Probing the Early Universe with Gamma Ray Bursts

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The galactic baryon cycle
The galactic baryon cycle

- Molecular Gas Mass
- Star Formation Rate
- Chemical Enrichment
- Gas Kinematics
- Galaxy Stellar Mass

- Afterglow Light Pattern 400,000 yrs.
- Dark Ages
- Development of Galaxies, Planets, etc.

- Halo
- ISM
- Nuclear activity
- Jets/winds
- Stellar mass loss
- Supernovae
- WMAP
Observations of nearby galaxies

Chemical Composition/SFR

Stellar Mass/SFR

Gorosabel+05

Credit: Robert Gendler
Increasingly distant galaxies
Very distant galaxies

Credit: NASA/ESA/R.Bouwens & G.Illingworth
Using GRBs as a probe of cosmic chemical build-up
Gamma Ray Bursts (GRBs)
GRB emission mechanism

Compact star mergers

Core collapse of massive star
Absorption-derived metallicities are largely model-independent and sensitive down to very low metallicity values.
Cosmic chemical evolution

Want to....
- measure host galaxy stellar mass and SFR
- cross calibrate absorption to emission-line derived metallicities

Yates, PS+in prep
Cross-calibrate metallicity diagnostics

\[ Z_{\text{em}}: \text{More sensitive for more massive, chemically evolved galaxies} \]

\[ Z_{\text{abs}}: \text{More sensitive for low-mass, chemically unenriched galaxies} \]
Cross-calibrate metallicity diagnostics

Absorption-based metallicities

Emission-based metallicities

Highly model dependent

Local rather than global

With JWST+GRBs can study discrepancy in metallicity diagnostics

Yates, Schady+in prep
Summary

• Long GRBs are excellent and unique probes of distant, star forming galaxies

• The imprint left on their afterglow spectra from intervening material provides a unique view of the chemical composition and conditions of the ISM in their host galaxies

• To optimise their use as probes of distant galaxies, need to investigate how properties inferred from absorption spectroscopy compare to emission-based analysis

• The future NASA JWST mission (all $9.66 of it!) promises significant headway in this area or research, and in the cosmic chemical evolution in general

• Future, sensitive infrared and X-ray missions (Theseus, ATHENA) will greatly increase high-z GRB samples