We present observations of GRB 050318 by the Ultra-Violet and Optical Telescope (UVOT) on-board the Swift observatory. The data are the first detections of a Gamma Ray Burst (GRB) afterglow decay by the UVOT instrument, launched specifically to open a new window on these transient sources. We showcase UVOTs ability to provide multi-color photometry and the advantages of combining UVOT data with simultaneous and contemporaneous observations from the high-energy detectors on the Swift spacecraft. Multiple filters covering $\lambda\lambda$ 1,800–6,000Å reveal a red source with spectral slope steeper than the

1NASA Goddard Space Flight Center, Greenbelt, MD 20771
2Universities Space Research Association
3Department of Astronomy and Astrophysics, Pennsylvania State University, 525 Davey Laboratory, University Park, PA 16802
4Mullard Space Science Laboratory, University College London, Holmbury St. Mary, Dorking, RH5 6NT Surrey, UK
5Joint Center for Astrophysics, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250
6Department of Physics and Astronomy, Brigham Young University, N208 ESC, Provo, UT 84602
7Department of Physics, University of Nevada, 4505 Maryland Parkway, Las Vegas NV 89154
8ASI Science Data Center, ESRIN, 00044 Frascati, Italy
9Department of Physics & Astronomy, University of Leicester, Leicester LE1 7RH, UK
10Osservatorio Astronomico di Roma, Via Frascati 33, 00040 Monteporzio Catone (Roma), Italy
simultaneous X-ray continuum. Spectral fits indicate that the UVOT colors are consistent with dust extinction by systems at $z = 1.2037$ and $z = 1.4436$, redshifts where absorption systems have been pre-identified. However, the data can be most-easily reproduced with models containing a foreground system of neutral gas redshifted by $z = 2.8 \pm 0.3$. For both of the above scenarios, spectral and decay slopes are, for the most part, consistent with fireball expansion into a uniform medium, provided a cooling break occurs between the energy ranges of the UVOT and *Swift*’s X-ray instrumentation.

**Subject headings:** astrometry – galaxies: distances and redshifts – gamma rays: bursts – shock waves – X-rays: individual (GRB 050318)

1. **Introduction**

The multi-instrument *Swift* observatory (Gehrels et al. 2004) was launched on Nov 20, 2004. It carries three science instruments, the wide-angle, hard X-ray, Burst Alert Telescope (BAT; Barthelmy et al. 2005) which locates GRBs to within 3′ on the sky, the narrow-field X-Ray Telescope (XRT; Burrows et al. 2005) and the UVOT. Specifications of the UVOT are described in Roming et al. (2005). The UVOT instrument has a vital role imaging the field containing the burst, minutes after a trigger, and reporting rapidly the afterglow location to < 1″ accuracy via the GRB Coordinate Network (GCN). UVOTs subsequent role is to provide a relatively-uniform sample of the afterglow decay. It is this subsequent role that we report on here, describing the first afterglow detected by UVOT in multiple colors, and monitoring the decay until 40 ksec after the burst.

2. **Observations**

The *Swift*-BAT made a 17σ detection of GRB 050318 at 15:44:37 UT (Krimm et al. 2005a). Burst parameters revised from Krimm et al. (2005c) include a $T_{90}$ burst duration of $32 \pm 2$ s, with a total fluence of $2.1 \times 10^{-6} \text{ erg cm}^{-2}$ in the 15–350 keV band. Within this energy band we find evidence of spectral evolution across three peaks in the prompt emission light curve. Peak 1, between $T-1s$ and $T+5s$, (where $T$ is the trigger time), is well fit by a simple power law with spectral index $\beta_{\text{BAT}} = -1.1 \pm 0.2$ ($\chi^2 = 57$ for 57 d.o.f.). All uncertainties in this paper are reported to a 90% confidence level while spectral and temporal decay indices are provided with respect to flux density, e.g., $F_{\nu} \sim t^{\alpha} \nu^{\beta}$. The burst was quiet for the next 17 seconds, followed by two overlapping, but resolved peaks. Peak 2 ($T+22-27s$) fits to a
cut-off power law with \( \beta_{BAT} = -0.2 \pm 0.5 \) and \( E_p = 68^{+23}_{-10} \) keV (\( \chi^2 = 66 \) for 56 d.o.f.). The spectrum softens considerably during the third peak (\( T+27-32s \)), and is fit with \( \beta_{BAT} = 0.2 \pm 0.4 \), where \( E_p = 46 \pm 7 \) keV. BAT event data were not recorded for the final 2s of the burst. However, examination of the BAT rate data in four energy bands suggests continued spectral softening during this period.

The burst was located to within 3' (90% containment) of RA = 49.651, Dec = -46.392 (J2000). This corresponds to a Galactic latitude of \(-55^\circ\) with a local reddening of \( E(B-V) = 0.018 \) mag (Schlegel, Finkbeiner & Davis 1998) and a H-equivalent Galactic column density of \( N_H = 2.8 \times 10^{20} \) cm\(^{-2}\) (Dickey & Lockman 1990). After a 54 min delay for Earth occultation, \textit{Swift} slewed so that the narrow-field instruments could monitor the target.

Within the first 100s settled observation of the UVOT sequence, a \( V = 17.8 \) source was found 2'6 from the BAT position (Fig 1), with no counterpart in archival plates (McGowan et al. 2005) and consistent with the ground-based report of Mulchaey & Berger (2005). Subsequent exposures revealed a fading source, 1''1 from a transient X-ray counterpart (Markwardt et al. 2005; Nousek et al. 2005; Beardmore et al. 2005). A complete analysis and description of the XRT data reduction is reported in a separate paper (Perri et al. 2005). The UVOT position, as reported by De Pasquale et al. (2005), is RA = 03\textsuperscript{h} 18\textsuperscript{m} 51\textsuperscript{s}.15, Dec = -46\textdegree 23' 43'' 7 (J2000), with 0''3 uncertainties.

The UVOT completed 36 exposures before GRB 050319 triggered the BAT and became the new automated target (Krimm et al. 2005b). All detections of GRB 050318 \( \geq 2\sigma \) above the background are tabulated in Table 1. AB filter magnitudes and background limits are based upon in-orbit zero-point calibrations, and differ from those used by McGowan et al. (2005) and De Pasquale et al. (2005), which were based on pre-flight calibrations and Vega magnitudes. The afterglow is not detected in UVW1 (centered at approximately 2,500Å), UVM2 (2,200Å) or UVW2 (1,800Å) light; the first settled exposures yield 3\( \sigma \) upper limits of 19.3, 19.5 and 21.2 mag, respectively. Detections are made through the U (3,500Å), B (4.400Å) and V (5,300Å) filters between T+3,200–5,400s. On the next rotation of the filter wheel at \( T+21,000s \) the source has decayed below the 3\( \sigma \) background threshold in both the U and B bands. The magnitudes and detection significances at this epoch are \( U = 21.9 \pm 0.5 \), detected at 2.3\( \sigma \) above background and \( B = 21.6 \pm 0.8 \), 1.3\( \sigma \) above background. The V source persists for three wheel rotations before fading below the background threshold between T+23,000–34,000s. The U band contains two further marginal source detections between 2–3\( \sigma \) above background at T+28,609 and T+40,193.
2.1. Source decay

All U, B and V points, bar the first 2s B exposure, are plotted in Fig. 2. Detections \( \geq 2\sigma \) are provided with 90% confidence error bars, while all other points are given as upper limits at the 3\( \sigma \) level. Using the first three V filter exposures, the powerlaw decay index for the V light curve is \( \alpha_V = -0.87 \pm 0.24 \) (\( \chi^2 = 1.1 \) for 1 dof). Assuming a powerlaw decay, the four U band detections, \( \geq 2\sigma \) above background, yield a consistent slope \( \alpha_U = -1.00 \pm 0.25 \) (90% confidence, \( \chi^2 = 2 \) for 2 dof). A weighted-mean of the U and V decay slopes provides \( \alpha_{U+V} = -0.94 \pm 0.17 \) and the best fits to U and V data using this slope are plotted in Fig. 2. A curve of the same slope is extrapolated to pass through the B detection at T+5,382s. The XRT light curve at this epoch, presented by Perri et al. (2005), has a powerlaw decay index of \( \alpha_{\text{XRT}} = -1.2 \pm 0.1 \). The probability that \( \alpha_{\text{XRT}} \) and \( \alpha_{U+V} \) are identical is 8%.

Source detection in the T+21,105s B exposure is significant only to 1.3\( \sigma \) and, using the B detection at T+5,382s as an anchor point, is inconsistent with the powerlaw decay index of \( \alpha_{U+V} \) with 99.9% confidence. Either there is under-sampled variability in the source which provides us with a biased measure of the decay indices, or we are observing spectral evolution. Perhaps it is no coincidence that the next exposure after the second B band observation is the one point on the U curve that is an outlier relative to the best-fit powerlaw decay index. It is inconsistent with \( \alpha_{U+V} \) with 96% confidence. So short-timescale variability is perhaps the most plausible interpretation.

2.2. Spectral properties

The two absorption systems at \( z_1 = 1.2037 \) and \( z_2 = 1.4436 \) reported by Berger et al. (2005) should produce Lyman systems redshifted into the UVM2 band. Assuming that consistent non-detections in filters blueward of a particular wavelength reveal either dust or the Lyman limit of the host and its redshift, in this section we formally measure the spectral slope across the UVOT bands and search for a Lyman edge. All spectral models below include Galactic extinction appropriate for the source direction (Sec. 1), using the analytic formalism of Pei (1992) with \( R_V = 3.08 \). For simplicity, we assume that there is no Ly\( \alpha \) forest in front of the host.

Using \( \alpha_{U+V} \), source rates in each filter were interpolated or extrapolated to a common epoch of T+4,061s. Using the \( \chi^2 \) fitting method outlined in Arnaud (1996) and references therein, a simple powerlaw model to all six points yields a fit with spectral index \( \beta_{\text{UVOT}} = -4.9 \pm 0.5 \) and \( \chi^2 = 24 \) for 4 dof. The fit is poor statistically and the index is steep compared to the 0.2–5 keV slope obtained from simultaneous XRT data of \( \beta_{\text{XRT}} = -1.1^{+0.2}_{-0.4} \) (Sec. 2.3).
By adding an absorption edge to the powerlaw model, the quality of the fit improves to a statistically acceptable solution; $\beta_{\text{UVOT}} = -2.4 \pm 1.5$ and, assuming the edge is due to the Lyman series, $z = 2.8 \pm 0.2$ ($\chi^2 = 1.0$ for 3 dof). The best-fit redshift is inconsistent with $z_2 = 1.4436$ (from Berger et al. 2005). For comparison, if $z$ is forced to be 1.4436, the best fit yields $\beta_{\text{UVOT}} = -4.5 \pm 1.5$ with $\chi^2 = 15$ for 4 dof. For completeness, fixing $z$ at a value of 1.2037 yields $\beta_{\text{UVOT}} = -4.5 \pm 0.5$ ($\chi^2 = 20$ for 4 dof).

We add host extinction to the model above, assuming an SMC grain content with $R_V = 2.93$ (Pei 1992), and coupling the redshift of the dust to the neutral gas. The best solution yields $\beta_{\text{UVOT}} = -1.0 \pm 5.0$, $z = 2.9 \pm 0.2$ and $E(\text{B-V}) < 0.26$ ($\chi^2 = 1.0$ for 2 dof), i.e. dust is not a necessary component for this model in order to provide a good description of the UVOT data. However, when the dust and gas is re-situated at $z_2$, the fit does converge to an acceptable solution, provided we also include dust and gas at $z_1$, with $\chi^2 = 3.2$ for 2 dof, $\beta_{\text{UVOT}} = +1.0 \pm 2.0$, $E(\text{B-V})_1 = 0.4 \pm 0.2$ and $E(\text{B-V})_2 < 0.27$, where $E(\text{B-V})_1$ and $E(\text{B-V})_2$ are the color excesses at $z_1$ and $z_2$ respectively. Consequently, gas and dust, at the redshifts of the two absorption systems reported by Berger et al. (2005) in front of a powerlaw continuum provide an adequate fit to the UVOT data. However, the model containing a single gas and dust complex at the larger redshift of $z = 2.8 \pm 0.2$ provides the better fit.

Next we investigate whether the solutions above are biased by assuming an inappropriate temporal decay slope during the interpolation of UVOT data to a common epoch. For comparison, we repeat the previous exercise using the XRT decay index $\alpha_{\text{XRT}} = -1.2$. Best-fit parameters and fit quality vary only a little compared to the previous analysis, and this results from the choice of a common epoch which minimizes the systematic uncertainty in the interpolation. The best-fit solution without a dust component in the host (which does not formally improve the fit) is $\beta_{\text{UVOT}} = -1.0 \pm 5.0$ and $z = 2.9 \pm 0.5$ ($\chi^2 = 1.0$ for 3 dof). The best fit with two dust and gas systems at $z_1$ and $z_2$ yields $\chi^2 = 2.6$ for 2 dof, $\beta_{\text{UVOT}} = +1.0 \pm 4.1$, $E(\text{B-V})_1 = 0.5 \pm 0.4$ and $E(\text{B-V})_2 < 0.35$. Both solutions are identical to the previous analysis within uncertainties.

Intrinsic continuum slopes in the above models are poorly constrained due to a combination of low count rates and the relatively small spectral range of the filters. In the next sections, by combining the UVOT data with a simultaneous XRT spectrum, we can place further constraints on the UVOT continuum, refine the redshift test and dust measurements, and compare a simple fireball model to the data.
2.3. Spectral energy density

Good XRT events have been extracted from within the time interval T+3,180–5,822s, which is the epoch between the start of the first V exposure and the end of the subsequent B detection, and binned by pulse height. The spectral fits below contain a core model of a floating powerlaw, combined with fixed quantities for Galactic reddening and extinction in the local rest frame (Sec. 1). Galactic abundances are from Anders & Grevesse (1989). We use the April 5, 2005 empirical version of the XRT response calibration, which requires an additional absorption feature added to spectral models, corresponding to the neutral O K feature at 0.54 keV, due to the optical filter.

The best fit to the XRT data alone yields a powerlaw slope of $\beta_{\text{XRT}} = -1.2 \pm 0.3$ and an integrated 0.2–5 keV flux of $(1.7 \pm 0.3) \times 10^{-11}$ erg s$^{-1}$ cm$^{-2}$. No extra spectral components are required with $\chi^2 = 10$ for 21 dof. On comparing the UVOT spectrum to the XRT spectral model, not only do we find an observed optical/UV spectral index much steeper than the X-ray continuum, but also the UV fluxes are $> 1$ order of magnitude fainter than those predicted by the XRT model, therefore the different slopes cannot be caused by a spectral break alone. A combined fit of the UVOT and XRT data to the core model yields a poor fit with a spectral index $\beta = -0.45 \pm 0.03$ and $\chi^2 = 506$ for 28 dof.

An acceptable combined fit of $\chi^2 = 13$ for 25 dof is obtained by adding SMC-like dust and neutral gas with Magellanic cloud metallicities ($<\text{H}/\text{Fe}> = -0.5$) at one, free floating redshift: $\beta = -1.0 \pm 0.1$, $z = 2.8 \pm 0.3$, $E(\text{B-V}) = 0.12 \pm 0.04$ and $\log N_\text{H} < 2.0 \times 10^{21}$ cm$^{-2}$. The alternative model from Sec. 2.2 replaces the $z = 2.8$ gas and dust with two systems at $z_1$ and $z_2$. Best fit parameters are $\beta = -1.1 \pm 0.1$, $E(\text{B-V})_1 = 0.23 \pm 0.12$, $E(\text{B-V})_2 < 0.17$, $N_{\text{H}_1} < 1.7 \times 10^{21}$ cm$^{-2}$ and $N_{\text{H}_2} < 1.8 \times 10^{21}$ cm$^{-2}$, with $\chi^2 = 16$ for 24 dof. These two fits are plotted in Fig. 3. Plotting the $\chi^2$ landscape of this second model in the $E(\text{B-V})_1$–$E(\text{B-V})_2$ plane (Fig. 4) reveals that the majority of dust in this scenario is associated with the closer of the two systems at $z_1$.

In summary, model fits to the spectrum of GRB050318 at T+4,061s where SMC-like neutral gas and dust are situated at $z_1$ and $z_2$ in front of a simple powerlaw source reproduce the UVOT spectral index observed. The spectrum is also well-fit using a single system of gas and dust at $z = 2.8 \pm 0.3$. 
3. Discussion

3.1. Dust and gas properties

SMC dust has typically proved to be a good fit to extinction curves in GRB host galaxies, e.g. Jakobsson et al. (2004), as one might expect from a host containing a younger stellar population (Calzetti et al. 2000). The neutral column density within the host is poorly constrained, but by adopting the best fit value from the SMC-dust spectral model with $z = 2.8$, we find a gas-to-dust ratio of $N$(H_1)/$A$(V) < 7.6 x 10^{21} \, \text{cm}^{-2} \, \text{mag}^{-1}$, < 50% of typical SMC lines-of-sight (Gordon et al. 2003). If we substitute the SMC dust with the Milky Way dust prescription of Pei (1992; $R_V = 3.08$) and assume Solar metallicities in the neutral gas (Anders & Grevesse 1989) then the fit is also acceptable with $\chi^2 = 12$ for 25 dof, providing slightly different best fit parameters of $\beta = -1.1 \pm 0.1$, $z = 2.4 \pm 0.5$, $E$(B-V) = 0.28 $\pm$ 0.13 and $N_H < 1.6 \times 10^{21} \, \text{cm}^{-2}$. The gas-to-dust ratio for this case is $N$(H_1)/$A$(V) < 3.0 $\times$ 10^{21} \, \text{cm}^{-2} \, \text{mag}^{-1}$, consistent with the Galactic mean (Bohlin, Savage & Drake 1978). Similarly, LMC dust and gas properties with $R_V = 3.16$ (also from Pei 1992) yield $\beta = -1.0 \pm 0.1$, $z = 2.5 \pm 0.5$, $E$(B-V) = 0.17 $\pm$ 0.07 and $N_H < 3.2 \times 10^{21} \, \text{cm}^{-2}$, $\chi^2 = 13$ for 25 dof. In this case, $N$(H_1)/$A$(V) < 7.5 $\times$ 10^{21} \, \text{cm}^{-2} \, \text{mag}^{-1}$, which is consistent with the LMC model from Gordon et al. (2003). This general model is therefore acceptable statistically for a range of dust and gas content.

A similar exercise applied to the alternative model, with extinction and absorption occurring at $z_1$ and $z_2$, yields a poor fit of $\chi^2 = 50$ for 24 dof when Milky Way dust and gas populations are assumed. Best fit parameters are $\beta = -1.4 \pm 0.2$, $E$(B-V)$_1$ = 0.28 $\pm$ 0.10, $E$(B-V)$_2$ = 0.34 $\pm$ 0.08, $N_{H1} < 2.0 \times 10^{21} \, \text{cm}^{-2}$ and $N_{H2} < 2.7 \times 10^{21} \, \text{cm}^{-2}$. An LMC gas and dust model results in $\chi^2 = 18$ for 24 dof, where $\beta = -1.2 \pm 0.1$, $E$(B-V)$_1$ = 0.25 $\pm$ 0.15, $E$(B-V)$_2$ = 0.17 $\pm$ 0.12, $N_{H1} < 3.2 \times 10^{21} \, \text{cm}^{-2}$ and $N_{H2} < 2.6 \times 10^{21} \, \text{cm}^{-2}$. The gas-to-dust ratio, $N$(H_1)/$A$(V), for the LMC model is limited to < 5.0 $\times$ 10^{21} \, \text{cm}^{-2} \, \text{mag}^{-1}$ in the system at $z_2$, which is a good candidate for the host galaxy; the same ratio for the SMC model is unconstrained. While SMC and LMC models provide acceptable fits, the Milky Way model does not, although we have made the simplifying assumptions that the dust contents of the two systems are identical and that a Ly$\alpha$ forest is absent in front of the burst. We also note that the constraint from Sec 2.3 that the majority of dust is located in the $z = 1.2037$ complex can be dropped if the extinction law in both systems is assumed to be featureless, e.g. Savaglio & Fall (2004), where $A(\lambda)/R_V = E(B - V)(5,500\AA/\lambda)^{\delta}$. In this scenario an acceptable fit of $\chi^2 = 16$ for 23 dof is obtained where $\beta = -1.1 \pm 0.1$, $E$(B-V)$_1$ < 0.51, $E$(B-V)$_2$ < 0.46, $\delta = 1.6^{+1.3}_{-0.8}$, $N_{H1} < 6.4 \times 10^{20} \, \text{cm}^{-2}$ and $N_{H2} < 4.7 \times 10^{20} \, \text{cm}^{-2}$. 

3.2. Interpretation

The simplest afterglow emission model assumes synchrotron emission from a relativistic fireball, expanding into a uniform interstellar medium (Sari, Piran & Narayan 1998; Zhang & Mészáros 2004). Assuming that the injection break occurs at an energy < 400 eV then the X-ray spectral slope of GRB 050318 indicates that $p = 2.4 \pm 0.2$, where $\beta = -p/2$ according to the parameterization of Sari et al. (1998). The simple fireball model then predicts that the temporal decay slope should have an index of $\alpha = (2 - 3p)/4 = -1.3 \pm 0.2$. This is consistent with the XRT decay index and the B band lower limit, but comparison with the other optical bands is less convincing. The U and V indices are consistent with $p$ with 14% and 3% confidences respectively.

If we assume that the cooling break occurs at an energy greater than the injection break, and between the UVOT and XRT bandpasses, then the emission models predicts $\alpha_{\text{UVOT}} = 3(1 - p)/4 = -1.05 \pm 0.2$. In this case, the U and V indices are consistent with $p$, with confidences of 80 and 36% respectively. While the best spectral fit from Sec. 2.3 does not formerly require a cooling break, it does not preclude it either. By replacing the model powerlaw continuum from Sec. 2.3 with a broken powerlaw of fixed spectral indices $\beta_{\text{UVOT}} = -1.05$ and $\beta_{\text{XRT}} = -1.2$, an acceptable fit is found using SMC dust with $\chi^2 = 13$ for 25 dof, $z = 2.9^{+0.3}_{-0.4}$, $E(\text{B-V}) = 0.15 \pm 0.02$, $\log N_H = 19.9 \pm 1.5 \text{ cm}^{-2}$ and providing a lower limit on the cooling break of $\nu_c > 4.8 \times 10^{15}$ Hz. The model with two dusty sytems at $z_1$ and $z_2$ yields $\chi^2 = 16$ for 24 dof, $E(\text{B-V})_1 = 0.23 \pm 0.12$, $E(\text{B-V})_2 < 0.17$, $\log N_{H1} < 21.1 \text{ cm}^{-2}$, $\log N_{H2} = 19.7 \pm 1.5 \text{ cm}^{-2}$ and $\nu_c > 2.4 \times 10^{15}$ Hz. While the above model of a slow-cooling fireball within a uniform ISM fits most of the Swift data well in both redshift scenarios, the one caveat is the inconsistency between the B decay index limit and $\alpha_{\text{U+V}}$.

Assuming $z = 2.8$ is the host redshift and a cosmological model of $H_0 = 65 \text{ km s}^{-1} \text{ Mpc}^{-1}$, $\Omega_m = 0.3$ and $\Omega_A = 0.7$, then the BAT 15–350 keV fluence yields an isotropic energy of $E_{\text{iso}} = (3.6^{+0.7}_{-1.2}) \times 10^{52}$ erg. Transforming a time-averaged value of $E_p = 49$ keV to the rest frame of the burst, we find $E'_p = 196^{+33}_{-51}$ keV (cf $E_{\text{iso}} = (1.4^{+0.2}_{-0.4}) \times 10^{52}$ erg and $E'_p = 119^{+22}_{-35}$ keV at $z_2 = 1.4436$). Since both redshifts yield spectral parameters consistent with the $E_{\text{iso}} - E_p$ relationship derived by Amati et al. (2002), the BAT spectral analysis of this burst cannot provide useful diagnostics for testing the optical redshift candidates.

4. Conclusion

This paper reports the first significant optical detection of a GRB afterglow, and subsequent monitoring of the decay, by the UVOT instrument on-board the Swift observatory.
Compared to a simple powerlaw continuum model, the general deficit of UV emission can be fit using either gas extinction at redshifts of $z_1 = 1.2037$ and $z_2 = 1.4426$, corresponding to the absorption systems found by Berger et al. (2005), or Lyman depletion from an object at $z = 2.8 \pm 0.3$, which would indicate that the two systems at $z_1$ and $z_2$ belong to foreground objects. Consequently the UVOT data cannot unambiguously determine the host galaxy redshift for this burst. This will be a common occurrence when Swift does not detect a UV source. We note that there is no evidence for a $z = 2.8$ host galaxy in the $\lambda \lambda 5,000–7,000\AA$ spectroscopy of Berger et al. (2005), however hosts at this redshift have typically been identified by absorption features at bluer wavelengths such as a damped Ly$\alpha$ line (Hjorth et al. 2003) which would occur at 4,617$\AA$ at $z = 2.8$. Since an identified absorption line provides only a lower limit to the host redshift, currently available evidence only allows a lower limit to be placed on the redshift of $z \geq 1.4436$. Decay curves and the UVOT/XRT SED reveal mostly consistency with the picture of a slow-cooling fireball in a uniform ISM. However the inferred steepness of the B band decay slope, relative to U and V, may indicate some deviations from the simple model.

This work is sponsored at Penn State by NASA’s Office of Space Science through contract NAS5-00136 and at MSSL and Leicester by funding from PPARC. We gratefully acknowledge the contributions of all members of the Swift team.

REFERENCES

Anders, E., Grevesse, N., 1989, Geochimica et Cosmochimica Acta, 53, 197

Amati, L., 2002, A&A, 390, 81

Arnaud, K.A., 1996, Astronomical Data Analysis Software and Systems V, eds. Jacoby, G., & Barnes, J., p.17, ASP Conf. Series vol. 101.

Barthelmy, S. et al., 2005, Sp. Sci. Rev., 2005 in press

Beardmore, A.P. et al., 2005, GCN Circ. 3133

Berger, E., & Mulchaey, J., 2005, GCN Circ. 3122

Berger, E. et al., 2005, ApJ, submitted

Bohlin, R.C., Savage, B.D., Drake, J.F., 1978, ApJ, 224, 132

Burrows, D.N., et al., 2005, Sp. Sci. Rev., in press
Calzetti, D., Armus, L., Bohlin, R. C., Kinney, A. L., Koornneef, J., Storchi-Bergmann, T., 2000, ApJ, 533, 682
De Pasquale, M. et al., 2005, GCN Circ. 3123
Dickey, J.M., & Lockman, F.J., 1990, ARA&A, 28, 215
Gehrels, N., et al., 2004, ApJ, 611, 1005
Gordon, K.D., Clayton, G.C., Misselt, K.A., Landolt, A.U., Wolff, M.J., 2003, ApJ, 594, 279
Hjorth, J., et al., 2003, ApJ, 597, 699
Krimm, H. et al., 2005a, GCN Circ. 3111
Krimm, H. et al., 2005b, GCN Circ. 3117
Krimm, H. et al., 2005c, GCN Circ. 3134
Jakobsson, P., et al., 2004, A&A, 427, 785
Markwardt, C., Boyd, P., Gehrels, G., Hurley K., Marshall, F.E., & Still, M., 2005, GCN Circ. 3112
McGowan, K. et al., 2005, GCN Circ. 3115
Mulchaey, J., & Berger, E., 2005, GCN Circ. 3114
Nousek, J.A. et al., 2005, GCN Circ. 3113
Pei, Y.C., 1992, ApJ, 395, 130
Perri, M., et al., 2005, ApJ, submitted
Roming, P.W.A. et al., 2005, Sp. Sci. Rev., in press
Sari, R., Piran, T. & Naryan, R., 1998, ApJ, 497, L17
Savaglio, S., Fall, S.M., 2004, ApJ, 614, 293
Schlegel, D.J., Finkbeiner, D.P. & Davis, M, 1998, ApJ, 500, 525
Zhang, B., Mészáros, P., 2004, Int. J. Mod. Phys. A, 19, 2385

This preprint was prepared with the AAS LaTeX macros v5.2.
Table 1. UVOT detections (> 2σ above background) of GRB 050318 with mid-exposure times relative to the trigger (T+), exposure durations, filters, AB magnitudes and significance of the detection over background. Filter bandpasses are provided in Roming et al. (2005).

| T+ (s) | Exposure (s) | Filter | Magnitude   | Significance (σ) |
|--------|--------------|--------|-------------|-----------------|
| 3,230  | 100          | V      | 17.8$^{+0.3}_{-0.2}$ | 5.1             |
| 3,648  | 100          | U      | 19.6$^{+0.3}_{-0.2}$ | 4.2             |
| 5,382  | 880          | B      | 18.9$^{+0.1}_{-0.1}$ | 19.6            |
| 11,201 | 811          | V      | 19.1$^{+0.2}_{-0.1}$ | 6.7             |
| 17,041 | 707          | U      | 22.0$^{+0.6}_{-0.4}$ | 2.3             |
| 22,827 | 703          | V      | 19.5$^{+0.3}_{-0.2}$ | 4.5             |
| 28,609 | 712          | U      | 21.8$^{+0.5}_{-0.3}$ | 2.8             |
| 40,193 | 687          | U      | 22.1$^{+0.8}_{-0.4}$ | 2.0             |
Fig. 1.— Stacked UVOT-V filter image of the field with the transient source at RA = 03$^h$ 18$^m$ 51.15, Dec = -46$^\circ$ 23$'$ 43.7 (J2000) and 3$'$ BAT error circle and 6$''$ XRT error circles overlaid. Total exposure time for the stacked image is 3,732s.
Fig. 2.— U, B and V light curves of GRB 050318. The dashed lines are the best powerlaw fits to the U and V time-series, $\alpha_{U+V}$, excluding upper-limits. The Dotted curve is an identical powerlaw model, renormalized to the first-epoch B magnitude.
Fig. 3.— The combined UVOT and XRT spectrum of GRB 050318 at epoch T+4,061s, compared to two best-fit models, both containing a powerlaw model, reddened and absorbed by Galactic material. The Solid line represents this model with an additional system of neutral gas and SMC-like dust at \( z = 2.8 \). The dotted line represents the model with two systems of neutral gas and SMC-like dust at \( z_1 = 1.2037 \) and \( z_2 = 1.4436 \). The dashed line is the best-fit intrinsic powerlaw spectrum.
Fig. 4.— Confidence map in the $E(B-V)_1 - E(B-V)_2$ plane. The two parameters represent the color correction, assuming $R_V = 2.93$, in two SMC-like dusty complexes at $z_1 = 1.2037$ and $z_2 = 1.4436$. Contours are 68, 95 and 99.7% confidence levels and indicate that a significant fraction of dust must reside in the closer of the two systems at $z_1$. 