Statistical properties of GRBs afterglow parameters as evidence of host galaxies cosmological evolution

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50% grb with known redshifts → 60% optical emission

10% peaked light curves in R-band 990123-110205A
A(U)

**AFTERGLOWS**

grb 050730

grb 081010
THE PHYSICS OF OPTICAL EMISSION

grb, prompt optical em.
internal shocks

thick, thin shell
\[ \Delta \sim t_\gamma c. \]

afterglows reverse shock
\[ t_A \sim \min(t_\gamma, \Delta/c) \]

afterglows forward shock

undisturbed ISM
shocked ISM
jet
cocoon

contact discontinuity
reverse shock
jet
cocoon
$T_{rev} \sim 10\,\text{sec}$

$T_{forw} \sim 100\,\text{sec}$
OBSERVED PARAMETERS

- Galactic absorption
- Luminosities of grb’s host galaxies

\[ L_{opt} = 4\pi \kappa_{opt}(z) D_l^2(z) F_{opt} \]

\[ E_{opt} = \frac{4\pi \kappa_{opt}(z) D_l^2(z) S_{opt}}{(1+z)} \]

\[ T_{90, opt} = \frac{t_{90, opt}}{(1+z)} \]

\[ T_{peak} = \frac{t_{peak}}{(1+z)} \]
$\gamma = 100 \div 300$  \hspace{1cm} n $= 1 \div 10 \ cm^{-3}$ \hspace{1cm} $\rho = \text{const}$

$\varepsilon_e \approx 0.01$ \hspace{1cm} $\varepsilon_B \approx 0.01$
\[
d\Delta(z)/dz = 4\pi(c^3r_0/H_0^3)e(z)F(z, \Omega_M, \Omega_\Lambda)/(1 + z)
\]

\[
\varphi(L) = C \left( \frac{L}{L_0} \right)^{-\lambda} \exp \left( -\frac{\ln^2(L/L_0)}{2\sigma^2} \right) \exp \left( -\frac{L}{L_0} \right)
\]

\[
L_{\text{opt}} \propto T_z^{-\alpha}
\]

\[
m_{\text{lim}} \approx 23 \text{ mag}
\]
A type: $L \propto (1 + z)^{5.4 \pm 0.9}$
A(U) type: $L \propto (1 + z)^{3.9 \pm 2.0}$
A+A(U): $L \propto (1 + z)^{5.3 \pm 0.8}$
A+A(U)+P/A(U): $L \propto (1 + z)^{5.3 \pm 0.7}$
CONSTRaining ISM density

Forward shock

\[ \nu_i, \nu_c \quad L \propto n^{\frac{\beta+1}{2}} \quad \beta = \frac{p-1}{2} \]
\[ \nu > \nu_i, \nu_c \quad L \propto n^{\frac{3\beta-1}{6}} \quad \beta = \frac{p}{2} \]

So \[ L \propto n^{0.75\pm1} \quad \text{and} \quad n \propto (1+z)^{5.4\pm0.9\pm7.2\pm1.2} \]

Reverse shock

\[ T_{\text{peak}} \gg T_{90} \quad \text{thin shell case} \quad L \propto n^{\frac{p+1}{4}} \quad \text{and} \quad L \propto n^{0.75\pm1} \]
determined by the critical Lorentz factor

\[ \Gamma_0 \approx 1.4 \left( \frac{3E_{iso}}{32\pi m_p c^5 \eta T_{peak}^3} \right)^{1/8} \]

\[ \eta = \frac{E_{iso}}{E} \]

\[ \Gamma_0 = 100, \eta = 0.2 \]

The model of galaxies' evolution

Ciardi B., Loeb A.

\[ n(z) = n_0 (1 + z)^4 \]
SFR evolution

KS law

\[ \sum_{\text{SFR}} - \sum_{\text{star}}^{0.5} \sum_{\text{gas}} \]

![Graph showing SFR evolution with data points and various fits labeled as best linear fit, [1] fit, [2] fit, and [3] fit. A table below the graph lists the slopes and errors for each fit.]
THANK U 4 ATTENTION!