Finding the First Cosmic Explosions with WFIRST



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Numerical Simulations of Pop III Star Formation



Observational Probes of the Properties of The First Stars

- direct detection of Pop III stars not possible now or even with 30 – 40 m class telescopes
- might get lucky and catch the lensed H II region of a Pop III star, but need a magnification µ > 300 (Rydberg et al. 2013)
- stellar archaeology: hunting for the ashes of the first SNe in ancient, dim metal-poor stars

Direct Detection of Pop III SNe in the NIR

- Pop III SNe are hundreds of thousands times brighter than their host galaxies
- build up a rough Pop III IMF by binning transients by explosion type
- constrain cosmic star formation rates by counting transients

Final Fates of the First Stars Heger & Woosley 2002, ApJ 567, 532



Los Alamos Supernova Light Curve Project

Frey, Even, Whalen et al. 2013 ApJS, 204, 16

- model final pre-SN structure of star with a stellar evolution code such as Kepler
- simulate explosion in the Los Alamos RAGE rad hydro code
- post process RAGE profiles with SPECTRUM code to compute spectra and light curves
- use the LANL OPLIB database of atomic opacities to get absorption / emission lines







PI SN NIR light curves

CC SN NIR light curves

- JWST and 30 40 m telescopes will see PI and PPI SNe out to z ~ 20 - 30
- CC SNe and explosions of compact progenitors will be visible at z ~ 10 - 15

- JWST and the ELTs have high sensitivities that can capture PI SNe at any epoch, but their narrow fields of view may not encounter many events
- they will also only detect CC SNe out to z ~ 10 -15, the era of the first galaxies, not first light
- the Pop III IMF cannot be constrained with PI SNe alone, need CC SN detections at z ~ 20

Cluster Lenses as Cosmic Telescopes



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Cluster Surveys of High Redshift SNe with JWST and ELTs





CLASH SN detection rates

Frontier Fields SN detection rates

WFIR T Wide-Field Infrared Survey Telescope



5.04 deg² Deep SN Survey: AB mag 29.3 @ 2 µm

- WFIRST can see PI SNe at z ~ 15 20
- it will see CC SNe at z ~ 7 10
- the 5.04 deg² Deep SN survey field could enclose tens of thousands of cluster lenses
- these lenses could boost flux from CC SNe at z ~ 20 above the 29.3 AB mag limit of the survey in the NIR
- if so, WFIRST might capture hundreds or thousands of Pop III CC SNe at this epoch

Constraining the Pop III IMF and SFRs with WFIRST

- we are now constructing strong lensing magnification maps for the WFIRST Deep SN field
- we will convolve these pdfs with our SN light curves to estimate CC SN detection rates at 5 < z < 20
- the detection of lensed CC SNe at z ~ 20 by WFIRST with PI SNe, which need no magnification, could constrain the Pop III IMF
- these detections could also probe cosmic SFRs down to the least optimistic values predicted by simulations