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
### GRB Redshifts

<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>5.47</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>

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<td>2.35</td>
<td>051109A</td>
<td></td>
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GRB Host Spectroscopy

GRB 050505

- $z = 4.275$
- Damped Ly$\alpha$
- $N(\text{HI}) = 10^{22} \text{ cm}^{-2}$
- $n \sim 10^2 \text{ cm}^{-3}$
- $Z = 0.06 \, Z_\odot$
- $M_{\text{progenitor}} < 25 \, M_\odot$

Metallicity vs Redshift

Savaglio 2006
GRB 050904  z=6.29

Subaru Telescope
Kowai et al. 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 \quad 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 = $7^\circ$

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

![Graph showing the time structure of Short GRBs](image-url)
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)*

![Graph showing short, long, and Swift GRBs with different markers and circles indicating their characteristics.](image)

- **Short GRBs**
- **Long GRBs**
- **Swift GRBs (mostly)**

Parameters:

- \( \log [ E_{iso} \text{ (ergs)} ] \)
- \( \log \left[ \frac{T_{90}}{(1+z)} \right] \)
Implications for Grav. Wave Detections

Assuming all short GRBs are due to NS-NS mergers, merger rate is \( \sim 300 \text{ Gpc}^{-3} \text{ yr}^{-1} \)

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

\[ \Rightarrow \text{Advanced LIGO detection rate of } \sim 30 \text{ yr}^{-1} \]

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

\[ \Rightarrow \text{Detection with enhance LIGO} \]

Swift will be in orbit until > 2020