High-redshift supernova rates measured with the gravitational telescope A1689

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Why supernova (SN) rates?

Core collapse (CC) SNe	SNe Ia
CC SNe are explosion of massive and short lived stars. Their rates are directly related to the star formation history (SFH).	The SN Ia rate depends on the mechanism leading up to the explosion. The rate can be used to measure the delay time, which can be used to constrain the progenitor scenario.

Unlike SNIa, CC SN rates have been measured poorly for long time for several reasons:

- CC SNe are on average intrinsically fainter than SNIa
- CC SNe explode often in dusty environments

At high-z, SN light shifts from optical to NIR where atmosphere is troublesome.

SN rates are important for understanding several mechanisms in galaxies, such as chemical evolution.

Aim: measure CC rates at high-z (and compare to SFH) by using ground-based instruments

Use galaxy clusters as gravitational telescopes

Surveys to find high-z lensed supernovae

We used Abell 1689 at z = 0.18, that has magnification maps with good precision and an extended Einstein radius of ~50".

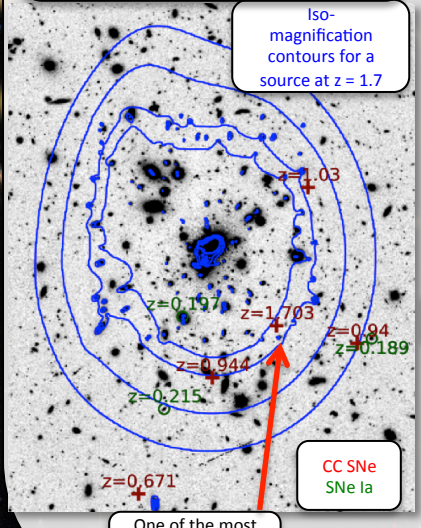
We performed a rolling search in **near-infrared (HAWKI/VLT)** and **optical (ALFOSC/NOT):**

- J band (1.25 μm)
- 31 epochs over ~5 yrs

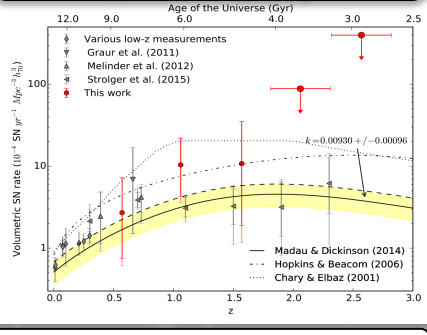
- Mostly i-band, some g and r
- 25 epochs over ~4 yrs

Results of the surveys

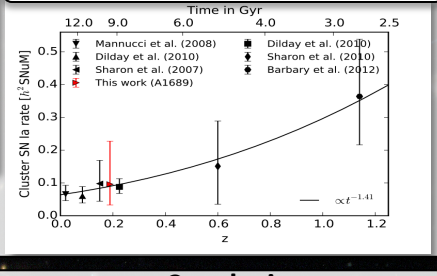
5 High-z CC SNe with significant magnification (0.31-1.58 mag) and 2 SNe Ia in A1689



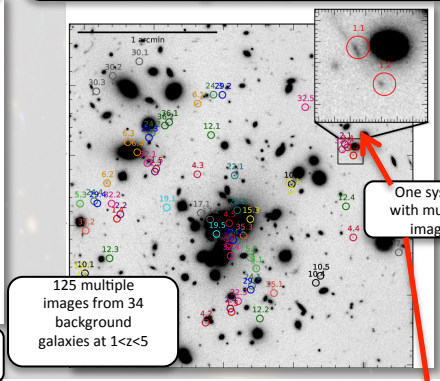
Volumetric CC SN rates + comparison with the Star formation history

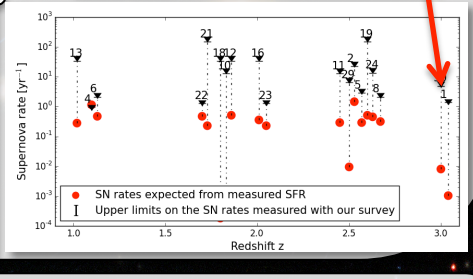


Cluster SN Ia rates



Expected SNe in the resolved strongly lensed multiply-imaged galaxies





Conclusions

✓Compared to large space HST programs, we have performed relatively small ground NIR+optical survey. Thanks to the power of the gravitational telescope, we have measured volumetric CC SN rates that are in agreement with previous results and the expectations from the SFH.

✓ Tens of strongly lensed SNe with multiple images can be expected to be discovered behind A1689 by upcoming transient surveys such as LSST, and in particular WFIRST. Until the first light of these surveys, using gravitational telescopes is the only way to find high-z SNe using available ground-based instruments.