Swift Observation of GRB 091109A

S. R. Oates (MSSL-UCL), A. P. Beardmore (U Leicester), and H. A. Krimm (GSFC/USRA) report for the Swift Team

1 Introduction

BAT triggered on GRB 091109A at 04:57:43 UT (Trigger 375246) (Oates, *et al.*, *GCN Circ.* 10138). *Swift* XRT and UVOT observations began 154s and 156s after the BAT trigger, respectively. A source was detected by the XRT (Beardmore, *et al.*, *GCN Circ.* 10140) and a faint source was detected in the UVOT (Oates, *et al.*, *GCN Circ.* 10143). Our best position is the UVOT location RA($J2000$) = 309.25749 deg (20h 37m 01.80s), Dec($J2000$) = -44.1582 deg ($-44d$ 09′ 29.4″) with an error of 0.6 arcsec (radius, 90% containment). The optical afterglow was also detected by REM (Antonelli, *et al.*, *GCN Circ.* 10139 & 10147),Faulkes Telescope South (Guidorzi, *et al.*, *GCN Circ.* 10142), GROND and VLT (Afonso, *et al.*, *GCN Circ.* 10158). A redshift of of 3.5 has been determined photometrically by GROND and spectroscopically by VLT, but these observations are also consistent with a host galaxy at a redshift of 0.44, which can not be excluded at this time (Afonso, *et al.*, *GCN Circ.* 10158).

2 BAT Observation and Analysis

Using the data set from T-240 to T+962 sec we report on the analysis of BAT GRB 091109A (trigger 375246) (Oates, et al., GCN Circ. 10138). The BAT ground-calculated position is RA, Dec($J2000$) = 309.252,   − 44.177 deg, which is

RA($J2000$) = 20h 37m 00.5s
Dec($J2000$) = $-44d$ 10′ 36.0″

with an uncertainty of 2.1 arcmin, (radius, sys+stat, 90% containment). The partial coding was 19%.

The mask-weighted light curve, shown in Fig. 1, consists of a couple overlapping peaks. The first starts at T-15 sec, peaks at T+10 sec. The second (weaker) peaks at T+40 sec and ends at T+60 sec. T90 (15-350 keV) is 48± 17 sec (estimated error including systematics).

The time-averaged spectrum from T-0.8 to T+51.5 sec is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.31 ± 0.25. The fluence in the 15-150 keV band is $1.6 \pm 0.2 \times 10^{-6}$ erg cm^{-2}. The 1-sec peak photon flux measured from T+8.20 sec in the 15-150 keV band is 1.3 ± 0.4 ph cm^{-2} sec^{-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/375246/BA/`

3 XRT Observations and Analysis

We have analyzed 97.2 ks of Swift-XRT data for GRB 091109A (Oates, *et al.*, *GCN Circ.* 10138), from 154 s to 815 ks after the BAT trigger. The data span four orbits, comprising 37 s in Windowed Timing (WT) mode with the remainder in Photon Counting (PC) mode. The best position is that derived from using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue to correct the X-ray location astrometrically: RA, Dec ($J2000$) = 309.25767,   − 44.15863 deg which is equivalent to:

RA ($J2000$) : 20h 37m 1.84s
Dec ($J2000$) : $-44d$ 09′ 31.1″

with an error of 1.5 arcsec (radius, 90% containment).

A spectrum formed from the PC mode data (from 175 s to 18.1 ks after the trigger) can be fitted with an absorbed power-law, giving a photon index of 2.10 ± 0.19. The best-fitting absorption column is $(9.9^{+2.1}_{-4.4}) \times 10^{20} \mathrm{cm}^{-2}$, in excess of the Galactic value of $3.0 \times 10^{20} \mathrm{cm}^{-2}$ (Kalberla et al. 2005) in the direction of the burst. The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is $3.5 \times 10^{-11} (4.8 \times 10^{-11}) \, \mathrm{erg \, cm}^{-2} \, \mathrm{count}^{-1}$.

The light curve produced from all observations is shown in Fig. 2. The light curve can be modeled by a broken power-law with an initial decay slope of 2.79 ± 0.37, breaking at 370^{+70}_{-40} s to a shallower decay of 0.91 ± 0.05.

The results of the XRT-team automatic analysis are available at
`http://www.swift.ac.uk/xrt_products/00375246`

4   UVOT Observation and Analysis

The Swift/UVOT began observing the field of GRB 091109A 156s after the BAT trigger (Oates, *et al.*, *GCN Circ.* 10138). The optical afterglow, which faded rapidly, was detected in the white filter only. A light curve can be seen in Fig. 3. Re-analysis of the UVOT position using UVOTDETECT provides a refined position of RA($J2000$) = 309.25749, Dec($J2000$) = $-44.1582 \, deg$ which is:

RA ($J2000$) = $20h \, 37m \, 01.80s$
Dec ($J2000$) = $-44d \, 09' \, 29.4''$

with an error of 0.6 arcsec (radius, 90% containment). The white magnitude and the 3σ upper limits for the summed exposures are reported in Table 1.

The standard UVOT products are available at `http://gcn.gsfc.nasa.gov/swift_gnd_ana.html`

Filter	Start (s)	Stop (s)	Exposure (s)	Mag/3σ UL
white	156	306	147	19.88 ± 0.14
white	5371	5571	197	> 21.26
v	4345	5981	393	> 19.94
b	5166	5365	197	> 20.49
u	314	6572	615	> 20.97
uvw1	4755	6392	393	> 20.59
uvm2	4550	6186	393	> 20.46
uvw2	4140	5777	393	> 20.68

Table 1: White magnitude and 3σ upper limits from UVOT observations. The values quoted above are not corrected for the expected Galactic extinction corresponding to a reddening of E(B-V) = 0.03 mag in the direction of the burst (Schlegel, Finkbeiner & Davis, 1998).
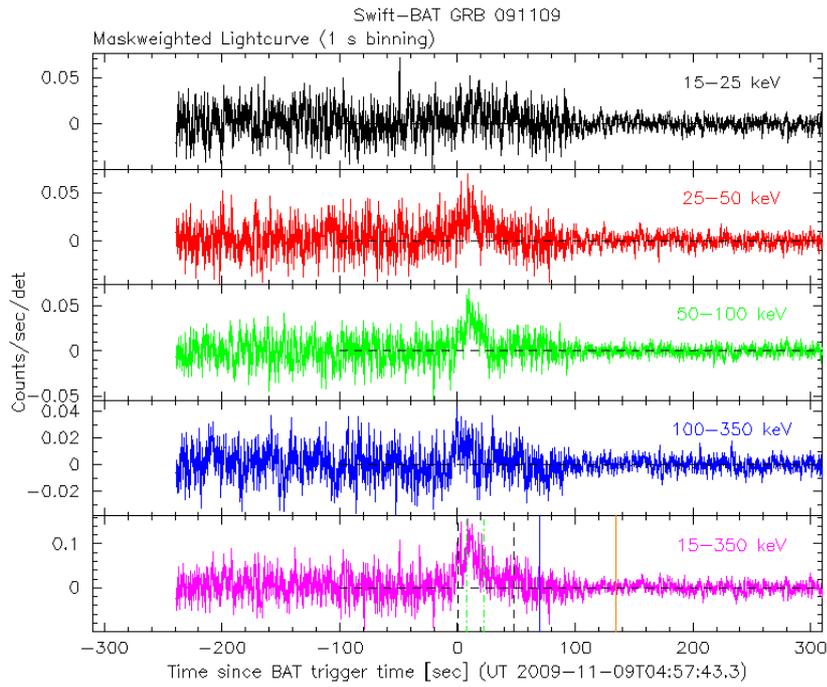
Figure 1: BAT Light curve. The mask-weighted light curve over all energy bands. The units are counts/s/illuminated-detector and T_0 is 04:57:43 UT.
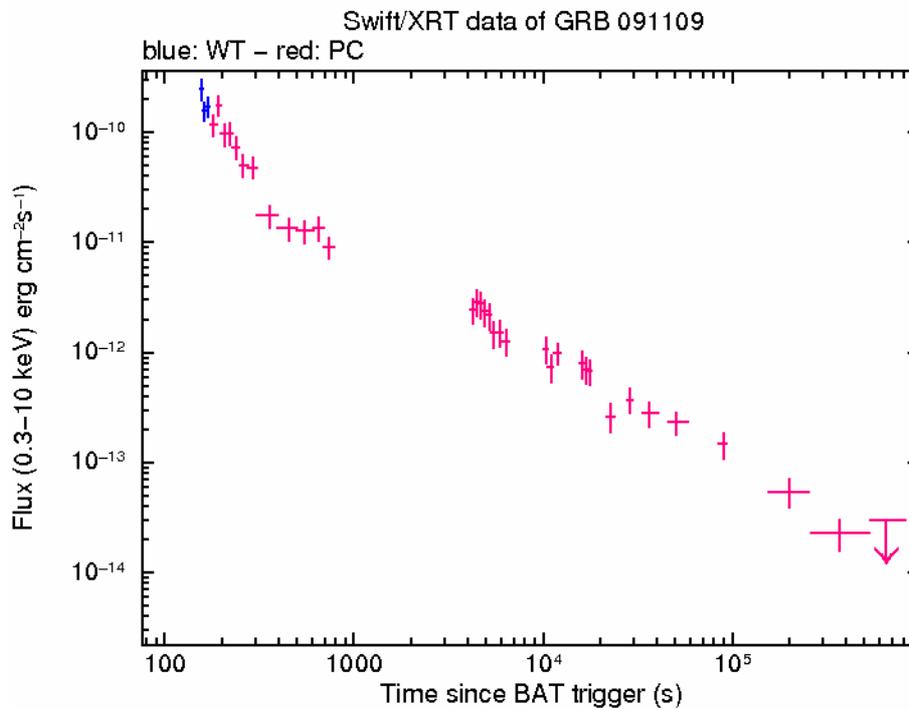

Figure 2: XRT light curve in the 0.3-10 keV band. The counts-to-flux conversion factor is 1 count = 3.5×10^{-11}erg cm^{-2} s^{-1}.
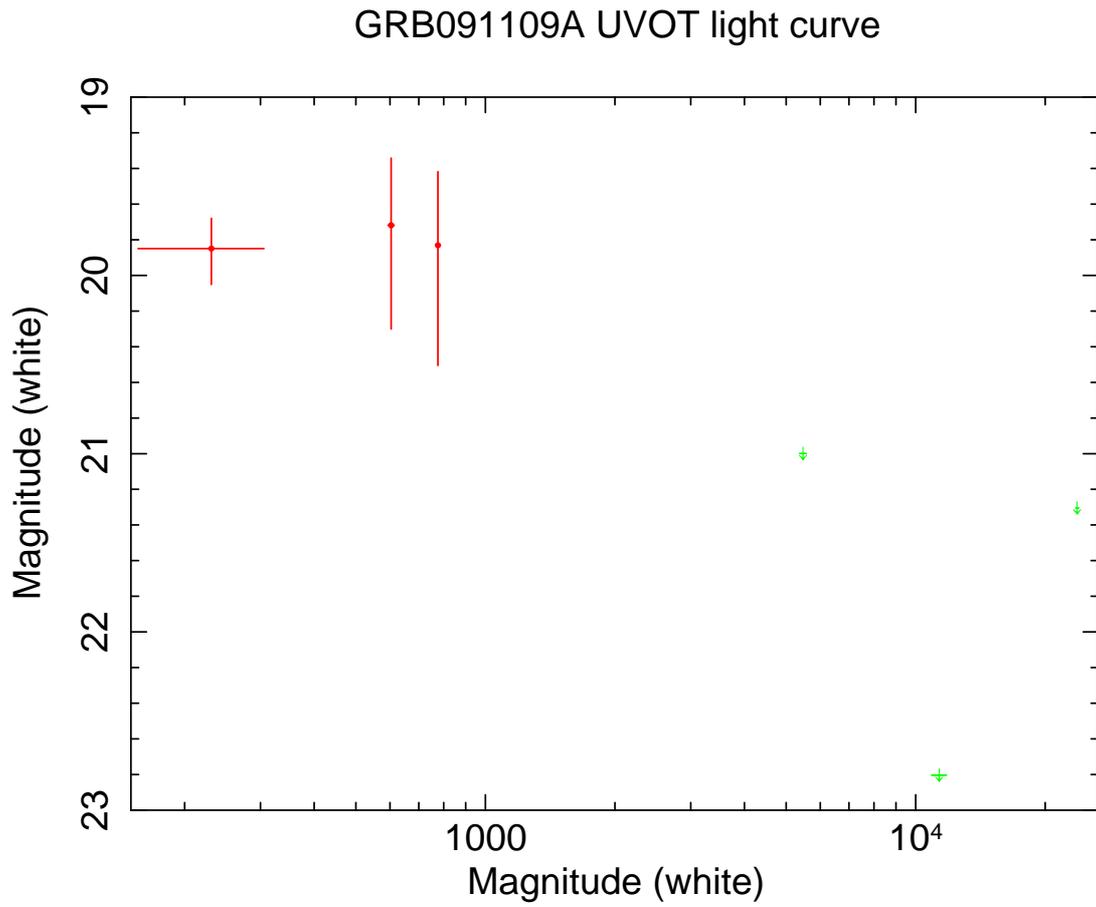
Figure 3: UVOT white filter light curve. Green arrows are 3σ upper limits.