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 $\mu > 300$ (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
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
• JWST and 30 – 40 m telescopes will see PI and PPI SNe out to $z \sim 20 - 30$

• CC SNe and explosions of compact progenitors will be visible at $z \sim 10 - 15$
• 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 $z \sim 10 - 15$, 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 $z \sim 20$. 
Cluster Lenses as Cosmic Telescopes

J0717
Cluster Surveys of High Redshift SNe with JWST and ELTs

CLASH SN detection rates

Frontier Fields SN detection rates
WFIRST can see PI SNe at $z \sim 15 - 20$

it will see CC SNe at $z \sim 7 - 10$

the 5.04 deg$^2$ Deep SN survey field could enclose *tens of thousands* of cluster lenses

these lenses could boost flux from CC SNe at $z \sim 20$ 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