Classifying the X-ray Afterglow Light Curves Based on the Pulse Structure of the GRB Prompt Emission

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Prompt emission vs. X-ray afterglow light curve

Global connection between the prompt emission and X-ray afterglow?

Sakamoto, Hullinger et al. 2008:

Classify GRBs based on the spectral hardness of the prompt emission:

- **XRFs** ($E_{\text{peak}} < 30$ keV)
- **XRRs** ($30$ keV < $E_{\text{peak}}$ < 100 keV)
- **C-GRBs** ($E_{\text{peak}} > 100$ keV)

**C-GRB:**
Break around $10^3$-$10^4$ sec

**XRF:**
Simple decay with the index of -1
Flux is systematically lower
Swift 140 long GRBs with known-z (2005-2009)

The BAT 1-s peak photon flux > 0.5 ph cm\(^{-2}\) s\(^{-1}\)

Based on the BAT light curve (116 GRBs):

- Single pulse event: 30 GRBs
- Multi-structured event: 77 GRBs
- Two long-separated (~100s) event: 9 GRBs

XRT light curve:
- U. of Leicester’s automatic products
- Redefined \(T_0\) as the start time of the emission in BAT (\(T_{100}\) start)
- Luminosity light curve: k-correction (PC mode photon index) and \(t/(1+z)\)
Single pulse event
Multi-structured event
Two long-separated event

050319

050820A

060210

060526

060904B

061121

070306

070721B

100901A

15–350 keV

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Single pulse event

$L_{\text{iso}} \left(10^{45} \text{ erg/s}\right)$ vs $\text{Time [s]}$
Multi-structured event
Two long-separated event
Swift

Single pulse event
Multi-structured event
Two long-separated event
X-ray Luminosity @ T+10^4 s

- Single pulse event
- Multi-structured event
- Two long-separated event
X-ray Luminosity @ T+10^4 s

Single pulse event

Multi-structured event

KS-test (single vs. multi): \( p = 5.2 \times 10^{-4} \)
KS-test (multi vs. two): \( p = 3.6 \times 10^{-2} \)

Two long-separated event
Redshift distribution

- Single pulse event
- Multi-structured event
- Two long-separated event
Redshift distribution

Single pulse event

Multi-structured event

Two long-separated event

KS-test (single vs. multi): $p = 3.9 \times 10^{-1}$
KS-test (multi vs. two): $p = 6.4 \times 10^{-1}$
(i) Patchy shell (multiple jet) model (e.g. Kumar & Piran; Toma et al.)

(ii) Off-axis jet model (e.g. Yamazaki et al.)
Summary

Classifying the X-ray afterglows based on the pulse structure of the prompt emission

X-ray afterglow luminosity tends to be lower for single pulse GRBs comparing to that of multi-structure GRBs

This finding might expand the variability-luminosity relation in the prompt emission into the X-ray afterglow regime