Swift Observations of GRB 130131A

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1 Introduction

At 13:56:22 UT on 2013-01-31, the Swift Burst Alert Telescope (BAT) triggered and located GRB 1301031A (trigger=547407). Swift slewed immediately to the burst and found an uncatalogued X-ray source (Grupe et al., *GCN Circ.* 14156).

The best *Swift* position of this burst is the Swift XRT position given in Evans et al. (*GCN Circ.* 14160) with RA-2000 = 11h 24m 30.29s, and Dec-2000 = +48° 04′ 33.2″ with an uncertainty of 1.8″.

Various ground-based observatories reported on observing the filed of GRB 130131A. UKIRT reported on the detection of the afterglow in K=16.4mag and J=19.4mag starting approximately 54 minutes after the BAT trigger (Tanvir et al. *GCN Circ.* 14157). Observations about 20.5 hours after the trigger by UKIRT confirmed the fading of the afterglow (Tanvir et al. *GCN Circ.* 14175). A fading afterglow was also reported by Volnova et al. (*GCN Circ.* 14182) using the Mondy Observatory in R starting about 25 minutes after the trigger. Upper limits were reported by the Faulkes telescope, MITSuME, RAPTOR, and RARIR (Virgili et al. *GCN Circ.* 14158, Kuroda et al. *GCN Circ.* 14166, Wren et al. *GCN Circ.* 14177, and Fox et al. *GCN Circ.* 14178, respectively. A detection was reported by Laskar et al. (*GCN Circ.* 14171) in the radio at 5.8 GHz using the VLA at a level of 30±11 μJy and by CARMA at 3 mm at a level of 0.5 mJy (Zauderer et al., *GCN Circ.* 14172).

2 BAT Observation and Analysis

At 13:56:22 UT on 2013-01-31, the Swift Burst Alert Telescope (BAT) triggered and located GRB 130131A (trigger=547407, Grupe et al., *GCN Circ.* 14156). Using the data set from T-239 to T+903 s, the BAT ground-calculated position is RA, Dec = 171.091, +48.064 deg which is

RA(J2000) = 11h 24m 21.9s

Dec(J2000) = +48° 03′ 51.0″

with an uncertainty of 2.1 arcmin, (radius, sys+stat, 90% containment). The partial coding was 97% (Palmer et al. *GCN Circ.* 14163).

The mask-weighted light curve (Figure 1) shows two separate peaks starting at T-5 s, peaking at T+1s and ending at T+15s. The T_{90} (15-350 keV) is 51.6±2.4 s (estimated error including systematics).

The time-averaged spectrum from T-0.95 to T+52.15 s is best fit by a single power law. This fit gives a photon index of 2.12±0.32 (χ^2 = 47.6 for 57 d.o.f.). For this model the total fluence in the 15-150 keV band is 3.1 ±0.6 × 10^{-7} erg cm^{-2}. The 1s peak flux measured from T+0.02 s in the 15-150 keV band is 0.7 ±0.1 photons 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/547407/BA/.

3   XRT Observations and Analysis

The XRT began observing the field of GRB 130131A at 13:57:20.5 UT on 2013-01-31, 58.5 seconds after the BAT trigger. Using 574 s of XRT Photon Counting mode data and 1 UVOT image for GRB 130131A, Evans et al. (*GCN Circ.* 14158) found an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue): RA, Dec = 171.12621, +48.07589 which is equivalent to:

RA (J2000): 11h 24m 30.29s

Dec (J2000): $+48° 04' 33.2''$

with an uncertainty of $1.8''$ (radius, 90% confidence). The latest position can be viewed at http://www.swift.ac.uk/xrt_positions. Position enhancement is described by Goad et al. (2007, A&A, 476, 1401) and Evans et al. (2009, MNRAS, 397, 1177).

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of $\Gamma = 2.44^{+0.20}_{-0.18}$. The best-fitting absorption column is $3.47^{+0.65}_{-0.64} \times 10^{21}$ cm^{-2}, in excess of the Galactic value of 1.4×10^{20} cm^{-2} (Kalberla et al. 2005). Following the relation given in Grupe et al. (2007, AJ, 133, 2216) the excess column density $\Delta N_{\mathrm{H}} = 3.33 \times 10^{21}$ cm^{-2} suggests that the redshift of this burst is z<2.5. The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is 3.6×10^{-11} (6.1×10^{-11}) erg cm^{-2} count^{-1}. The analysis if the afterglow data in pc, however, show that the spectrum had changed dramatically and is showing that the X-ray spectrum is consistent with a single power law model with $\Gamma = 1.63^{+0.14}_{-0.13}$ with the absorption column density at the level of the Galactic value.

The light curve of the X-ray afterglow displays a strong flare peaking at about 300 s after the trigger. The $0.3 - 10$ keV light curve given below (Fig.2) can be modeled by a broken power-law model, with a decay slope during the plateau phase of $\alpha_2 = 0.92 \pm 0.05$. There is some indication of a break at about 30ks after the trigger.

The results of the XRT-team automatic analysis are available at

http://www.swift.ac.uk/xrt_products/00547407.

4   UVOT analysis

The Swift/UVOT began observations of the field of GRB 130131A 67 s after the BAT trigger (Grupe et al., *GCN Circ.* 14156) with the finding chart in the white filter. Siegel & Grupe (*GCN Circ.* 14180) reported that no optical/UV counterpart consistent with enhanced XRT position (Evans et al, *GCN Circ.* 14160) was found.

The 3σ upper limits for the summed images are listed in Table 1.

Filter	T_{Start}	T_{stop}	Exposure	Mag
white_FC	68	217	147	>21.8
u_FC	280	529	246	>20.8
white	68	7570	839	>22.5
v	609	18681	1378	>21.0
b	535	7369	549	>21.7
u	280	13670	1434	>22.0
w1	658	12906	1434	>21.7
m2	1932	18851	1263	>21.3
w2	758	17768	1336	>22.0

Table 1: 3σ upper limits from UVOT observations of GRB 130131A. The quoted values have not been corrected for the expected Galactic extinction along the line of sight of $E_{\text{B}-\text{V}} = 0.01$ mag (Schlegel et al., 1998). All photometry uses the UVOT photometric system as described in Poole et al. (2008, MNRAS, 383, 627) and Breeveld et al. (2011, AIP Conf. Proc., Vol. 1358, 373)
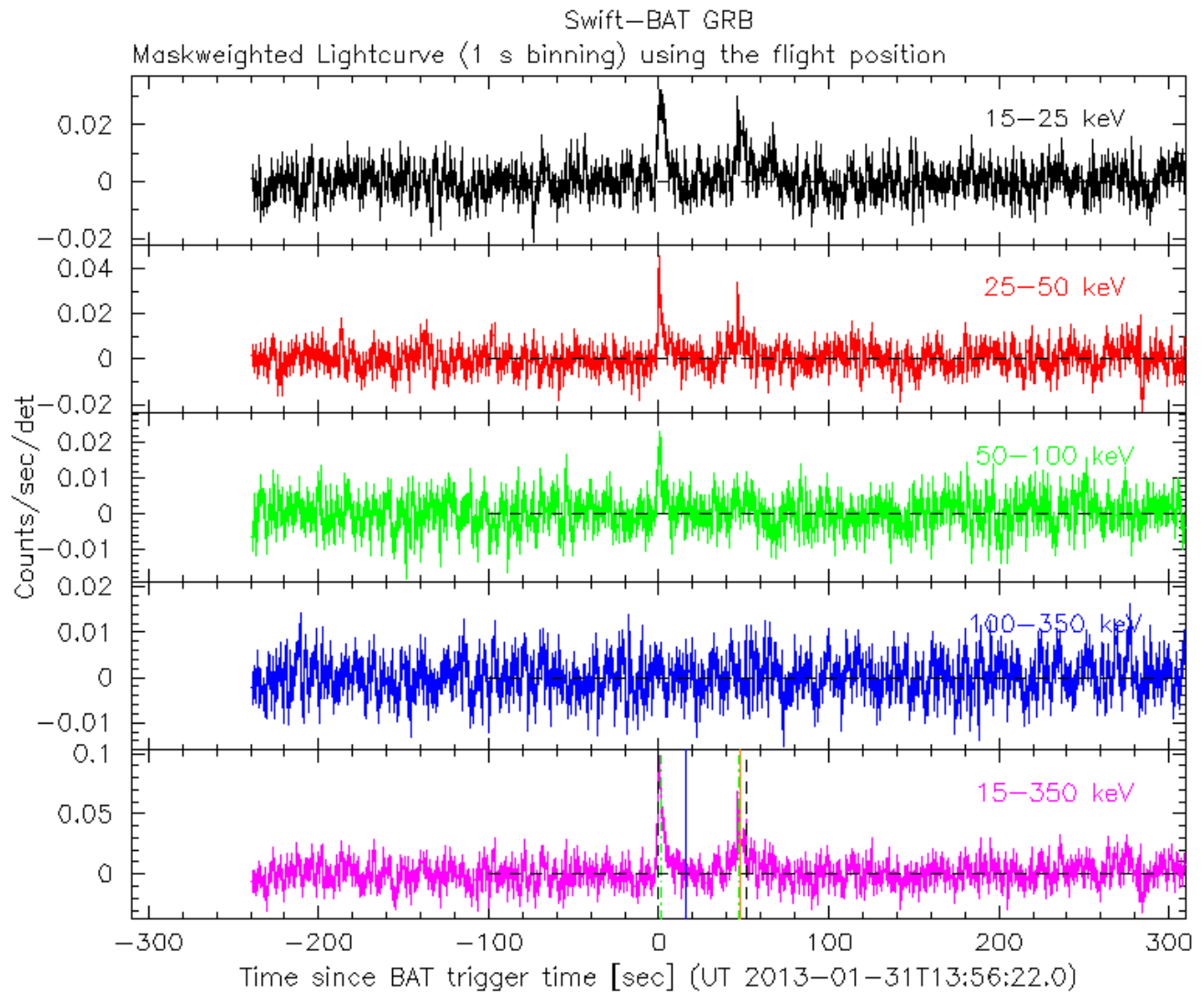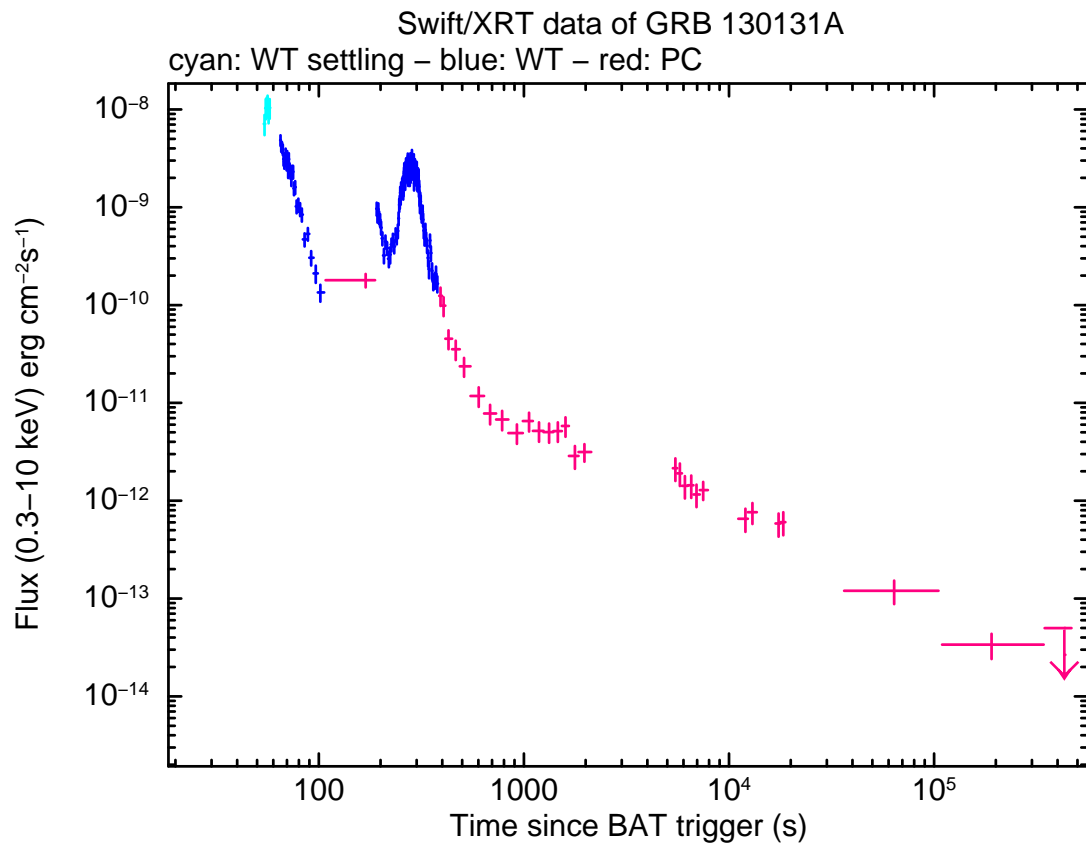
Figure 1: BAT Light curve of GRB 130131A.

Figure 2: XRT flux light curve of GRB 130131A in the 0.3-10 keV band. The approximate conversion is 1 count s^{-1} = $\sim 3.6 \times 10^{-11}$erg s^{-1} cm^{-2}.