Investigating Dust Properties of (Long) GRB Host Galaxies

Adria C. Updike
Clemson University, NASA GSFC

Dieter H. Hartmann
Clemson University

D. Alexander Kann
Thüringer Landessternwarte Tautenburg
Dust Models

- Pei (1992) MW, LMC, SMC templates
- Calzetti (1994) starburst galaxy template
- Li (2008) the Drude model

Graphite and Silicate Model

- Based on dust models of Draine & Lee (1984, 1985)
  \[ \tau_\lambda = \int_{a-}^{a+} \pi a^2 C \Sigma_d \left( \frac{a}{a_0} \right)^{-3.5} Q_{\text{ext}} \, da \]
- Assumes spherical particles, MRN size distribution, dust temperature of 20 K (Pei 1992)
  \[ F_\lambda = F_0 \nu^{-\beta} e^{-(\xi_s \Sigma_s + \xi_g \Sigma_g)} \]
  \[ \xi_d = \tau_\lambda / \Sigma_d \]
Extinction Curves

- Silicate, $10^{12} \text{ cm}^{-2}$
- Graphite, $10^{12} \text{ cm}^{-2}$
Dust Formation

- $9+ M_{\odot}$: Core-collapse supernovae (Cherchneff & Dwek 2009, 2010) form silicates
- $0.1 - 9 M_{\odot}$: Asymptotic Giant Branch stars (Karakas 2010) form carbon

Bromm & Loeb 2006

Pop III Silicates, Pop I/II Silicates, Pop I/II Carbon

Updike 2010
Photometric SEDs, data from the literature with established redshifts

Data from the literature compiled using the methods of Zeh et al. 2006 and Kann et al. 2006 to construct broad-band afterglows at one day after the trigger assuming no achromaticity

82 GRBs total, 77 with good reduced $\chi^2$

5+ SED data points red of Lyman alpha
A Few Results of our Fit

GRB 070125

\(z = 1.547\)
\(\Delta t_g = 0.1\%\)
\(A_V = 0.18 \pm 0.02\)

\(\Sigma_G = 1.03 (\pm 0.47) \times 10^{10} \text{ cm}^{-2}\)
\(\Sigma_S = 1.67 (\pm 0.08) \times 10^{11} \text{ cm}^{-2}\)
data from Updike et al. 2008

GRB 080607

\(z = 3.036\)
\(\Delta t_g = 0.01\%\)
\(A_V = 1.55 \pm 0.07\)

\(\Sigma_G = 3.23 (\pm 0.18) \times 10^{11} \text{ cm}^{-2}\)
\(\Sigma_S = 8.11 (\pm 0.23) \times 10^{11} \text{ cm}^{-2}\)
data from Perley et al. (accepted)
$A_V$ Distribution in Our Data Set

$A_V$ distribution in our data set versus the same GRBs for which $A_V$ values existed in the literature.
Graphite vs Silicate in GRB Host Galaxies
Graphite-to-Silicate in GRB Host Galaxies
Graphite Detections in 17 GRB Hosts

GRB 970508
GRB 991216
GRB 010921
GRB 030115
GRB 030329
GRB 030723
GRB 050502A
GRB 050730
GRB 070802
GRB 071010
GRB 080319B
GRB 080603
Moving away from templates gives more information about the dust properties of the hosts.

Graphite and silicate model has four parameters with physical significance.

More silicate than graphite is found in all hosts.

17 / 77 hosts show significant graphite column densities.

No evidence for evolution of graphite-to-silicate ratio between redshifts ~ 0 – 4.8.