Radiative Transfer Analysis of SN2012fr Using SYNOW and Phoenix

A Detailed Spectral Study

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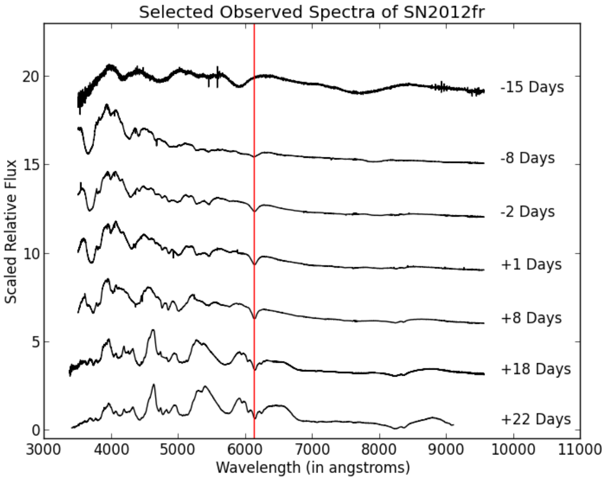
- First observed October 26th, 2012.
- Identified as a Type Ia supernova. Unusually high-velocity Silicon II features were observed in the spectra.

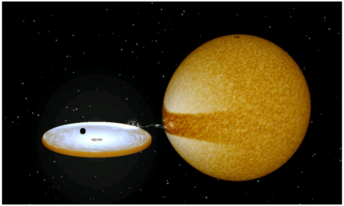
SN2012fr: Observations

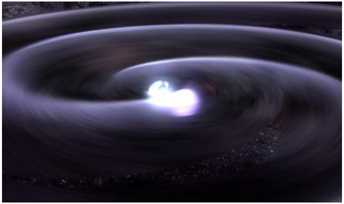
Observations of SN2012fr cover times ranging from -16 days to $+120$ days with respect to maximum light.



Importance of Type Ia Supernovae

- Progenitors are near-Chandrasekhar Mass White Dwarfs.





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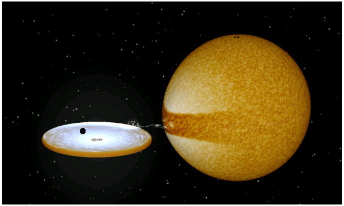

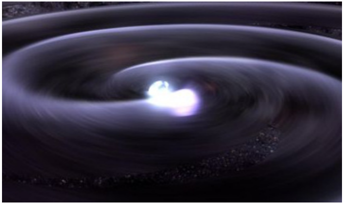

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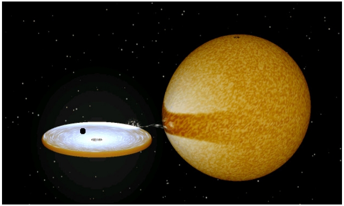
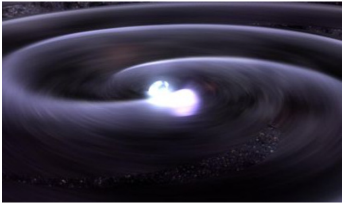
- Spectroscopically homogeneous cosmological reference points ("standard candles").
- Explosion mechanism is not well-understood.





Some Terms

- Homology - In an ideal, spherically symmetric supernova,

$$\text{Ejecta Velocity} \propto \text{Radius}$$

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- Detachment - Separation of some element (e.g. Si II) from the photosphere in velocity space.

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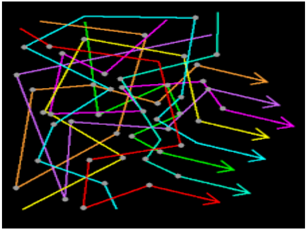

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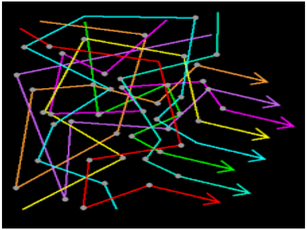
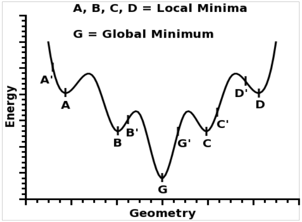
- Large free parameter space.





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SYNOW produces synthetic spectra which can be matched to observed spectra to obtain parameter estimates.

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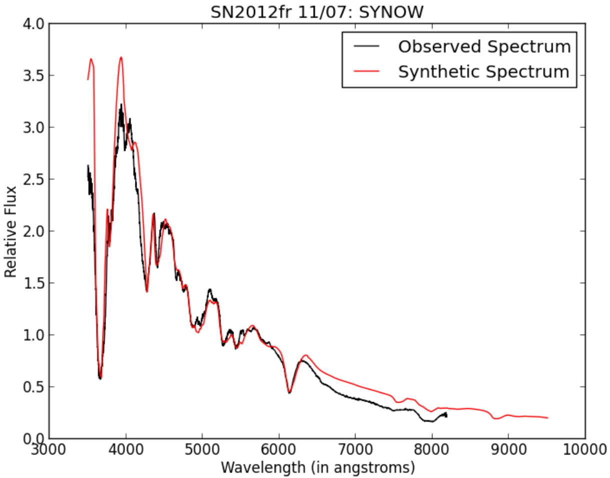

SYNOW Results (cont.)

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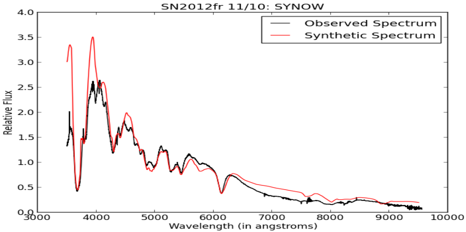

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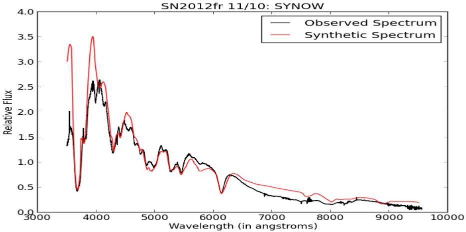

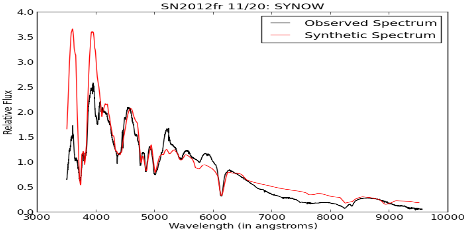

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- Provides information about detailed physical structure, as well as synthetic spectra.

- Much closer to first-principles than SYNOW.

Phoenix: Objectives

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- Use a Type Ia model called W7 to further test these results.
- Modify W7 density and abundance structure to better reflect trends in SYNOW.

Results: Toy Model

Fits were made for at several epochs starting with SYNOW velocities and temperatures.

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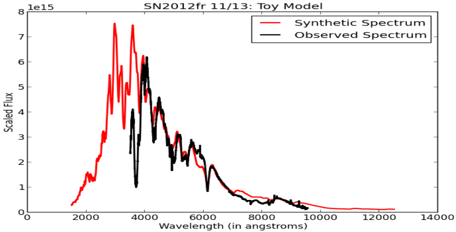

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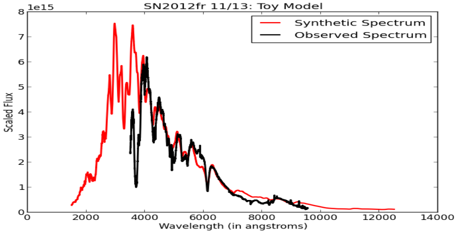

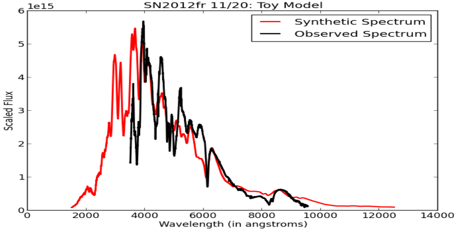

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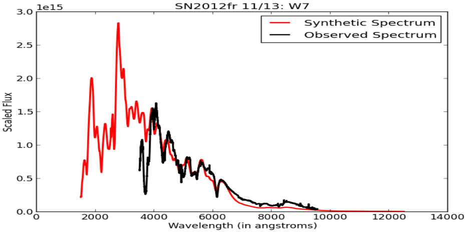

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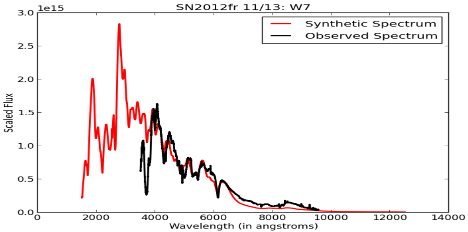

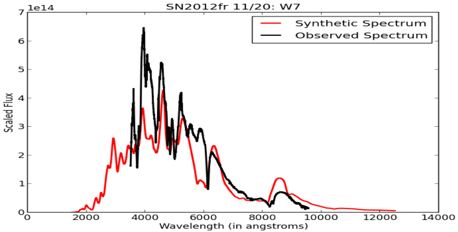

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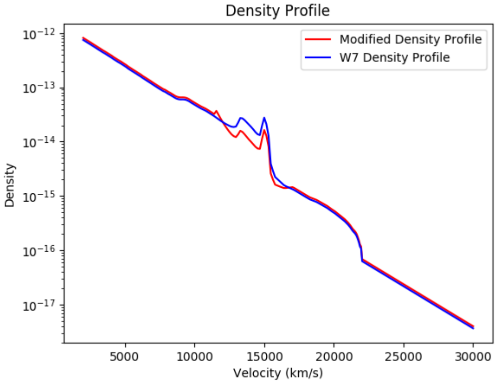
- Adjust W7 density profile to reflect SYNOW in that range.
- Run Phoenix with modified density profile.

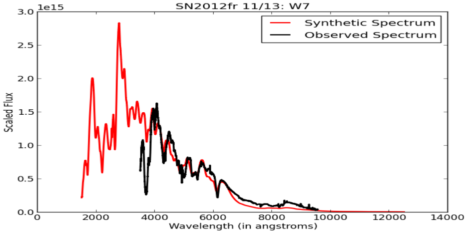
Results: Density Profile

The modified density profile decays at a different rate at SYNOW velocities.



Preliminary Phoenix Results: Modified W7

Maximum light fits without (top) and with (bottom) the modified density profile.



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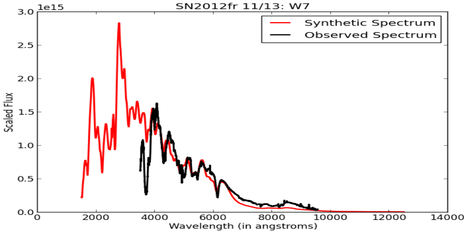

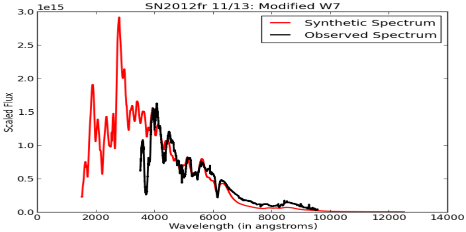

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- Phoenix fits confirmed that Si II density falls off quickly.

- Working hypothesis: SN2012fr contains an optically thick, fast-moving Silicon shell that persists at late times.

Future Research

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- Develop procedure for modifying abundances using SYNOW results.

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- Develop procedure for modifying abundances using SYNOW results.
- Long term: Understand significance of SN2012fr in broader picture of Type Ia supernovae.

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Thank You!