Swift Observations of GRB 090313

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1 Introduction

At 09:06:27 UT, the Swift Burst Alert Telescope (BAT) triggered and located GRB 090313 (trigger=346386). The position is given below. The BAT light curve showed a broad series of multiple peaks from approximately T-10 s to T+40 s. The peak count rate was 1300 counts/s (15-350 keV), at 4 s after the trigger. Since this was an image trigger, the light curve shows only rather weak peaks.

Due to a Moon observing constraint, Swift could not slew to the BAT position until 16:45 UT. Thus there were no prompt XRT or UVOT data for this trigger.

The optical afterglow was discovered by Chornock et al. (GCN 8979) and then confirmed by the GROND team using IR observations (Updike et al., GCN 8983). The afterglow was observed to rise and peak around 1.3 ks post burst by the Faulkes Telescope North (Guidorzi et al., GCN 8989). De Ugarte Postigo et al. (GCN 8992) reported on the optical ongoing plateau phase. Chornock et al. (GCN 8994) measured the spectroscopic redshift z=3.375. AAVSO High Energy Network (Nissinen GCN 8993), PAIRITEL (Morgan et al., GCN 8995), TAROT (Klotz et al., GCN 8998 ), MITSuME Okayama (Yoshida et al., GCN 9002), SMARTS (Cobb, GCN 9008), VLT (Thoene et al., GCN 9012) and X-shooter (de Ugarte Postigo et al., GCN 9015) also observed the optical afterglow.

AMI Large Array (frequency range 14.5 to 17.5 GHz) obtained a flux density of 820 μJy with an rms noise of 71 μJy (Pooley GCN 9003, but see Pooley GCN 9007). The Combined Array for Research in Millimeter-Wave Astronomy (CARMA) detected a flux density of (4.0 ± 0.6) mJy at a frequency of 92.5 GHz (Bock et al., GCN 9005). The Very Large Array (VLA) reported a flux density 269±31 μJy at 8.46 GHz band (Frail et al., GCN 9011). Westerbork Synthesis Radio Telescope observed the radio counterpart at 4.9 GHz with a flux density of (165 ± 30) μJy (van der Horst & Kamble GCN 9016).

2 BAT Observation and Analysis

Using the data set from T-239 to T+963 s, the BAT ground-calculated position is RA, Dec = 198.400, 8.086 deg, which is RA(J2000) = 13h 13m 36.0s, Dec(J2000) = +08d 05’ 10.7” with an uncertainty of 2.2 arcmin, (radius, sys+stat, 90% containment). The partial coding was 15%.

The mask-weighted light curve (Fig. 1) shows emission starting before T-100 s. BAT triggered on the peak starting at T-20 s, peaking at T+10 s, and ending at T+90 s. T90 (15-350 keV) is 78 ± 19 s (estimated error including systematics).

The time-averaged spectrum from T-21.3 to T+66.6 s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.91 ± 0.29. The fluence in the 15-150 keV band is (1.4 ± 0.2) × 10⁻⁶ erg cm⁻². The 1-sec peak photon flux measured from T+4.86 sec in the 15-150 keV band is (0.8 ± 0.3) ph cm⁻² s⁻¹. All the quoted errors are at the 90% confidence level.

The results of the batgrbproduct analysis are available at

http://gcn.gsfc.nasa.gov/notices_s/346386/BA/
3 XRT Observations and Analysis

Due to a Moon constraint, XRT began observing GRB 090313 26.8 ks after the trigger (Mao et al., GCN Circ. 8980). Using 2038 s of XRT Photon Counting mode data and 1 UVOT image, the astrometrically corrected X-ray position was found to be: RA, Dec = 198.40130, 8.09730 which is equivalent to: RA (J2000): 13h 13m 36.30s, Dec (J2000): +08d 05' 50.4" with an uncertainty of 1.8 arcsec (radius, 90% confidence).

The lightcurve (Fig. 2) can be modeled as a double broken power-law with the following parameters: $\alpha_1 = 1.48 \pm 0.28$, $\alpha_2 = 0.64 \pm 0.38$, and $\alpha_3 = 2.27 \pm 0.12$; the values of break times are about $t_{b1} = 4.5 \times 10^4$ s and $t_{b2} = 7.9 \times 10^4$ s respectively.

The PC mode spectrum spanning from 26.8 to 28.6 ks can be fit with an absorbed simple power-law, with a photon index of $2.12 \pm 0.33$ and an absorbing column density of $(1.29 \pm 0.97) \times 10^{21}$ cm$^{-2}$, in excess of the Galactic value of $2.10 \times 10^{20}$ cm$^{-2}$ (Kalberla et al., 2005). The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is $5.1 \times 10^{-11} (5.9 \times 10^{-11})$ erg cm$^{-2}$ count$^{-1}$.

The results of the automatic XRT analysis are available online at http://www.swift.ac.uk/xrt_products/00346386.

4 UVOT Observation and Analysis

The Swift/UVOT began observing the field of GRB 0903013 27ks after the BAT trigger. A fading source is detected in the v filter and marginally in the b-band filter. These observations are in agreement with the spectroscopic redshift $z=3.375$ (Chornock et al., GCN 8994). The magnitudes and 3-sigma upper limits for GRB 090313 within each co-added UVOT filter are reported in Table 1:

<table>
<thead>
<tr>
<th>Filter</th>
<th>$T_{mid}$ (hrs)</th>
<th>Exp (s)</th>
<th>Mag/3-sigma UL</th>
</tr>
</thead>
<tbody>
<tr>
<td>v</td>
<td>11.0</td>
<td>551</td>
<td>20.10 $\pm$ 0.30 (3.6 sigma)</td>
</tr>
<tr>
<td>b</td>
<td>11.2</td>
<td>770</td>
<td>21.50 $\pm$ 0.38 (2.8 sigma)</td>
</tr>
<tr>
<td>u</td>
<td>8.1</td>
<td>1024</td>
<td>&gt; 21.44</td>
</tr>
<tr>
<td>uvw1</td>
<td>8.6</td>
<td>1771</td>
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</tr>
<tr>
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<td>886</td>
<td>&gt; 21.22</td>
</tr>
<tr>
<td>uvw2</td>
<td>10.9</td>
<td>886</td>
<td>&gt; 21.58</td>
</tr>
</tbody>
</table>

Table 1: Magnitudes from UVOT observations.

where $T_{mid}$ is the weighted mean time of the observations. The values quoted above are not corrected for the Galactic extinction due to the reddening of $E(B-V) = 0.03$ in the direction of the burst (Schlegel et al., 1998). All photometry is on the UVOT photometry system described in Poole et al., (2008, MNRAS, 383, 627).
Figure 1: BAT Lightcurve. The mask-weighted light curve in the 4 individual plus total energy bands: 15-25 keV (black), 25-50 keV (red), 50-100 keV (green), 100-350 keV (blue), 15-350 keV (magenta).

Figure 2: XRT Lightcurve in the 0.3-10 keV band. The approximate conversion is 1 count s\(^{-1}\) \(\sim\) 5.1 \(\times\) 10\(^{-11}\) erg cm\(^{-2}\) s\(^{-1}\).