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
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<th>Optical/IR Brightness</th>
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<td>050904</td>
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Swift Long GRB Redshifts

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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

$z = 0.033$  \hspace{1em}  d = 145 \text{ Mpc}$

SN 2006aj  \hspace{1em}  SN Ib/c

$E_{\text{iso}} = \text{few} \times 10^{49} \text{ erg} - \text{underluminous}$
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

![Graph showing GRB 051221a](image)
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)*

![Diagram showing 3 Types of GRBs]

- Short GRBs
- Long GRBs
- SN GRBs

**Equations:**

\[ \log [ E_{\text{iso}} \text{ (ergs)} ] \]

\[ \log [ T_{90} / (1+z) ] \]
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)]

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

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

Swift will be in orbit until $> 2020$. 