What Can Supernovae Tell Us About Massive Stars?

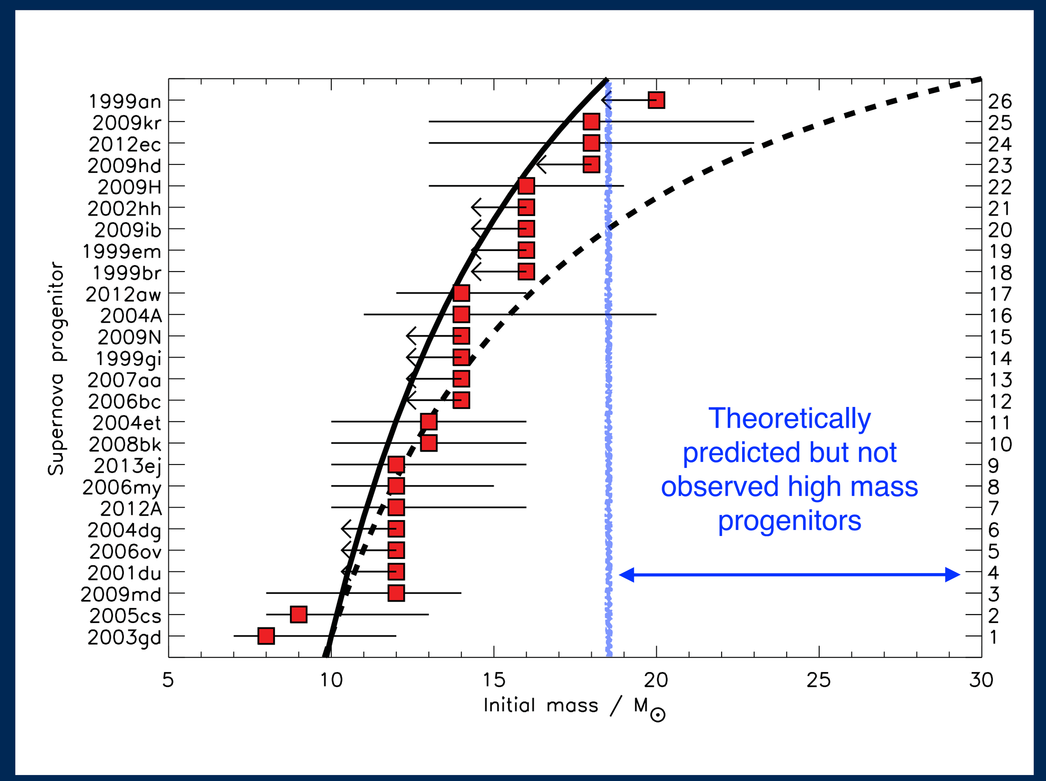
K. Azalee Bostroem, Stefano Valenti, David Sand, Viktoriya Morozova, Anders Jerkstrand, Assaf Horesh, et al.

Why use supernovae to study massive stars?

- Massive stars are rare
- Compared to supernovae, massive stars are faint and often blended
- Phases prior to explosion occur on rapid time scales —> difficult to catch at the right moment

Post-explosion techniques for determining progenitor mass

- Direct detection: (pre-explosion modeling) current method
- Light curve modeling: new post-explosion technique
- Nebular spectra modeling: new post-explosion technique



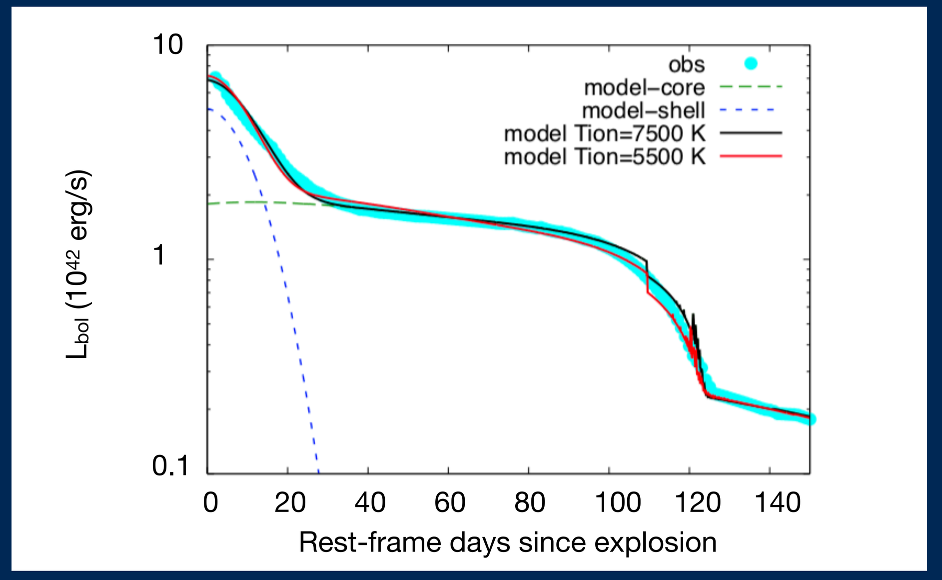
Population of progenitors determined from pre-explosion imaging does not agree with the predicted population.

Are the predictions wrong or is the interpretation of the observations incorrect?

Do all methods determine the same progenitor mass?

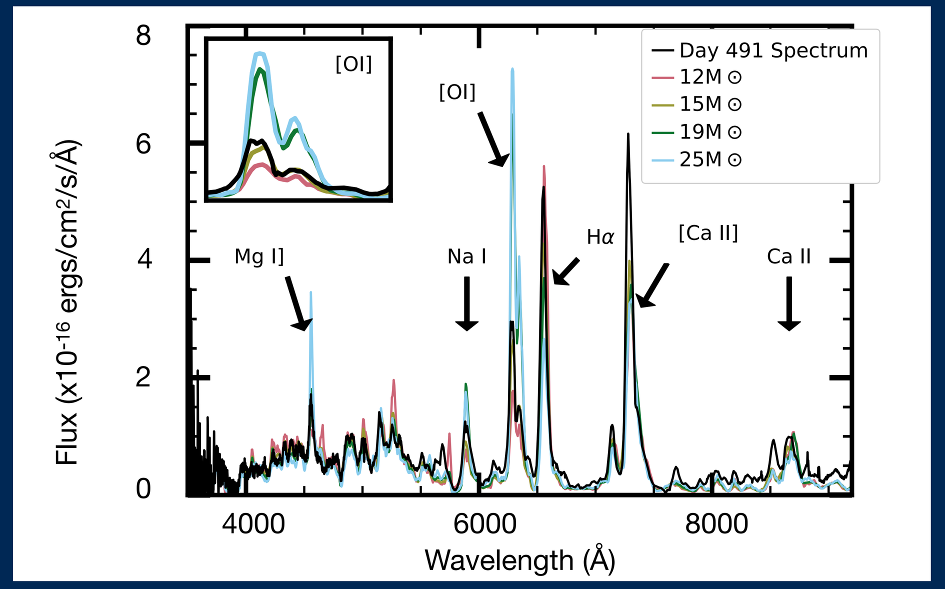
SN 2017eaw

Light Curve Modeling



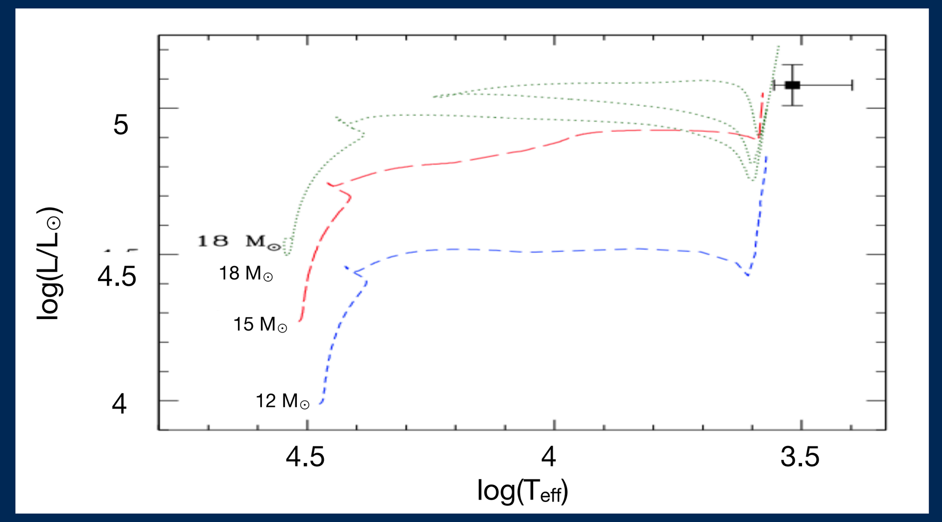
A 15 M⊙ progenitor is derived by modeling the bolometric light curve (from Szalai et al, arXiv: 1903.09048).

Nebular Spectra Modeling



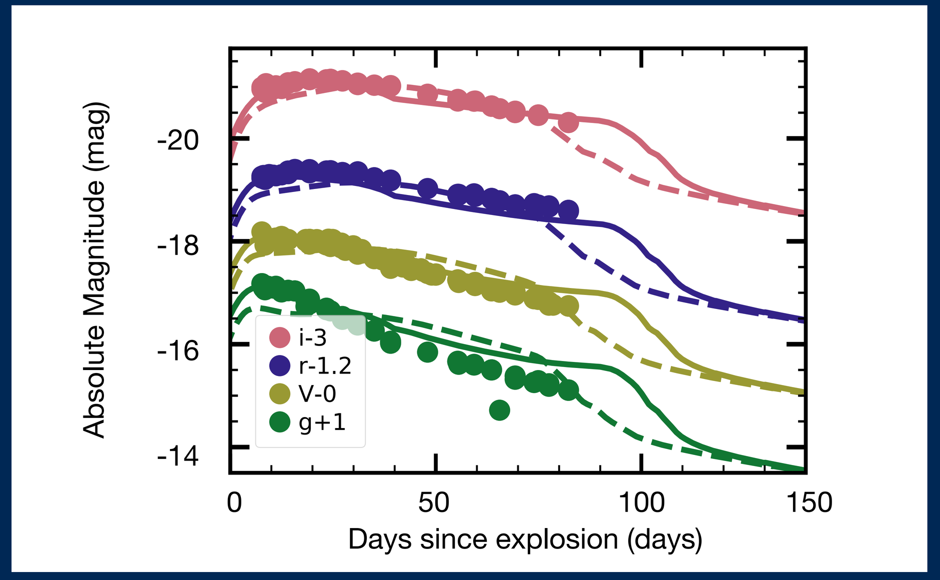
Nebular spectra of SN 2017eaw from multiple epochs are best characterized by a 15 M⊙ progenitor from the models of Jerkstrand et al (2012).

Pre-explosion Modeling

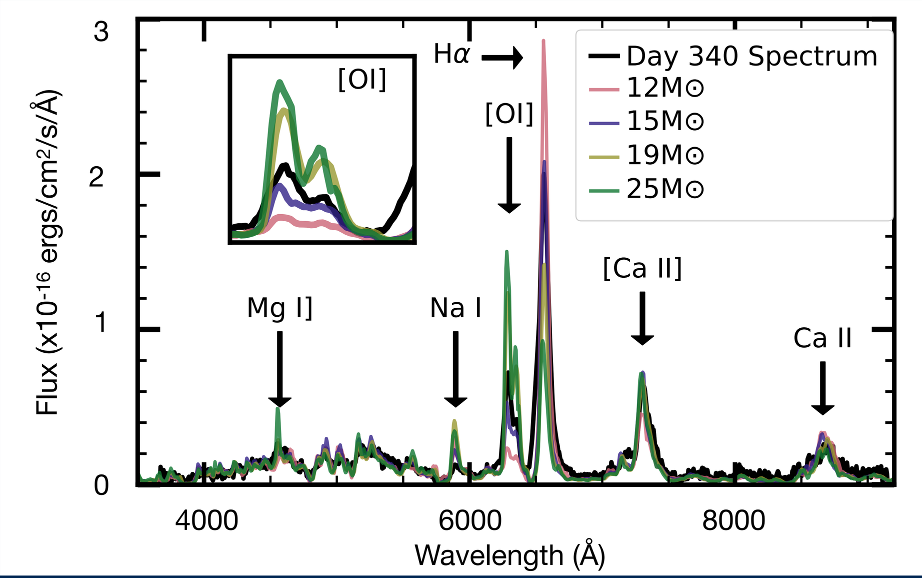


SN 2017eaw : nebular spectra, light curve modeling, and direct detection are consistent with a 15 M⊙ progenitor.

ASASSN-15oz



Multi-band light curve modeling of ASASSN-15oz using the SuperNova Explosion Code (SNEC; Morozova et al., 2015) shows that the observations are best fit by a 17 M⊙ progenitor.



An example of the comparison of the nebular spectra of ASASSN-15oz and the progenitor models of Jerkstrand et al (2012) which shows that the progenitor of ASASSN-15oz was between 15 and 19 M⊙.

Left: The HST and Spitzer pre-imaging of SN 2017eaw are consistent with a 15 M⊙ progenitor (from Van Dyk et al, arXiv 1903.03872).

ASASSN-15oz : nebular spectra and light curve modeling are consistent with a 17 M⊙ progenitor.

Maybe; need bigger samples

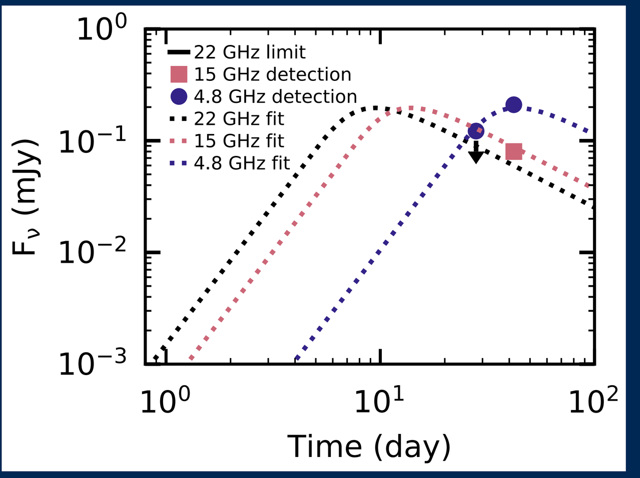
Using supernovae to probe red supergiant mass-loss

Do red supergiant undergo a period of extreme mass-loss prior to explosion?

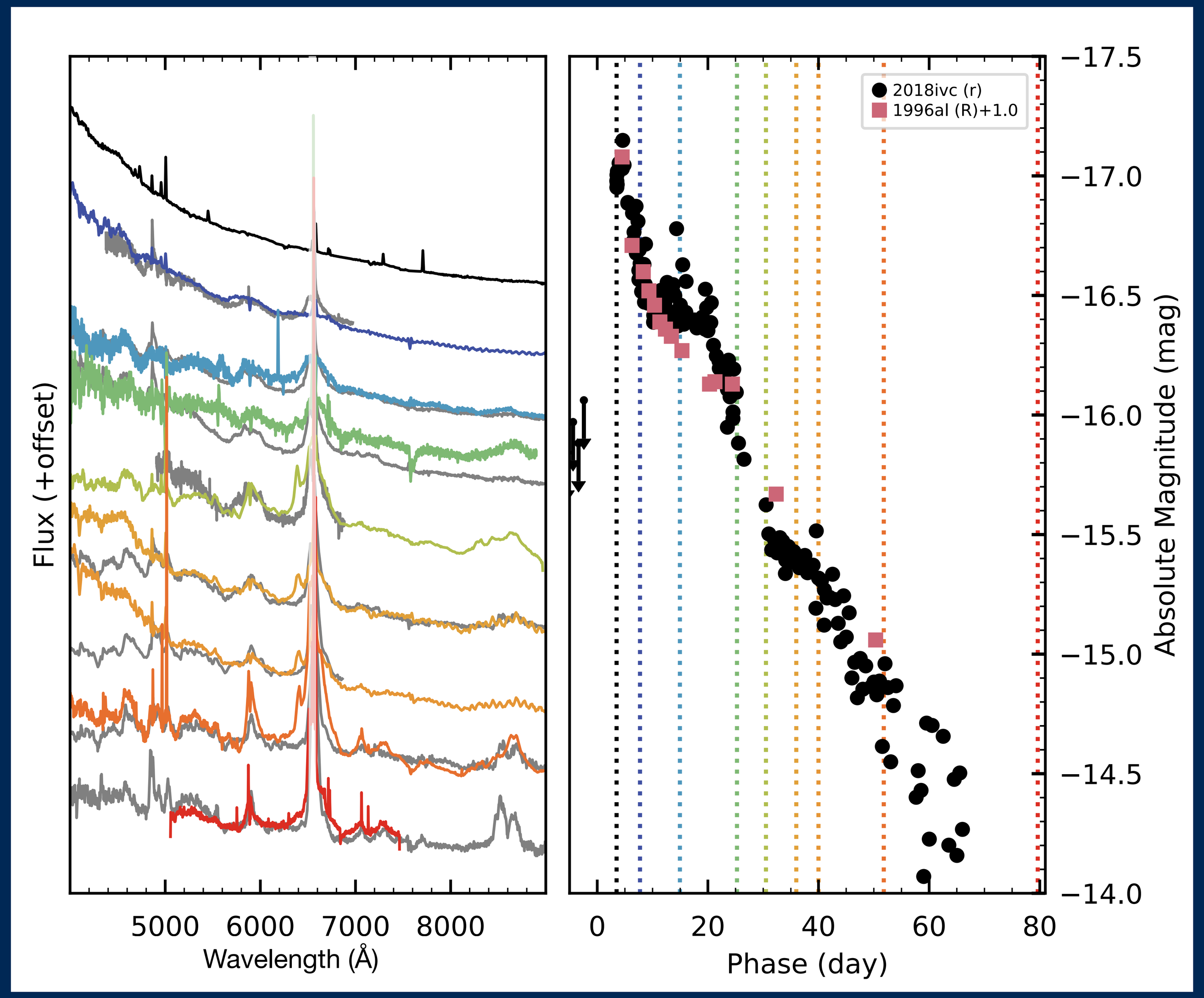
ASASSN-15oz

The multi-band light curve of ASASSN-15oz (left) is best fit by a SNEC model with 1.5 M⊙ of circumstellar material (dashed line). The best fit model without circumstellar material is also shown(solid line) although it is unable to reproduce the early rise in the light curve.

Modeling the radio observation of ASASSN-15oz shows a mass-loss rate of ~10^{-6} M⊙ yr



SN 2018ivc (DLT18aq)



The light curve and spectroscopic evolution of SN 2018ivc are similar to SN 1996al except that SN 1996al showed narrow emission lines. The light curve shape and intermediate width hydrogen emission feature imply strong interaction with a dense circumstellar material.