Swift Observation of GRB 090929B

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1 Introduction

BAT triggered on the long GRB 090929B at 10:09:07.2 UT (Trigger 371050) (Pagani, et al., GCN Circ. 9963), a burst with $T_{90} = 360 \pm 20$ sec. Swift slewed immediately to the burst. The XRT detected the afterglow in observations starting 84.1 sec after the trigger. The UVOT did not detect the optical afterglow (Curran, et al., GCN Circ. 9969). The fading optical afterglow was detected in observations by the RAPTOR telescope (Wren, et al., GCN Circ. 9967) but only upper limits were measured by Skynet/DSO (Haislip, et al., GCN Circ. 9970) and Gemini-North (Cucchiara, et al., GCN Circ. 9971). The burst was also detected by Konus-Wind (Golenetskii, et al., GCN Circ. 9975) that measured a peak energy of 282 (-78, +169) keV and by the Suzaku Wide-band All-sky Monitor (Ohmori, et al., GCN Circ. 9993) and by the INTEGRAL SPI Anti-Coincidence System (Beckmann, private communication; all SPI-ACS events can be found under http://isdc.unige.ch/Soft/ibas/ibas_acs_web.cgi). The afterglow optical analysis is complicated by the contamination of a USNO catalogued star (R2=19.3) and a bright (R = 9.5), near-by star.

2 BAT Observation and Analysis

Using the data set from $T - 239$ to $T + 691$ sec, further analysis of BAT GRB 090929B has been performed by the Swift team (Krimm, et al., GCN Circ. 9979). The BAT ground-calculated position is RA(J2000) = 117.712deg (07h50m50.9s), Dec(J2000) = -0.645deg (-00d38'41.2") ± 1.4 arcmin, (radius, systematic and statistical, 90% containment). The partial coding was 63%.

The mask-weighted light curve (Fig.1) shows many peaks interspersed with intervals with no detected flux, from T-10 to T+380 sec when the source left the coded field of view due to a observing constraint. There may have been small and/or low-energy peaks beyond this time. The largest peak was at about T+30 to T+40 sec. $T_{90}(15 - 350keV)$ is 360 ± 20 sec (estimated error including systematics).

The time-averaged spectrum from $T - 9.8$ to $T + 371.0$ sec is best fitted by a simple power law model. The power law index of the time-averaged spectrum is 1.85 ± 0.08. For this model the total fluence in the 15 – 150 keV band is $(5.9 \pm 0.3) \times 10^{-6}$ergs/cm$^2$, and the 1-sec peak flux measured from $T + 30.67$ sec in the 15 – 150 keV band is $3.3 \pm 0.2$ ph/cm$^2$/sec. All the quoted errors are at the 90% confidence level considering the statistical and usual systematic effects.

The results of the batgrbproduct analysis are available at:
http://gcn.gsfc.nasa.gov/notices_s/371050/BA/

3 XRT Observation and Analysis

Using 2438 sec of overlapping XRT Photon Counting mode and UVOT data for GRB 090929B, we find an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue): RA(J2000) = 117.72015deg (07h50m52.84s), Dec(J2000) = -0.65764 deg (-00d39'27.5") ± 1.8 arcsec (radius, 90% confidence) (Goad, et al., GCN Circ. 9964).
The 0.3 – 10 keV light curve (Fig. 2) shows intense flaring activity during the first orbit with the strongest emission of $\sim 7.0 \times 10^{-9}$ ergs/cm$^2$/sec at $T + 150$ sec. The following orbits can be modeled with a broken power-law decay with an initial decay index of $\alpha = 0.97 \pm 0.05$ and a jet break after $\sim 2.2 \times 10^5$ sec with decay index $\alpha = 2.5^{+1.1}_{-0.5}$.

The X-ray spectrum of the first orbit of Windowed Timing mode data from $T + 90$ sec to $T + 190$ sec can be well fitted by an absorbed power law with spectral index $1.55 \pm 0.05$. The best-fitting absorption column is $1.6 \pm 0.2 \times 10^{21}$ cm$^{-2}$, in excess of the Galactic value of $5.4 \times 10^{20}$ cm$^{-2}$ in that direction (Kalberla et al. 2005). The Photon Counting mode spectrum has a spectral index of $2.09 \pm 0.14$ and a best-fitting absorption column of $(1.32^{+0.40}_{-0.33}) \times 10^{21}$ cm$^{-2}$ The average absorbed flux over 0.3 – 10 keV for the WT spectrum is $4.09 \times 10^{-10}$ ergs/cm$^2$/sec, which corresponds to an unabsorbed flux of $5.0 \times 10^{-10}$ ergs/cm$^2$/sec.

4 UVOT Observation and Analysis

The UVOT began observing the field of GRB 090929B 94 sec after the BAT trigger (Curran et al., GCN Circ. 9969). No optical afterglow is detected in the b, u or uvw2 UVOT exposures. There is
Figure 2: XRT Lightcurve. Counts/sec in the 0.3-10 keV band: Window Timing mode (blue), Photon Counting mode (red). The approximate conversion is 1 count/sec $\sim 3.9 \times 10^{-11}$ ergs/cm$^2$/sec.

a detection in the white filter, consistent with the enhanced XRT position (Page, et al., GCN Circ. 9965), the proposed optical counterpart (Wren, et al., GCN Circ. 9967) and a USNO catalogued star (R2=19.3). Since the photometry is contaminated by a bright (R = 9.5), near-by star, we cannot determine the nature of the source. Preliminary magnitudes and 3$\sigma$ upper limits for detecting a source are in Table 1. These values are on the UVOT Photometric System described in Poole et al. (2008, MNRAS, 383,627). These values are not corrected for the Galactic extinction in the direction of the burst corresponding to a reddening of $E_{B-V} = 0.073$ mag (Schlegel et al., ApJ. 500:525-553, 1998).

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<th>$T_{\text{stop}}$</th>
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Table 1: Magnitudes and upper limits from UVOT observations