GRB 090423: the new beacon at the frontier of the Universe

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on behalf of:

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Swift team
Overview: the cosmic “dark ages”

What is the Reionization Era?
A Schematic Outline of the Cosmic History

- The Big Bang
  The Universe filled with ionized gas
  The Dark Ages start

- The Universe becomes neutral and opaque
  The Dark Ages start

- Galaxies and Quasars begin to form

- Reionization complete, the Universe becomes transparent again

- Galaxies evolve

- The Solar System forms

- Today: Astronomers figure it all out!

Time since the Big Bang (years)

- ~ 300 thousand
- ~ 500 million
- ~ 1 billion
- ~ 9 billion
- ~ 13 billion

Hubble Space Telescope

WMAP

SDSS
Overview: the reionization history

Many open questions:
- when did the reionization happen?
- what are the main sources of ionizing photons?
- what is the relative contribution of PopIII/PopII stars?
- what are the feedback effect at play?
- ...
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No UVOT detection @ t-t_0 = 77 s

Krimm et al. GCN 9198
Palmer et al. GCN 9204

Evans et al. GCN 9205
Stratta & Perri GCN 9212

De Pasquale & Krimm GCN 9210
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Telescopio Nazionale Galileo
~14hrs after Trigger

Thoene et al. GCN 9216
Fernandez-Soto et al. GCN 9222
GRB 090423: TNG spectrum

spectrum taken with the Amici prism on the TNG/NICS camera at ~14 hrs

most distant object ever observed!

\[ \lambda_{\text{obs}} = 1216 \text{ Å (1} + z) \]

\[ z = 8.1^{-0.3}_{+0.1} \]

Amici prism:
\[ \lambda = 0.8 - 2.4 \mu m \]
\[ R \sim 50 \]

Salvaterra et al. 2009
GRB 090423: VLT spectrum

VLT-ISAAC

VLT-SINFONI

$z = 8.26^{+0.07}_{-0.08}$

Tanvir et al. 2009
GRB 090423: prompt

Rest frame properties:
\[ T_{90,\text{rf}} = 1.34 \text{ s} \]
\[ E_{\text{iso}} = 10^{53} \text{ erg (Fermi)} \]
\[ E_{p,\text{rf}} = 440 \text{ keV} \]
GRB 090423: X-ray afterglow

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**Canonical light curve**

**Analysis of the XRT spectrum shows intrinsic absorption**

\[ N_H = 7 \times 10^{22} \text{ cm}^{-2} \]

**Lower limit on the metallicity of the circum-burst medium**

\[ Z > 0.04 \, Z_\odot \]

**Above critical metallicity for PopIII:**

\[ Z_{\text{crit}} = 10^{-6} - 10^{-4} \, Z_\odot \]
GRB 090423: a rare event

\[ L_{\text{cut}} \propto (1+z)^{1.5-3} \]

\[ Z_{\text{th}} = 0.02-0.2 \ Z_\odot \]

probability

numbers yr\(^{-1}\)

Salvaterra et al. 2009
Expected GRBs/yr at $z>6$

The high-z population:

GRB 050904 @ $z=6.3$
GRB 080913 @ $z=6.7$
GRB 090423 @ $z=8.1$

1-7% of all Swift GRBs at $z>6$
for $P_{\text{lim}}=0.4 \text{ ph/s/cm}^2$

Salvaterra et al. 2009
Exploring the “dark ages”