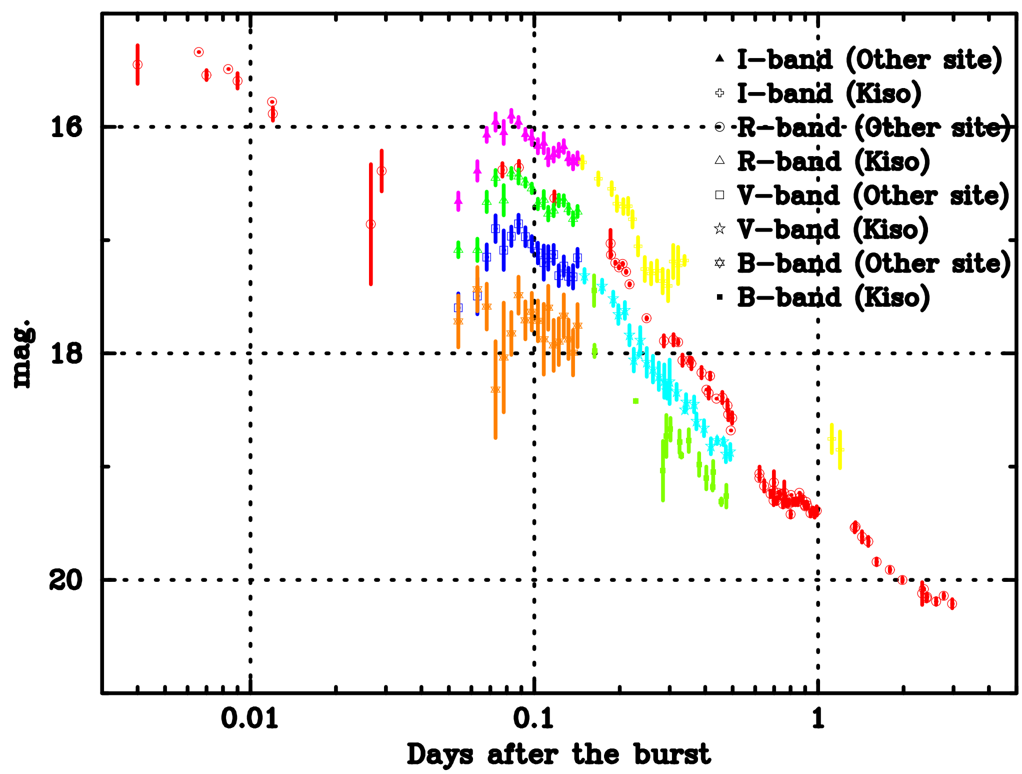

Fig. 2. The light curve of GRB021004. We can clearly see the early bump in V-, R-, and I-band whose peak is around 0.07 day after the burst..

4. Discussion

We plotted R-band light curves of GRB021004, GRB020813, GRB990123, and GRB021211 in figure 3. In the GRB990123 case, it show the prompt emission whose peak magnitude is $R = 8.9$ mag and decay is rapidly. In the GRB021211 case, it has been shown rapid decay until ∼0.05 day after the burst. The GRB020813 case, the behavior around 0.2 day after the burst looks like that of GRB021004. The V-, R-, and I-band light curves can be described by a broken power-law of $\alpha_1 \sim 0.4$ and $\alpha_2 \sim 1.3$, with a break point at ~ 0.2 days (Urata et al. 2003).

These four case light curves would be change the emission mechanism within or around 0.1 day after the burst. The light curve has a peak around ∼0.1 day after the burst. One of the possible interpretations is that it would be occurred by crossing the typical synchrotron frequency through the optical band (Kobayashi and Zhang, 2003).

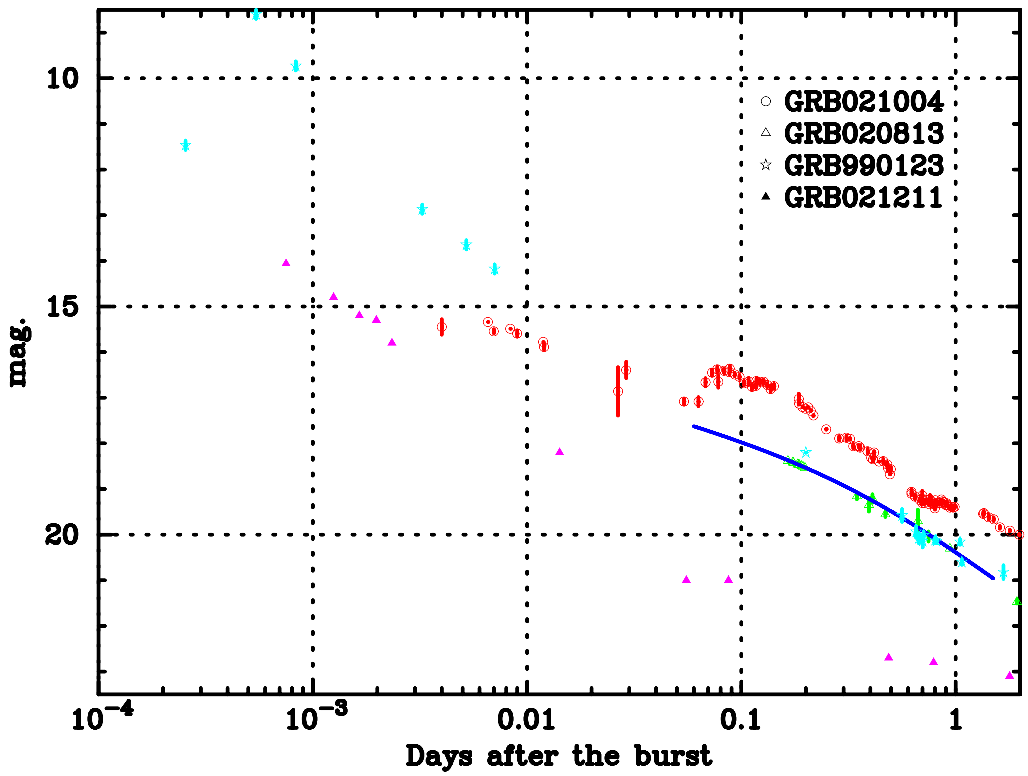

Fig. 3. The R-band light curve of GRB021004, GRB020813, GRB990123, and GRB021211.

We are preparing to install a low dispersion grism in filter wheel for 50'×50' FOV slitless spectrograph. This system allows us to change from imaging mode to spectroscopic mode quickly

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