FrontierSN: Supernovae and other Explosive Transients

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Design and operation

- Searching both HFF and GLASS data
- Multi-cycle GO program for HST follow-up
  40 orbits over 2 years (+ 20 for final year)
- Ground-based spectroscopy
  from Gemini, Keck, VLT
Testing Type Ia SN progenitor models with high-z rates
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A lensed Type Ia SN at $z=1.33$
SN HFF14Tom discovered in Abell 2744 prime field
The SN is < 40" from the cluster center
ACS G800L Spectrum confirms Type Ia at z=1.33
Light Curve fit provides luminosity distance

SN HFF14tom

\( z = 1.33 \pm 0.02 \)

\( A_V = 0.05 \pm 0.06 \)

\( \Delta = -0.06 \pm 0.1 \)
Light Curve fit provides luminosity distance

\[ \text{dm}_{\text{field}} = (1.69 \pm 0.54)(z-1.33) + 44.85 \pm 0.05 \]

\[ \mu_{\text{obs}} = 1.92 \pm 0.21 \ (0.71 \pm 0.12 \text{ mag}) \]
Light Curve fit provides luminosity distance

\[
\text{distance modulus} \quad \mu_{\text{obs}} = 1.92 \pm 0.21 \ (0.71 \pm 0.12 \text{ mag})
\]

\[
dm_{\text{field}} = (1.69 \pm 0.54)(z-1.33) + 44.85 \pm 0.05
\]
Direct measure of magnification confronts existing lens models

Lensing Magnification, $\mu$

- CATS: $2.28^{+0.04}_{-0.04}$
- Sharon: $2.59^{+0.18}_{-0.16}$
- Sharonv2: $2.71^{+0.13}_{-0.05}$
- Jauzac: $3.39^{+0.04}_{-0.04}$
- Zitrin-LTM: $2.98^{+0.77}_{-0.37}$
- Zitrin-NFW: $2.29^{+0.22}_{-0.22}$
- Williams: $2.80^{+2.69}_{-1.16}$
- Bradac: $2.47^{+0.18}_{-0.16}$
- Merten: $2.23^{+0.67}_{-0.20}$
- Lam: $2.77^{+0.36}_{-0.36}$

median best
Direct measure of magnification confronts existing lens models

- All models systematically overpredict the magnification
- Uncertainties are mostly underestimated
This SN is (at least) placing a stringent test on systematic uncertainties at the edge of the strong-lensing region.
Can we learn more about dark matter substructure?

Jauzac+ 2014
A peculiar transient in a multiply-imaged host
SN HFF14Spo behind MACSJ0416

HFF14spo : SN Spock in MACSJ0416 04:16:09.358  -24:04:12.87
F125W  F140W  CLASH  HFF  diff  F160W

2011 Aug 2014 Difference

Steve Rodney (JHU)
Discovered in the last HFF visit:
SN Spock was faint, young, and red
Host galaxy is image 1 (or 2) of a triply imaged system at $z=1.0$

Time delay between images 1 and 2: few days or years
to image 3: ~ decade

Magnification: $\mu \sim 20 - 40$ (3 - 4 mag)
The search for Spock:
No supernova during the CLASH survey
Another detection!

A SN was present in the other image of the host during the HFF ACS campaign: January 2014.
But wait... that’s not a supernova.

The optical transient appears, rises by 1 mag, then fades away, all in <3 rest-frame days.
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The optical transient appears, rises by 1 mag, then fades away, all in <3 rest-frame days.
The mysterious "SN" Spock

figure from M. Kasliwal
The mysterious "SN" Spock

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The Realm of Fast SN

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The Realm of Fast SN

Drout+ 2014
Spock is not a SN

Drout+ 2014
What’s left?
• VLT + Xshooter spectrum shows no AGN features
Afterglow of an unseen GRB?

Cenko+ 2013
Ia : “Failed” explosion

- AM CVn star
- White Dwarf + He donor
- He shell explosion
- C/O core undetonated

also: kilonova ?
extreme M dwarf flares?
FrontierSN year 1 summary

25 SN discoveries to z~1.5

A peculiar strongly-lensed transient (or two)

Lensed SN Ia testing magnification predictions

More to come ...
More exotic and unexpected transients
FrontierSN could discover the first...
FrontierSN could discover the first...

Multiply Imaged Type Ia SN

(a) Most multiply-imaged galaxies are at $z \sim 2$

(b) Many have $\Delta t < 5$ yrs

(c) Most have errors on $\Delta t$ at $\sim 10\%$ or better.
FrontierSN could discover the first...

Pop III Core Collapse Supernova

![Graph showing F160W AB magnitude over time.](graph.png)

- Red Super-giant at z=7 zero metallicity
- $E = 2.4 \times 10^{51}$ erg

HFF detection limit

$\mu = 13$

$\Delta m = 2.5 \log_{10}(\mu) = 2.75$

- 25 $M_\odot$
- 15 $M_\odot$
- 40 $M_\odot$