Swift Observation of GRB 070721B

0 Revisions

Ground observations of the afterglow and confirmation of its fading is added. The XRT light curve, its slopes and break time is updated.

1 Introduction

BAT triggered on GRB 070721B at 10:33:48 UT (Trigger 285654) (Ziaeepour, et al., GCN Circ. 6640). This was a 2.048 sec rate-trigger with significance of 12 on very long burst with $T_{90} \gtrsim 340 \pm 10$ sec. Swift slewed to this burst immediately and XRT began follow-up observations at $T + 92.8$ sec, and UVOT at $T + 88$ sec. Our best position is the UVOT location RA($J2000$) = 33.1373 deg (02h12m32.95s), Dec($J2000$) = −2.1946 deg (−02d11′40.6″) with an error of 0.9 arcsec. The initial optical magnitude of the afterglow was 16.82 ± 0.1 in White filter (160 – 650 nm). Ground follow-up of this burst at $\sim T + 5.45$ hours (Melandri, et al., GCN Circ. 6647) did not find any new source in the refined XRT error circle. The magnitude limits are $R > 19.3$ and $I > 17.8$ at 6.4 and 6.2 hours after the trigger, respectively. Deep observations by the NOT and the VLT respectively at $\sim T + 17.6$ hours and at $\sim T + 21.6$ and $\sim T + 47.3$ hours (Malesani, et al., GCN Circ. 6651, Fynbo, et al., GCN Circ. 6655) find two sources close to the UVOT position with R magnitudes 23.8 and 24.3. The second source is found to be fading. Its position is RA($J2000$) = 02h12m33.00s, Dec($J2000$) = −02d11′41.4″ and its spectrum shows a DLA and several metallic lines inferring a redshift of $z = 3.626$. This redshift is consistent with the non-detection of the afterglow in filters bluer than V (De Pasquale & Ziaeepour, GCN Circ. 6650). The afterglow has not been detected in radio frequency 8.46 GHz by the VLA (Chandra & Frail, GCN Circ. 6705) $\sim 10$ days after the trigger.

2 BAT Observation and Analysis

Using the data set from $T – 239$ to $T + 903$ sec, further analysis of BAT GRB 070721B has been performed by Swift team (Sakamoto, et al., GCN Circ. 6643, Barthelmy, et al., GCN Circ. 6649). The BAT ground-calculated position is RA($J2000$) = 33.128 deg (02h12m30.8s), Dec($J2000$) = −2.198 deg (−02d11′54″) ± 1.2 arcmin, (radius, systematic and statistical, 90% containment). The partial coding was 23\% (the offset angle was 26.67 deg).

The masked-weighted light curves (Fig.1) starts at trigger time $\sim T – 20$ sec a mildly FRED peak with substructures that returns to background at about $T + 20$ sec, following by a small peak lasting until $\sim T + 40$ sec. Another episode of activity begins at $\sim T + 230$ sec to $T + 380$ sec with multiple peak emission observed in all BAT bands. Gaps in the later data do not permit to know if the activity of the source continues further. $T_{90}$ (15 – 350 keV) is 340 ± 10 sec (estimated error including systematics).

The time-averaged spectrum from $T – 6.7$ to $T + 359.9$ sec is best fitted by a simple power law model. This fit gives a photon index of 1.34 ± 0.11, ($\chi^2 = 50.05$ for 57 d.o.f.). For this model the total fluence in the 15 – 150 keV band is (3.6 ± 0.2) × $10^{-6}$ ergs cm$^{-2}$ and the 1-sec peak flux measured from $T – 0.19$ sec in the 15 – 150 keV band is 1.5 ± 0.3 ph cm$^{-2}$ sec$^{-1}$. All the quoted errors are at the 90\% confidence level.
3 XRT Observations and Analysis

Using all the available data of the XRT for GRB 070721B (∼ 5.78 ksec in Photon Counting mode), the refined XRT position RA(J2000) = 33.13710 deg (02h12m32.90s), Dec(J2000) = −2.19462 deg (−02d11′40.6") ± 3.5 arcsec (90% confidence, including boresight uncertainties) (Beardmore, et al., GCN Circ. 6646). This position is within 8.9 arcsec of the initial XRT position (Ziaeepour, et al. GCN Circ. 6640) and 0.7 arcsec from the UVOT position (Schady GCN Circ. 6641).

The 0.3 − 10 keV light curve (Fig.2) shows an initial steep decay from $T + 100$ sec to $T + 144$ sec, followed by a number of flares from $T + 255$ sec to $T + 800$ sec which reached a maximum count rate of 50 count/s at $T + 315$ sec. They coincide with peaks observed in the BAT bands. The underlying decay is a power-law with a decay slope of 0.271 ± 0.03. There is break at ∼ $T + 9163^{+861}_{−911}$ sec where the slope steepens to 2.18 ±0.24.

The X-ray spectrum from the Windowed Timing mode data obtained during the non-flare intervals from ($T + 144$ sec to $T + 220$ sec and $T + 400$ sec to $T + 475$ sec) can be fit with an absorbed power-law to give a photon index of 1.48 ±0.18 and a column density of $1.9_{-1.8}^{+1.9} \times 10^{20}$ cm$^{-2}$, consistent with the Galactic value of $2.3 \times 10^{20}$ cm$^{-2}$ in this direction (Kalberla, et al., 2005). The observed 0.3 − 10 keV flux is $2.37 \pm 0.25 \times 10^{-10}$ ergs cm$^{-2}$ sec$^{-1}$ which corresponds to an unabsorbed flux of $2.45 \pm 0.25 \times 10^{-10}$ ergs cm$^{-2}$ sec$^{-1}$.

4 UVOT Observation and Analysis

The UVOT began observing the field of GRB 070721B at 10 : 35 : 10 UT, 88.3 sec after the initial BAT trigger (Schady, GCN Circ. 6641, De Pasquale et al., GCN Circ. 6650). The optical afterglow is detected by Swift/UVOT in White filter and V filter finding chart exposures, taken from ∼ 100 sec to 200 sec and from 207 sec to 607 sec after the BAT trigger. It is not detected at 3 − σ level in other filters and in the same filters after ∼ $T + 700$ sec. Table 1 summarizes the magnitudes/magnitude limits of the afterglow.

<table>
<thead>
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<th>Filter</th>
<th>$T_{mid}$ sec</th>
<th>Exposure (sec)</th>
<th>Mag/3σ UL</th>
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<td>100 − 200</td>
<td>99</td>
<td>16.82 ± 0.1</td>
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<td>V</td>
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<td>16.7 ± 0.1</td>
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<td>V</td>
<td>621 − 641</td>
<td>19</td>
<td>&gt; 17.5</td>
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Table 1: Magnitudes from UVOT observations
Figure 1: BAT light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts/ sec/illuminated-detector and $T$ is 10:33:46.3 UT.

Figure 2: XRT light curve. Counts/sec in the 0.3–10 keV band: Window Timing mode (black), Photon Counting mode (red). The approximate conversion of the absorbed flux is 1 count/sec $5.4 \times 10^{-11}$ ergs cm$^{-2}$ sec$^{-1}$. 