GRB 070518: A Gamma-ray Burst with Optically Dim Luminosity

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ABSTRACT
We present our optical observations of Swift GRB 070518 afterglow obtained at the 0.8-m Tsinghua University-National Astronomical Observatory of China telescope (TNT) at Xinglong Observatory. Our follow-up observations were performed from 512 sec after the burst trigger. With the upper limit of redshift ∼0.7, GRB 070518 is found to be an optically dim burst. The spectra indices β_{ox} of optical to X-ray are slightly larger than 0.5, which implies the burst might be a dark burst. The extinction A_V of the host galaxy is 3.2 mag inferred from the X-ray hydrogen column density with Galactic extinction law, and 0.3 mag with SMC extinction law. Also, it is similar to three other low-redshift optically dim bursts, which belong to XRR or XRF, and mid-term duration (T_{90} < 10, except for GRB 070419A, T_{90}=116s). Moreover, its R band afterglow flux is well fitted by a single power-law with an index of 0.87. The optical afterglow and the X-ray afterglow in the normal segment might have the same mechanism, as they are consistent with the prediction of the classical external shock model. Besides, GRB 070518 agrees with Amati relation under reasonable assumptions. The Ghirlanda relation is also tested with the burst.

Key words: gamma rays:bursts–gamma rays: observations–individual: GRB 070518.

1 INTRODUCTION
Since the first optical counterpart of gamma-ray burst (GRB) was identified on 1997 February 28, more and more GRBs have been optically detected, especially after Swift was launched successfully, which allows early follow-up observations with ground-based optical telescopes. However, about 40 per cent of Swift GRBs still failed to be identified with optical or infrared counterparts (Burrows et al. 2008). For the nature of the dark burst, several models have been proposed: extinction from dusty opaque star-forming regions (e.g. Groot et al. 1998; Reichart & Price 2002); high redshift, which diminishes the GRB optical luminosity (Lamb & Reichart 2000), as the lya forest is shifted into the observational energy range; intrinsically dim bursts (Fynbo et al. 2001; Rol et al. 2005); the observational effect. As a result of the late response to the bursts, Jakobsson et al. (2004) have proposed an operational definition of dark burst (i.e. optical-to-X-ray spectral index β_{ox} < 0.5), according to the fireball model.

However, GRBs with an optical afterglow have been studied widely and in depth (e.g. GRB 060218, GRB 080319B). This has resulted in an increasing number of GRBs with known redshift, which has allowed statistical studies to be carried out. The optical luminosity distribution of GRBs varies widely up to several magnitudes (Kann et al. 2006; 2008). After being transformed into a common redshift (e.g., z = 1), the optical luminosity shows a bi-modal phenomenon (Nardini et al. 2006; Liang et al. 2006; Kann et al. 2006; Kann et al. 2006; 2008): optically luminous and optically dim. The bi-modal distribution is also found to exist in other energy bands (Gendre et al. 2008a,b).

Liang & Zhang (2006) found that the apparent bimodality cannot be interpreted as a manifestation of the extinction effect, and they suggested that there might be two types of progenitors or two types of explosion mechanisms in operation. Considering the dark burst is usually a type of GRBs with a faint optical afterglow, optically dim bursts might
related to dark bursts (Nardini et al. 2006). However, the number of well-studied optically dim bursts is very limited. Thus, increasing the number of known optically dim bursts may help us to understand the origin of the bi-model distribution, the nature of optically dim bursts and dark bursts.

One such interesting case is GRB 070518. It was detected by Gamma-ray Burst Alert Telescope (BAT) onboard Swift at 14:26:21 (UT) on 2007 May 18. The X-ray telescope (XRT) and ultraviolet/ optical/ telescope (UVOT) on board Swift observed the counterpart beginning at 70 and 100 sec after the trigger, respectively. $T_{90}$ (15-350 KeV) is 5.5±0.2 s, $T_{32}$ is 2.9s (Sakamoto et al. 2008a). The values of duration mean the burst belongs to the short tail of the long group (Kouveliotou et al. 1993). Thus, it might be a classical long-duration GRB or an intermediate-long GRB (Horvath et al. 2003; Urata et al. 2005). The TNT telescope is equipped with landolt photometric standard stars with the TNT telescope on 2007 November 14 and December 12. Considering that the white band is not a standard band, we treated the white-band filter as a very broad filter. When we calibrated the white band data to $R$ band magnitude, no significant difference was found in the colour terms, and the response functions of the two filters were very similar with about 0.07 mag uncertainty. Since the redshift of GRB 070518 is no larger than 1, the white band data was calibrated to $R$ band magnitude, for simplicity. The transformation uncertainty of 0.07 mag is added to the final results.

In addition, other optical photometries for GRB 070518 are collected from the GRB Coordinate Network (GCN), in order to complete the optical light curves. All of these optical data are presented in Table 1.

3 ANALYSIS AND DISCUSSION

3.1 Light Curves and Chromatic Decay

The follow-up observations of GRB 070518 were performed with the TNT from 512s after the initial Swift trigger, and lasted for about 5.5 hours until the dawn time. A sequence of white, $R$, $V$, and $I$ bands images was obtained. After preliminary analysis, we first confirmed the counterpart of GRB 070518 (Xin et al. 2007) after the report of Swift UVOT.

Data reduction was carried out following standard routine in IRAF package, including bias and flat-field corrections. Dark correction was not performed, as the temperature of our CCD was cooled down to −110 °C. Point spread function (PSF) photometry was applied via DAOPHOT task in IRAF package to obtain the instrumental magnitudes. During the reduction, some frames were combined in order to increase signal-to-noise (S/N) ratio. Flux calibration was performed by re-observing the field of GRB 070518, together with Landolt photometric standard stars with the TNT telescope on 2007 November 14 and December 12. Considering that the white band is not a standard band, we treated the white-band filter as a very broad filter. When we calibrated the white band data to $R$ band magnitude, no significant difference was found in the colour terms, and the response functions of the two filters were very similar with about 0.07 mag uncertainty. Since the redshift of GRB 070518 is no larger than 1, the white band data was calibrated to $R$ band magnitude, for simplicity. The transformation uncertainty of 0.07 mag is added to the final results.

In this paper, we report on optical photometric follow-up observations of GRB 070518 at Xinglong Observatory of National Astronomical Observatories, Chinese Academy of Sciences. Afterglow observations and results are described in §2. An analysis and discussion are presented in §3, and a summary and conclusion are given in §4. In our calculations, a flat universe is assumed with matter density $\Omega_m = 0.3$, cosmological constant $\Omega_r = 0.7$, and Hubble constant $H_0 = 70$ km s$^{-1}$ Mpc$^{-1}$. The formula $f \propto t^{-\alpha} \nu^{-\beta}$ is used for the afterglow decay analysis.

2 TNT OBSERVATIONS AND DATA REDUCTIONS

We carried out a follow-up observation programme of Swift GRBs with the 0.8-m Tsinghua University-National Astronomical observatory of China optical telescope (TNT) at Xinglong Observatory, under the framework of the East-Asia Follow-up Observation Network (EAFON; Urata et al. 2003; Urata et al. 2005). The TNT telescope is equipped with a PI 1300 × 1340 CCD and filters in the standard Johnson-Bessel system. The field of view of the TNT is 11.4 × 11.4 arcmin, yielding 0.5 arcsec of the pixel scale. A custom-designed automation system has been developed for the GRB follow-up observations (Zheng et al. 2008).

\section*{References}

1 S(25-50KeV)/S(50-100KeV) = <0.72 C-GRB; 0.72 < S(25-50KeV)/S(50-100KeV) = <1.31 XRR; S(25-50KeV)/S(50-100KeV) > 1.32 XRF.

2 IRAF is distributed by NOAO, which is operated by AURA, Inc., under cooperative agreement with NSF.

3 http://irsa.ipac.caltech.edu/applications/DUST/
the fluctuations exist in both light curves, which might be a result of a low S/N ratio.

In order to investigate the decay properties between optical and X-ray light curves, we use the X-ray afterglow data downloaded from the website of the UK Swift science data center [5](labeled as USS) (Evans et al. 2007), where some analysis results are given, including the spectral indices for each segments in the X-ray light curve. These spectral indices are used directly for our later analysis. The X-ray light curve is also plotted by squares in Fig. 1, showing several drastic flares from the beginning up to about 250s after the burst trigger. Considering the sparse data between 2000 and 3 \times 10^3 \text{ sec}, we fit the light curve after 250 sec by separating it into two parts. one is between 250 sec and 2000 sec, and the other is from 3 \times 10^3 \text{ sec} to over 6 \times 10^5 \text{ sec}. The first part is well fitted by a single power law with an index of \( \alpha_{x,1} = 1.78 \pm 0.11 \) (\( \chi^2/\text{dof} = 0.76/3 \)), while the second is well fitted by a single power law with a slope of \( \alpha_{x,1} = 0.90 \pm 0.08 \) (\( \chi^2/\text{dof} = 5.83/8 \)). As shown in Fig. 1, the extrapolation of the first fitting is below the data detected after 1000 sec, suggesting that there is energy injection (Zhang et al. 2006) between the two segments, shown as a shallow decay. Therefore, the X-ray light curve displays a "steep-shallow-normal" decays (Zhang et al. 2006).

### 3.1.1 First Decay in X-ray Light Curve

The first steep decay in the X-ray afterglow light curve is usually explained by the Curvature Effect (e.g. Kumar & Panaitescu 2000; Zhang et al. 2009). According to their model, temporal index \( \alpha \) and spectral index \( \beta \) have a tight relation \( \alpha = 2 + \beta \). For GRB 070518, the first slope \( \alpha_{x,1} \) (1.78) of the X-ray light curve is definitely lower than the value (3.22, from 2 + \beta) expected for high-latitude emission (Here, \( \beta = 1.22 \) from USS). However, the high-latitude effect only provides an upper limit to the decay slope, as it assumes that the shell emission stops abruptly after the initial pulse (Mangano et al. 2007). The decline could be made in two cases: one is that residual emission from the shocked shells is still present, in which, the high-latitude emission would contribute only a small fraction of the overall radiation; the other is that the X-ray band is below the cooling frequency, in which case, the expected decay slope of high-latitude radiation would naturally be shallower than 2. For GRB 070518, the first possibility might be more reasonable, from the analysis for other segments of the X-ray light curve in the later sections.

### 3.1.2 Other Segments

The X-ray afterglow is analyzed by applying the closure relations given by Zhang et al. (2006) to the X-ray spectral

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4 [http://www.swift.ac.uk/xrt_curves/00279592/](http://www.swift.ac.uk/xrt_curves/00279592/)

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| T-T0 (mid day) | Exposure (Sec) | Band | Mag | Telescope or Reference |
|----------------|----------------|------|-----|------------------------|
| 0.00636        | 2×20           | W    | 19.03±0.10 | TNT                   |
| 0.00699        | 2×20           | W    | 19.23±0.10 | TNT                   |
| 0.09804        | 3×20           | W    | 19.37±0.12 | TNT                   |
| 0.09883        | 3×20           | W    | 19.27±0.08 | TNT                   |
| 0.09961        | 3×20           | W    | 19.68±0.14 | TNT                   |
| 0.01053        | 4×20           | W    | 19.56±0.12 | TNT                   |
| 0.01157        | 4×20           | W    | 19.74±0.13 | TNT                   |
| 0.01275        | 5×20           | W    | 20.08±0.15 | TNT                   |
| 0.01406        | 5×20           | W    | 20.06±0.18 | TNT                   |
| 0.02446        | 1×300          | R    | 20.20±0.10 | TNT                   |
| 0.02814        | 1×300          | R    | 20.76±0.16 | TNT                   |
| 0.03723        | 3×300          | R    | 20.48±0.10 | TNT                   |
| 0.01237        | -              | R    | 19.5     | GCN6443               |
| 0.23337        | -              | R    | 22       | GCN6483               |
| 0.35948        | -              | R    | 22.2     | GCN6418               |
| 0.37753        | -              | Rc   | 22.3±0.2 | GCN6458               |
| 0.71837        | -              | R    | 23.03±0.05 | GCN6462               |
| 1.45833        | -              | R    | 23.3     | GCN6426               |
| 1.70817        | -              | R    | 23.36±0.05 | GCN6462               |
| 3.60897        | -              | R    | 23.56±0.05 | GCN6462               |
| 0.02065        | 1×300          | V    | 20.74±0.15 | TNT                   |
| 0.06830        | 10×300         | I    | 20.47±0.17 | TNT                   |
| 0.10197        | 10×300         | I    | 20.92±0.13 | TNT                   |
| 0.15271        | 14×300         | I    | 21.37±0.14 | TNT                   |
| 0.20660        | 15×300         | I    | 21.23±0.24 | TNT                   |
and temporal indices. These relations help us to determine the location of the observed X-ray band relative to the synchrotron frequencies (να,νm,νc) and the environment where the burst occurred.

The normal decay segment with αx,3 = 0.99 and βx,3 = 1.11 ± 0.11, agrees with the non-injected closure relations: β = 1/2 and α = 3νc−2νm. These relations are consistent with two cases: when νx > νm in fast cooling phase or when νx > νc in slow cooling phase. Also, the environment condition [interstellar medium (ISM), Wind] could not be distinguished for the above cases.

The application of the closure relations to the X-ray temporal and spectral index in normal decay segment, combining the analysis in § 3.1 for the X-ray afterglow during 2000–2×104 sec, suggests that there is energy injection before the start of the normal decay phase.

3.1.3 Flares in the X-Ray Afterglow

The X-ray light curve of GRB 070518 shows drastic flares between 80 and 200 s since the trigger, as shown in the insert in the Fig. 1. Several XRFs were reported to have flares in X-ray afterglows (e.g. Bernardini et al., 2009; Krimm et al., 2007b). With the method of Krimm et al. (2007b), the ratio of raise time duration and the middle time for two big flares (peak times of about 106.9 s and 189 s, respectively) are calculated. ΔT(T) for two flares was about 0.2 and 0.1, respectively, and the ΔF(F) was about 1. Such steep and large amplitude rises in the observed flux, as in GRB 070518, could not be explained by a sudden increase in the external density (Nakar & Granot 2007). Another model, a patchy shell model, can produce the flare with ΔF(F) of about 1 (Nakar & Oren 2004), although it cannot interpret the flares with ΔT(T) << 0.1. For two big flares of GRB 070518, ΔT(T) are about 0.2 and 0.1, respectively. Therefore, the model might be possible. Moreover, such dramatic flares are also related to refreshed shocks or the central engine activity (e.g. Zhang et al. 2006). This is more reasonable for the case of GRB 070518, if we consider the above analysis that energy injection was still occurred after these flares.

3.1.4 Chromatic Decay and Afterglow Model

Chromatic decay could be seen in the case of GRB 070518, as shown in Fig. 1. The X-ray afterglow shows a "steep-shallow-normal" decay (Zhang et al. 2005), while optical afterglow is decaying with a constant index of 0.87 (if the correct of the late contamination was right). The decay index of the optical light curve (αopt=0.87) is slightly smaller than that of the normal decay segment (0.99) of the X-ray afterglow. The normal decay segment is usually explained the external shock model (Sari et al. 1998), as expected for the optical afterglow. However, the origin of the normal phase might also be related to the internal energy dissipation (see as the discussion by Urata et al. 2007). Thus, the classical external shock model will tested with the burst. According to the model, the difference between the decay indices of the optical and X-ray afterglow should be between -0.25 for the uniform ISM case and 0.25 for the wind medium case (Urata et al. 2007). For GRB 070518, αo − αX = 0.87 – 0.99 = −0.12, ignoring the uncertainties of those values. The case of GRB 070518 agrees with the prediction of the classical external shock model. Moreover, with the relation derived by Urata et al. (2007): αo−αX = −0.25+ s/(8−2s), where s shows the condition of ambient matter density as a formate of n < r−3, the value of s for GRB 070518 could be deduced to be 0.84. This suggests that the surrounding matter of the burst is a mix of ISM and wind-type medium.

3.2 Testing the Amati and Ghirlanda relations

The time-averaged spectrum of GRB 070518 from T-1.8s to T+4.5s is best fitted by a simple power-law model with a photon index Γ = 2.11 ± 0.25 (Krimm et al. 2007a; Guidorzi et al. 2007), corresponding to the energy spectral index of 1.11 ± 0.25 (β = Γ − 1). The fluence in the 15-150 KeV band is 1.6±0.2×10−7 erg cm−2 (Krimm et al. 2007a), which is lower than the average value of the Swift burst (Sakamoto et al. 2008a).

3.2.1 Amati relation

Fig. 2 shows the relation between Epeak,i in the rest frame and Eiso (i.e. Amati relation; Amati et al. 2002). The data shown by open symbols and the best fitting parameters are obtained from Amati et al. (2008). For GRB 070518, spikes in the BAT light curve reported by Guidorzi et al. (2007) were only clearly seen under 50 KeV, which implies that Epeak,o might be less than 50 KeV. Besides, if Epeak,o is within the BAT energy range, the photon index Γ of a simple power-law fit and Epeak,o are well correlated with a relationship (Liang & Zhang 2005):

\[ \log E_{\text{peak,o}} = (2.76 ± 0.07) - (3.61 ± 0.26) \log \Gamma \]

Sakamoto et al. (2009) also obtained a similar conclusion by combining the simulation: logEpeak = 3.258 − 0.829Γ

With Γ = 2.11 and the two relations above, Epeak,o = 38.8±16.96KeV and 30.8 are obtained, respectively. The mean value of ~ 35 KeV is taken from the above calculations as its peak energy in the observational frame. Thus Epeak,i = (1+z) × Epeak,o ~ 60 KeV in the rest frame. As a result, GRB 070518 is consistent with Amati relation within 3 σ uncertainties, as shown in Fig. 2.

3.2.2 Ghirlanda relation

Ghirlanda, Ghisellini & Lazzati (2004) proposed a relation between peak energy Epeak,i in the rest frame and the collimation-corrected energy Eγ: Epeak,i ≈ 480 × (Eγ,51)0.7 KeV, where Eγ,51 = Eγ/1051 ergs and Eγ = (1−cosθ)Eγ,iso. In this relation, the jet angle θ is very important, which was given by Sari, Piran & Halpern (1999):

\[ \theta = 0.161 \times (t_{\text{jet},d}/(1+z))^{1/8} \times (n \times \eta_f/E_{\gamma,\text{iso},52})^{1/8} \]

where z is the redshift, tjet,d is the break time in days. For GRB 070518, the time of a possible jet break should be later than the last observation of X-ray afterglow, tjet,d > 10 sec, according to the analysis of § 3.1. Thus, the opening angle of jet θ should be larger than ~25 degree, under an assumption of the typical values: n = 3 cm−3 and ηf = 0.2 (Ghirlanda et al. 2004). From the values of θ and Eγ,iso,52, Eγ is estimated to be larger than 6×1049 ergs.

However, Epeak,i has been estimated to be about 60 KeV in the observation frame, as analyzed in §3.2.1. The
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3.3 One of the Optically Dimmest Long Bursts to Date

Nardini et al. (2006) found that GRB optical luminosity at 12 hours (at rest-frame) after the trigger shows a bimodal distribution. With a redshift of 0.7 for GRB 070518, 12 h at the rest frame corresponds to 20.4 hours in the observer frame. Following the method of Nardini et al. (2006), and assuming $\beta_0 = 0.8$, $L_{\text{opt},12h,i} = 2 \times 10^{28}$ erg s$^{-1}$ is obtained based on the redshift of 0.7, and $\alpha_0 = 0.87$. The low value of $L_{\text{opt},12h,i}$ of GRB 070518 means that the burst is one of the optically dimmest GRB afterglows so far (Nardini et al. 2008).

We have also noted that the result might be affected by the subtraction of its contamination at late phase. In order to investigate this, we just calculate the optical luminosity at the rest frame with the data without correction of the contamination of its possible host galaxy. In this case, $L_{\text{opt},12h}, \sim 6 \times 10^{28}$ erg s$^{-1}$ is obtained with the assumptions as above, indicating that the burst is really an optically dim burst. Moreover, if the real redshift of the burst was lower than 0.7, its luminosity would become much lower than the value given above.

Another method to investigate the optically dim luminosity of GRB 070518 is to compare its light curve with other long bursts directly. Kann et al. (2007) have collected GRBs in the pre-Swift and Swift era to compare the luminosity of GRBs in the common redshift of 1. In this sample, GRB 050416A, GRB 060512A and GRB 070419A are at the lower edge of the distribution of optical light curves (Seen in the Figure 1 of Kann et al. 2008). In order to make the comparison, we have collected $R$ band data of the above three dim bursts from GCN Circular and other literature. These data are transformed into a common redshift $z = 1$, with $\beta_{\text{opt}} = 1.3$ for GRB 050416A (Soderberg et al. 2007) and fixed $\beta_{\text{opt}} = 0.8$ for other bursts, GRB 070518, GRB 060512 and GRB 070419A. In the transformation, all magnitudes are corrected for the Galactic extinction, and without considering the extinction from their host galaxies. In addition, for GRB 070518, flux contribution of host galaxy is corrected. As shown in Fig.3, the luminosity of GRB 070518 is close to that of the three bursts, based on the redshift of 0.7. Therefore, GRB 070518 should belong to optically dim bursts, like the other three bursts (e.g. GRB 050416A, GRB 060512 and GRB 070419A).
3.4 Extinction

One of the interpretations for the optically dim luminosity is the extinction and absorption from circumburst medium in its host galaxy. Here, we try to estimate the extinction along the line-of-sight to the burst. The observed neutral hydrogen column density along this line-of-sight to GRB 070518 determined by XRT onboard Swift is about $N_H = (9.6 \pm 1.6) \times 10^{20}$ cm$^{-2}$ (Guidorzi et al. 2007), larger than the previously measured Galactic value ($N_H = 2.2 \times 10^{20}$, Dickey & Lockman, 1990). The excess value is about $(7.4 \pm 1.6) \times 10^{20}$ cm$^{-2}$. If the excess value is from a previously unobserved overdensity located within or close to our Galaxy, then the excess extinction $A_V = 0.64$ would be obtained with the excess value of neutral hydrogen, based on the relation found by Predel & Schmitt (1995): $A_V = 0.56 \times N_H [10^{21}$ cm$^{-2}] + 0.23$ mag. If this is the case, extinction should not be a prominent cause for the optically dim luminosity.

It is likely that the excess column density is located within the host galaxy of GRB 070518. As in the discussion for GRB 051022 (Nysewander et al. 2006), the rest frame $N_H$ is given by the observed $N_{H,o} \times (1 + z)^2$. The source frame is about $N_{H,s} = (3 \pm 0.6) \times 10^{21}$ with $z = 0.7$. From the relation of host extinction $A_{V,s} = A_{V,obs} \times (1 + z)$ mag (Nysewander et al. 2006), $A_{V,s} = 3.2$ mag would be given in the rest frame based on a redshift of 0.7. Clearly, under these conditions, high extinction would be a dominate cause of the optically dim luminosity of GRB 070518.

However, all above estimates are made with an assumption of the Milky Way-type extinction. The optical extinction from the measured $N_H$ absorption should depend on the assumed dust-to-gas ratio. Some evidence shows that the extinction law in the GRB host galaxy is likely to be a Small Magellanic Clouds (SMC) type. Using the small dust-to-gas ratio of the SMC (Pei 1992), the host extinction $A_{V,s}$ would be 0.3 mag when $z = 0.7$. The difference of the extinction value estimated above is very large, about a factor of 10. Actually, the real extinction law in the GRB host galaxy is uncertain in most cases, like GRB 050401, for example, the extinction $A_V$ is estimated to be 0.62 $\pm$ 0.06 by fitting the optical spectrum, which is lower than the value $A_V \sim 9.1$ inferred from the X-ray column density (Watson et al. 2006). One reason for the case of GRB 050401 was that high energy release of gamma-ray and hard X-ray photons might destroy the circumburst dust in the GRB host galaxy (Watson et al. 2006). The reason might also be the case of GRB 070518.

3.5 Comparison with Other Three Optically Dim Bursts

As shown in Fig.3, three Swift optically dim bursts GRB 050416, GRB 060512A and GRB 070419A are labeled to compare with GRB 070518. In order to investigate the reason for the dim luminosity of GRB 070518, we try to compare them in different aspects.

Table 2 presented the main parameters for the three bursts along with those of GRB 070518. There are several similar properties, as follows.

1. The references for GRB 050416A are Sakamoto et al.(2005,2006), Holland et al. (2007) and Kann et al. (2007).
2. The references for GRB 060512 are Cummings et al. (2006), Starling R. et al. (2006), Bloom et al. (2006) and Kann et al.(2007).
3. The references for GRB 070419A are Cenko et al. (2007) and Stamatikos et al. (2007).

(2) The photon indices of these bursts are larger than 2, which implies that the spectra are so soft that these bursts belong to XRRs and XRFs.

(3) The redshifts of all these bursts are lower than 1.

Another aspect concerns the absorption and extinction of the GRB host galaxy. Of the bursts mentioned above, only GRB 050416A has been studied extensively (e.g. Sakamoto et al. 2006; Mangano et al. 2007; Soderberg et al. 2007), and the extinction from its host galaxy has been estimated to be $A_V = 0.2$ (Holland et al. 2007), or $A_V = 0.32 \pm 0.17$ (Kann et al. 2007). The two values are similar to the average value ($A_V=0.2$) of GRBs based on the study of Kann et al. (2007, 2008). However, they are significantly smaller than the extinction ($A_V \sim 3.8$) expected from the hydrogen column density inferred from X-ray observations of XRF 050416A, assuming a dust-to-gas ratio similar to that found for the Milky Way (Holland et al. 2007). The low value of extinction from host galaxy of GRB 050416A implies that the extinction of host galaxy of GRB 070518 might be not large, only about $A_V = 0.3$, as analyzed in §3.4.

3.6 Optical to X-ray Energy Spectral Index

Optically dim bursts might be related to dark bursts (Nardini et al. 2008). Considering that GRB 070518 is an optically dim burst, we wonder whether the burst is a dark burst or not.

The index of optical to X-ray spectrum $\beta_{ox}$ ($< 0.5$) at 11 h after the burst trigger is used to define dark bursts (Jakobsson et al. 2004). Cenko et al. (2009) argued that the X-ray flux at about 11 hours might be contaminated by the shallow decay for some bursts. As a result, the X-ray flux would be larger than the real X-ray flux radiated along with optical afterglow, which would make some normal bursts "dark" bursts. They calculated $\beta_{ox}$ for the bursts in their catalogue at 1000s after the trigger time. However, it is too early for most of the Swift bursts to carry out the calculation at 1000s after the trigger, because the X-ray light curves in
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according to the definition of Jakobsson et al. (2004). The optical extinction in its host galaxy inferred from X-ray hydrogen column density is 3.2 with Galactic extinction law, and 0.3 with SMC extinction law.

Afterglow model has been applied to the light curves. Energy injection is found to occur for the X-ray afterglow before the start of the normal decay segment. The behavior of the normal segment of the X-ray afterglow and the optical afterglow is consistent with the prediction of the classical external shock model (Urata et al. 2007), indicating that they come from the same origin. As an XRR burst, GRB 070518 agrees with Amati relation. Moreover, it fills the gape of high-luminosity and low-luminosity bursts in the Amati relation, similar to GRB 050416A (Sakamoto et al. 2005). It is also found that GRB 070518 agrees with the Ghalanda relation within reasonable assumptions.

Moreover, a comparison with three optically dim bursts (GRB 050416A, GRB 060512 and GRB 070419A and GRB 070518) reveals that several similar properties were shared: burst duration $T_{90} < 10s$ (expect for GRB 070419A, $T_{90} = 116s$), soft spectrum at BAT band $\Gamma > 2$, low redshift $z < 1$, etc.

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Figure 4. The optical and X-ray flux density light curves. The optical corresponds to the R band, shown as open hexagonal. The X-ray data at 3 KeV is shown as solid squares. The spectral indices are calculated at different times (1000s, 11 hours and 10$^5$s) by the interpolation of their light curves. The optical to X-ray spectral indices $\beta_{ox}$ are also shown.

some Swift GRBs might be at the steep or shallow decay segment about this time.

For GRB 070518, $\beta_{ox}$ at 1000s, 11 hours and 10$^5$s after the burst are calculated by interpolation, as shown in Fig.4. $\beta_{ox}$ for GRB 070518 is 0.666, 0.606 and 0.543 at the above three epochs, respectively. It seems that the burst is not a dark burst, for all of $\beta_{ox}$ are slightly larger than 0.5. However, spectral index $\beta_{ox}$ depends on the energy distribution $p$ of electrons (Jakobsson et al. 2004). For GRB 070518, $p$ should be 2.22±0.22, as $\beta_{ox} = 1.11 \pm 0.11$ (from analysis of USS) and $p = 2\beta$. In this case, the criterion for dark bursts should be $\beta_{ox} < 0.6 \pm 0.1$. Consequently, GRB 070518 might be a dark burst (Jakobsson et al. 2004) or a gray burst (Zheng et al. 2009).

4 SUMMARY AND CONCLUSION

We have presented optical afterglow observations of GRB 070518 from the TNT and an analysis of the optical and X-ray light curves. The optical afterglow shows a constant power law decay $\sim 0.87$, while the X-ray shows a “steep-shallow-normal” decay behavior. Based on the upper limit of redshift of 0.7, the optical luminosity at 12 hours in the rest frame was estimated to be $2 \times 10^{52}$ erg s$^{-1}$, which means that the burst is an optically dim burst. The conclusion is also supported by comparing with three other optically dim bursts: GRB 050416A, GRB 060512 and GRB 070419A. The spectral indices of $\beta_{ox}$ at 1000 s, 12 hours, $10^5$s are calculated. All $\beta_{ox}$ were slightly larger than 0.5, indicating that GRB 070518 might be a dark burst or a gray burst, accord
