Swift Observations of GRB 130505A

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1 Introduction

At T =08:22:28 UT, the BAT triggered and located GRB 130505A (trigger=555163; Cannizzo et al, GCN 14563). *Swift* could not immediately slew due to the Earth limb constraint. The BAT on-board calculated location is (RA, Dec) = (137.060, +17.485) deg, which is {09h 08m 14s; +17° 29' 06"} (J2000) with $\sigma = 3$ arcmin (radius, 90% containment, including systematic uncertainty). The BAT light curve shows a bright peak followed by a much weaker peak with a total duration of about 20 s. The peak count rate was ∼35,500 c s^{-1} ($15 - 350$ keV), at $\sim T + 0$ s.

The XRT began observing the field at 08:24:04.7 UT, 96.4 s after the BAT trigger. XRT found an uncatalogued X-ray source located at (RA, Dec) = (137.0626, 17.4857) which is: {09h 08m 15.02s; +17° 29' 08.5"} (J2000) with an uncertainty of 4.8 arcsec (radius, 90% containment). This location is 9.3 arcsec from the BAT onboard position, within the BAT error circle. The initial flux in the 2.5 s image was 7.35×10^{-9} erg cm^{-2} s^{-1} ($0.2 - 10$ keV).

UVOT took a finding chart exposure of 150 s with the White filter starting at $T + 106$ s. There is a candidate afterglow in the rapidly available $2.7' \times 2.7'$ sub-image at (RA, Dec) = (137.06100, 17.48479) which is: {09h 08m 14.64s; +17° 29' 05.2"} (J2000) with a 90%-confidence error radius of about 0.74 arcsec. This position is 6.4 arcsec from the center of the XRT error circle. The estimated magnitude is 14.14 with a 1σ error of about 0.14. No correction has been made for the expected extinction corresponding to $E(B - V)$ of 0.04.

Based on observations begining at ∼T+1 hr, a redshift $z = 2.27$ was obtained by the 8.1 m Gemini North with the GMOS-N spectrograph (Tanvir et al. GCN 14567).

The burst was also seen by *MAXI* GSC on the International Space Station (T_0 = 08:22:29 UT; Nakahira et al., GCN Circ. 14566). A source position was obtained: (RA, Dec) = (136.955, 17.585) which is: {09h 07m 49s; +17° 35' 05"} (J2000) with a 90%-confidence error radius of about 0.2°. The transit by *MAXI* occurred from 2013-05-05T08:22:18 (= $T - 10$ s, where T is the *Swift*/BAT trigger time) to $T + 40$s. The averaged X-ray flux was 3.17 ± 0.21 Crab ($2 - 20$ keV). The spectrum is fitted by a power-law model with a photon index of 1.37 ± 0.10. There was no significant excess flux at the previous transit at 2013-05-05 06:46 UT and at the next transit at 2013-05-05 09:55 UT with an upper limit of 20 mCrab for each.

The burst was also seen by *Konus-Wind* (Golenetskii et al. GCN 14575, Frederiks et al. GCN 14575). It triggered K-W at $T0$ = 30147.038s UT (08:22:27.038). The K-W light curve shows a bright pulse with a duration of ∼ 5s followed by a weaker decaying emission out to $\sim T0 + 30$s with a slight increase in the count rate at $\sim T0 + 15$s. The emission is seen up to ∼10 MeV. The main phase of the burst had a fluence of $(3.13 \pm 0.06) \times 10^{-4}$ erg cm^{-2} and a 64-ms peak flux, measured from $T0 + 2.496$ s, of $(6.9 \pm 0.3) \times 10^{-5}$ erg cm^{-2} s^{-1} (both $20 - 10^4$ keV, Frederiks et al. GCN 14575). The time-averaged spectrum ($T0$ to $T0 + 21.248$ s) is best fit in the $0.020 - 15$ MeV range by the GRB (Band) function with the following model parameters: low-energy photon index $\alpha = -0.69 \pm 0.04$, high energy photon index $\beta = -2.03 \pm 0.03$, peak energy $E_p = 631 \pm 31$ keV, $\chi^2 = 113/92$ d.o.f. Assuming $z = 2.27$ (Tanvir et al., GCN 14567) $H_0 = 70$ km s^{-1} Mpc^{-1},

$\Omega_M = 0.27$, and $\Omega_\Lambda = 0.73$, the isotropic energy release $E_{\rm iso} \simeq 3.8 \times 10^{54}$ erg, the peak luminosity $(L_{\rm iso})_{\rm max} \simeq 2.7 \times 10^{54}$ erg s^{-1}, and the rest-frame peak energy $E_{p,i} = 2.030$ MeV.

The burst was also seen by *Suzaku* WAM (Yasuda et al. GCN 14599) which triggered at $T0$ =UT 08:22:24.527 ($0.050 - 5$ MeV). The observed light curve shows a bright peak followed by a weaker emission seen up to $T0 + 30$ s with $T_{90} \simeq 14$s. The $100 - 1000$ keV fluence was $1.06 \pm 0.05 \times 10^{-4}$ erg cm^{-2}. The 1−s peak flux measured from $T0+4$ s was $53.1(+2.0/-2.5)$ photons cm^{-2} s^{-1}. The time-averaged spectrum from $T0-2$ s to $T0+30$ s is well fitted by a GRB Band model as follows: low-energy photon index $\alpha = -0.99(+0.17/-0.11)$, high-energy photon index $\beta = -2.33(+0.06/-0.07)$, and peak energy $E_{\rm peak} = 1094(+131/-175)$ keV (χ^2/d.o.f = 23.9/23). Using z = 2.27, the isotropic energy release (1 keV - 10 MeV) is $2.55(+0.12/-0.11) \times 10^{54}$ erg, and peak energy at the rest frame $3615(+532/-469)$ keV, where $\Omega_M = 0.27$, $\Omega_\Lambda = 0.73$, and $H_0 = 70$ km s^{-1} Mpc^{-1}.

The optical afterglow was observed within several hrs of T by several ∼1m telescopes:

− MITSuME (0.5m) at $T + 2.5$hr: $g' = 18.2 \pm 0.1$; $R_c = 18.2 \pm 0.1$; $I_c = 17.6 \pm 0.1$ (Kuroda et al., GCN 14568)

− MITSuME (0.5m) at $T + 2.7$hr: $g' = 18.8 \pm 0.1$; $R_c = 18.9 \pm 0.1$; $I_c = 18.0 \pm 0.1$ (Yoshii et al., GCN 14602)

− Weihai (1m) at $T + 3.4$hr: $r = 18.4 \pm 0.1$ (Xu et al., GCN 14570)

− Xinglong (0.8m) saw a decline in R between $T + 4.05$hr and $T + 4.85$hr: ∼18.05 to ∼18.68 (Xin et al., GCN 14571)

− Tautenburg Obs. (1.34m): at $T + 11.7883$hr, $R_c = 19.09 \pm 0.06$ (Kann et al., GCN 14593)

− Kharkiv National Univ. (0.7m): at $T + 12.7$hr, $R = 19.4 \pm 0.07$ (Krugly et al. GCN 14585)

− Observatorio Astronómico Nacional on Sierra San Pedro Mártir (1.5m): at $T + 42.84$ to $T + 44.87$hr, $r' = 21.10 \pm 0.27$, $i' = 20.98 \pm 0.23$ (Watson et al., GCN 14595)

2 BAT Observation and Analysis

Using the data set from $T - 240$ to $T + 962$ s, further analysis was performed (Lien et al., GCN Circ. 14589). The BAT ground-calculated position is (RA, Dec) = (137.060, 17.485) deg, which is {09h 08m 14s; +17° 29' 06"} (J2000) with an uncertainty of 1.5 arcmin, (radius, sys+stat, 90% containment). The partial coding was 2%.

The mask-weighted light starts at $\sim T - 3$ s, peaks at $\sim T + 0.3$ s, drops significantly at $\sim T + 5$ s, and has a long tail out to $\sim T + 350$ s. T_{90} ($15 - 350$ keV) is 88 ± 10 s (estimated error including systematics).

The time-averaged spectrum from $T - 3.0$ to $T + 363.3$ s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.18 ± 0.07. The fluence in the $15 - 150$ keV band is $2.1 \pm 0.1 \times 10^{-5}$ erg cm^{-2}. The 1 s peak photon flux measured from $T+1.44$ s in the $15-150$ keV band is 30.0 ± 3.1 ph cm^{-2} s^{-1}. All the quoted errors are at the 90% confidence level. The spectral results may be skewed toward harder values because of the effects of the extreme partial coding.

3 XRT Observation and Analysis

Using 1875 s of PC mode data and 5 UVOT images yields an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue): (RA, Dec) = {137.06069; +17.48471} which is: {09h 08m 14.57s; +17° 29' 05.0"} (J2000) (Evans et al. GCN Circ. 14569) with an uncertainty of 1.7 arcsec (radius, 90% confidence).

Using 11 ks of XRT data (Burrows et al. GCN Circ. 14577, 503s in WT mode and the remainder in PC mode), from 102 ks to 29.4 ks after the BAT trigger, reveals the following:

(i) The light curve can be modelled with a power-law decay with a decay index of $\alpha = 1.06(+0.03, -0.04)$.

(ii) The spectrum can be fit with an absorbed power-law with a photon spectral index of 1.86 ± 0.03. The best-fitting absorption column is $10.0 \pm 0.7 \times 10^{20}$ cm^{-2}, in excess of the Galactic value of 3.6×10^{20} cm^{-2} (Kalberla et al. 2005).

(iii) The counts to observed (unabsorbed) $0.3 - 10$ keV flux conversion factor deduced from this spectrum is 3.8×10^{-11} (4.7×10^{-11}) erg cm^{-2} count^{-1}.

4 UVOT Observation and Analysis

The Swift/UVOT began settled observations of the field of GRB 130505A 107 s after the BAT trigger (De Pasquale et al., GCN Circ. 14573). A bright but rapidly fading source was detected in the finding chart and initial exposures within the XRT error circle (Evans et al., GCN Circ. 14569).

Preliminary detections and 3σ upper limits using the UVOT photometric system (Breeveld et al. 2011, AIP Conf. Proc. 1358, 373) for the early exposures are:

Filter	T_start(s)	T_stop(s)	Exp(s)	Mag
white (FC)	107	256	147	14.14 +/- 0.05
white	3952	4151	197	17.96 +/- 0.07
v	4362	4561	197	17.50 +/- 0.11
b	3503	3946	197	17.71 +/- 0.08
u	320	542	218	14.66 +/- 0.04
uvw1	4772	4971	197	19.28 +/- 0.29 (~3sigma)
uvm2	4567	4766	197	>19.6
uvw2	4158	4357	197	>19.9

The non-detection of the optical source in um2 and uw2 filters is consistent with the redshift $z = 2.27$ found by Tanvir et al (GCN Circ. 14567)

The magnitudes in the table are not corrected for the Galactic extinction due to the reddening of $E(B-V) = 0.04$ in the direction of the burst (Schlegel et al. 1998).

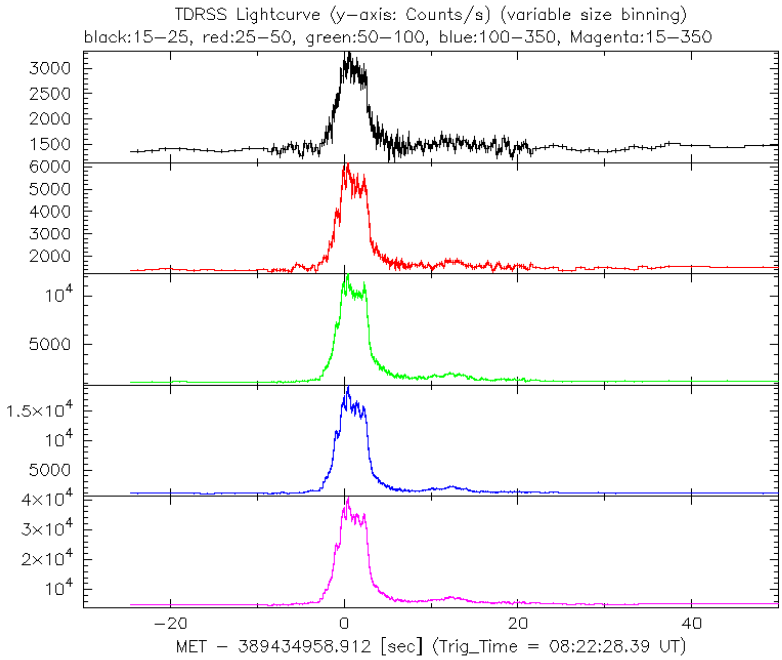

Figure 1: BAT Lightcurve. The light curve in the 4 individual plus total energy bands ($15-25$ keV, $25-50$ keV, $50-100$ keV, $100-350$ keV, and $15-350$ keV).

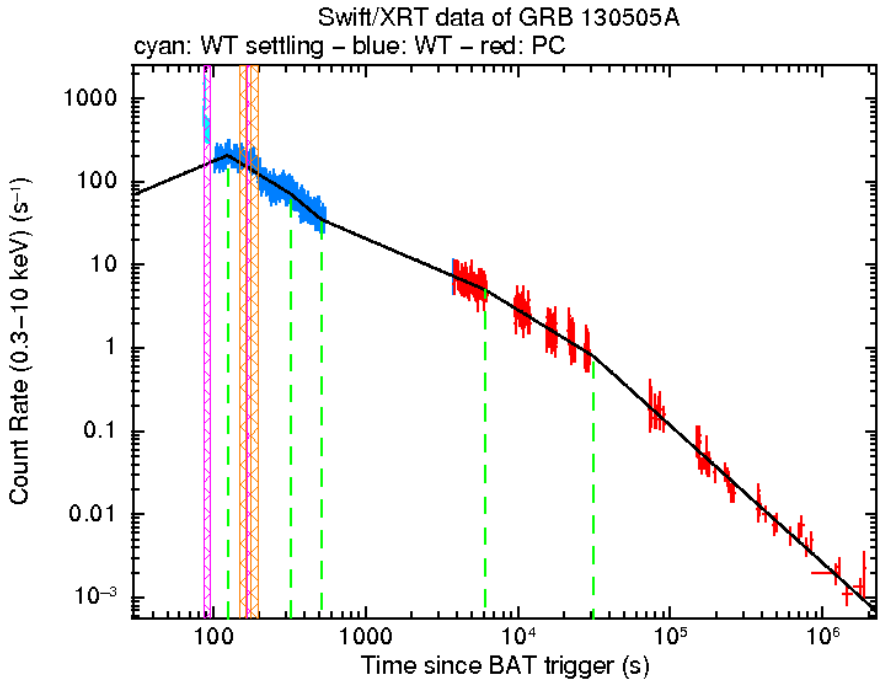

Figure 2: XRT Lightcurve. The best fitting model has 5 breaks: $\alpha_1 = -0.7[+0.3, -0.5]$, $T_{\rm break,1} = 126(+3, -5)$s; $\alpha_2 = 1.13[+0.05, -0.06]$, $T_{\rm break,2} = 325.1(+27.7, -21.9)$s; $\alpha_3 = 1.52(+0.74, -0.12)$, $T_{\rm break,3} = 515.2(+683.4, -100.2)$s; $\alpha_4 = 0.79(+0.04, -0.11)$, $T_{\rm break,4} = (6.3 \pm 2) \times 10^3$s; $\alpha_5 = 1.13(+0.08, -0.09)$, $T_{\rm break,5} = (3.2[+0.8, -0.7]) \times 10^4$s; $\alpha_6 = 1.65[+0.06, -0.05]$.

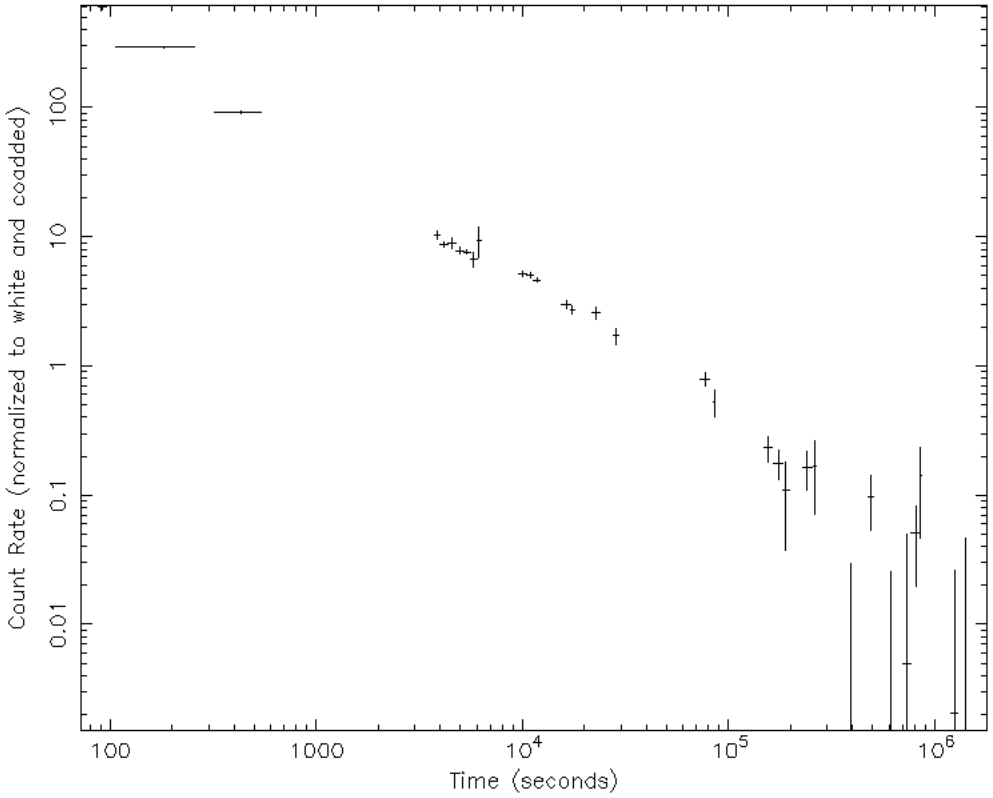

Figure 3: UVOT light curves normalized to white and coadded.