Probing Dust and Gas in GRB Host Galaxies

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ABSTRACT

Using a sample of GRBs detected by both the XRT and the UVOT, we construct the spectral energy distribution to determine the gas column density and dust extinction in the GRB local environment. We model the host galaxy dust on the SMC, LMC and Galactic extinction curves. In only one case does a model with a prominent absorption feature at 2175Å, typical of dust in the Milky Way, provide a better fit. The rest of the sample affected by extinction is best fit by SMC or LMC dust, suggesting the hosts to be irregular and low in metallicity. We investigate the factors that contribute to the extinction and absorption in GRB afterglows, and the implications on the properties of their host galaxies.

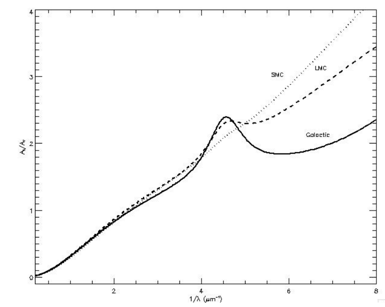


Figure 1. Galactic (solid), LMC (dashed) and SMC (dotted) extinction curves. Curve parameterisations are taken from Pei (1992)

THE MODEL

The afterglow SEDs were fitted with a power law and two dust and gas system components corresponding to the Galactic and the host galaxy absorption and extinction. The host galaxy extinction was modelled on the SMC, LMC and Galactic extinction laws, shown in Fig. 1.

The prominence of the 2175 Å absorption feature and amount of far-ultraviolet (FUV) extinction vary. The MW has the highest amount of absorption at 2175 Å and smallest amount of FUV extinction, whereas the SMC is the opposite of this with a FUV extinction rising faster than $1/\lambda$ and an insignificant 2175 Å feature. A further difference is in the amount of the reddening per H atom (Draine 2000), which is observed to be greatest in the MW and least in the SMC.

Figure 2.

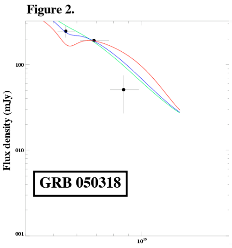
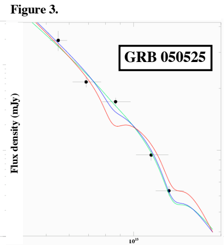


Figure 3.



Frequency (Hz)

Figure 2-5. Spectral Energy Distribution for four GRB afterglows in our sample zoomed into optical/UV energy range. Best-fit models are shown; SMC (green), LMC, (blue) and Galactic (red)

RESULTS

Only the SED of GRB 050802 was better fit by a model with Galactic dust at the host galaxy, which has a prominent 2175Å feature (Fig. 2). The rest of the sample affected by extinction is best fit by SMC or LMC dust, suggesting the hosts to be irregular and low in metallicity.

The 2174Å feature

The origin of the 2175Å feature is most likely to be carbonaceous material such as small spherical particles of graphite (a ≤ 15~nm), which have a strong feature at this wavelength and of a similar width. Its strength in the MW extinction curve would require ~15% of the solar abundance in carbon to be present in small particles of this size (Draine 2000), whereas it's absence in the SMC extinction curve can be explained by a difference in the relative abundances of graphite and silicate grains (Pei 1992). The evidence for the 2175Å absorption feature in the SED of GRB050802 suggests that the dust content in the surrounding environment of this burst was more carbon rich than is the case for the other bursts.

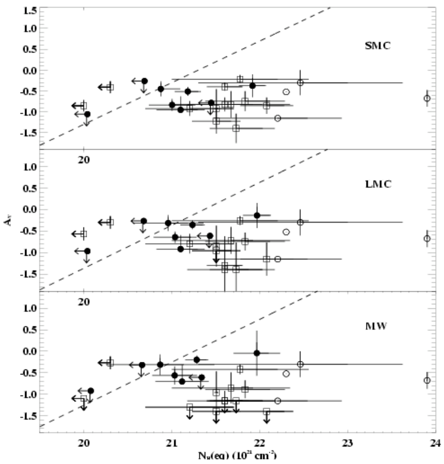


Figure 6. Host galaxy A_V vs. N_H. Solid circles are GRBs in our sample, open symbols represent pre-*Swift* GRBs. Dashed lines are empirical N_H/A_V relations for the SMC (top), LMC (middle) and MW (bottom).

N_H vs. A_v

The gas-to dust ratio in the host galaxy of the eight GRBs in our sample is lower than the previous studies have suggested, indicating a larger presence of dust in the GRB circumburst environment. This difference could be the result of the increased sensitivity of *Swift*, which is probing fainter, and more dust obscured GRBs. The host galaxy dust extinction against gas column density for our sample of GRBs (solid circles) and previous samples (open points) is plotted in Fig. 6.

The higher GRB host galaxy dust-to-gas ratio implied in our sample suggests the effects of dust destruction by the intense radiation emitted by the GRB are not as marked as previously indicated.

Figure 4.

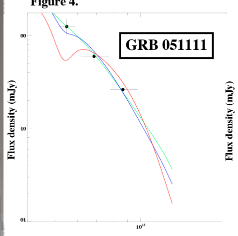
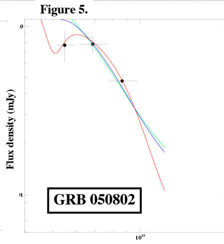


Figure 5.



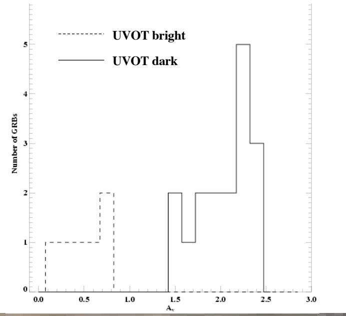
Frequency (Hz)

Extension to Dark Bursts

The bursts analysed in this paper have host galaxy extinctions ranging from < 0.09 to A_V = 0.63. However, these GRBs were selected on the criteria that they were detected in UVOT, and may represent the low end of the extinction distribution.

Using the X-ray to optical flux ratio typically observed in GRBs with optical counterparts, we estimate the host galaxy visual extinction for a sample of GRBs with no UVOT optical counterpart with deep upper limits, assuming the optical surpression is due to dust extinction. We show the distribution in A_V for these two samples of GRBs in Fig. 7.

Figure 7. A_V distribution for our sample of GRBs (dashd) and a sample of 17 *Swift* GRBs with no optical afterglow detected by UVOT (solid).



Conclusions

We modelled the SED for eight *Swift* GRBs to estimate the host galaxy dust extinction and gas column density using the SMC, LMC and Galactic extinction curves to model the host galaxy dust content.

In summary we found:

1. SED to GRB 050802 required an absorption component at rest frame wavelength ~2175Å.
2. Remaining GRBs with evidence of extinction in the local environment do no require this feature
3. The dust-to-gas ratio in the the GRB local environments is lower that previous studies have suggested, suggested dust destruction by the GRB radiation not be an important factor in observations
4. The A_V distribution in our sample of GRBs could represent the lower end of the distribution, with GRBs with no UVOT optical counterpart having significantly larger values of host galaxy A_V.

References:

1. Draine, B., 2000, ApJ, 532, 273
2. Pei, Y. C., 1992, ApJ, 395, 130