GRB Discoveries with Swift

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NASA-GSFC
**Swift GRB 070420**

**BAT prompt emission**

3 instruments, each with:
- lightcurves
- images
- spectra

**XRT afterglow**
Long GRBs
<table>
<thead>
<tr>
<th>$z$</th>
<th>GRB</th>
<th>Optical/IR Brightness</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.29</td>
<td>050904</td>
<td>J = 18 @ 3 hrs</td>
</tr>
<tr>
<td>5.6</td>
<td>060927</td>
<td>I = 16 @ 2 min</td>
</tr>
<tr>
<td>5.3</td>
<td>050814</td>
<td>K = 18 @ 23 hrs</td>
</tr>
<tr>
<td>5.11</td>
<td>060522</td>
<td>R = 21 @ 1.5 hrs</td>
</tr>
</tbody>
</table>
GRB Host Spectroscopy

GRB 050505

$z = 4.275$

Damped Ly$\alpha$

$N(\text{HI})=10^{22} \text{ cm}^{-2}$

$n \sim 10^2 \text{ cm}^{-3}$

$Z = 0.06 \ Z_\odot$

$M_{\text{progenitor}} < 25 \ M_\odot$

Savaglio 2006

Metallicity vs Redshift

Hubble time (Gyr)

$Z/Z_\odot$

Redshift

Savaglio 2006
GRB 060218: GRB + Supernova

Super-long GRB - ~35 minutes

BAT, XRT, UVOT during GRB

$z = 0.033 \quad d = 145 \text{ Mpc}$

SN 2006aj SN Ib/c

$E_{\text{iso}} = \text{few} \times 10^{49} \text{ erg} \quad - \text{underluminous}$
Afterglows
Typical Swift X-ray Lightcurves

50% with bright early component

>30% with flares

Burrows et al. 2005
Achromatic Jet Break - GRB 060526

$z = 3.21$
jet angle = 7°

Dai et al. 2007
• Many GRBs do not show jet breaks
• In other cases, optical and X-ray breaks are not coincident.
• Complex shape of afterglow lightcurves makes jet breaks hard to find

Other new papers:

Curran et al. (astro-ph 0706.1188) - evidence for achromatic breaks in several Swift GRBs

Oates et al. (astro-ph 0706.0669) - GRB 050802 case with X-ray break clearly seen but no optical break
Short GRBs
Short GRB Time Structure
Short GRB - Current Status

*Swift* short GRB observations

- 23 short bursts detected (+2 from HETE, +1 from INTEGRAL)
- 78% with X-ray afterglow detected by XRT (95% long GRBs)
- 28% with optical detection (58% long GRBs)
- ~50% with host IDs

~1/2 shorts accompanied by soft extended emission up to 100 sec

Redshift range from $z = 0.2$ to 1

- $<z>_{\text{short}} = 0.6$
- $<z>_{\text{long}} = 2.3$

GRB 070714B $z = 0.92$

(Graham et al. 2007)
3 Types of GRBs

Swift GRBs (mostly)

Short GRBs

Long GRBs

SN GRBs

$\log \left[ \frac{T_{90}}{(1+z)} \right]$ vs $\log \left[ E_{\text{iso}} \right]$ (ergs)
Assuming all short GRBs are due to NS-NS mergers, merger rate is \(~300\, \text{Gpc}^{-3}\, \text{yr}^{-1}\)

[Consistent with NS-NS population synthesis modeling O'Shaughnessy, Kalogera, & Belczynski (2005)]

\(\Rightarrow\) Advanced LIGO detection rate of \(~30\, \text{yr}^{-1}\)

Nakar et al.:
Possible much higher rates of \(10^5\, \text{Gpc}^{-3}\, \text{yr}^{-1}\).
\(\Rightarrow\) Detection with enhanced LIGO

Swift will be in orbit until \(> 2020\)