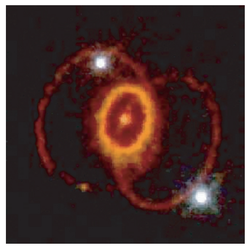
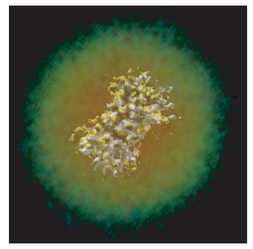


SUPERNOVAE IN 3-D!

Bridging the Gap Between Observations and Theory



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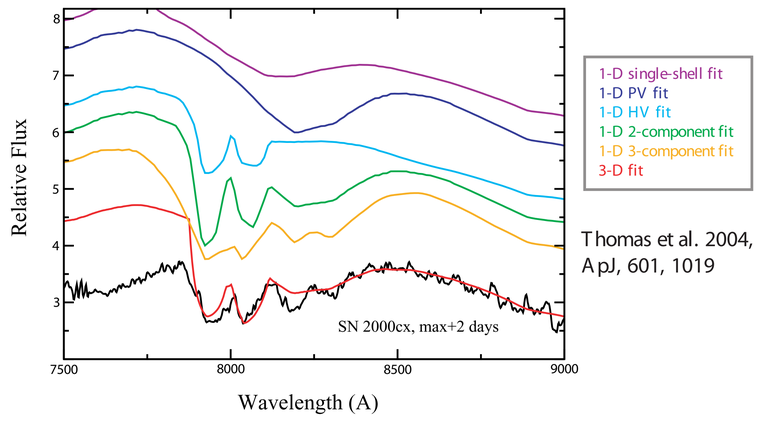
http://qso.lanl.gov/~clf/

The Bottom Line: Using spectrum synthesis and radiative transfer codes, we can learn about the shapes of supernova ejecta by 1) predicting the spectropolarimetric consequences of 3-D hydrodynamical models and 2) interpreting spectropolarimetric observations in light of those models.

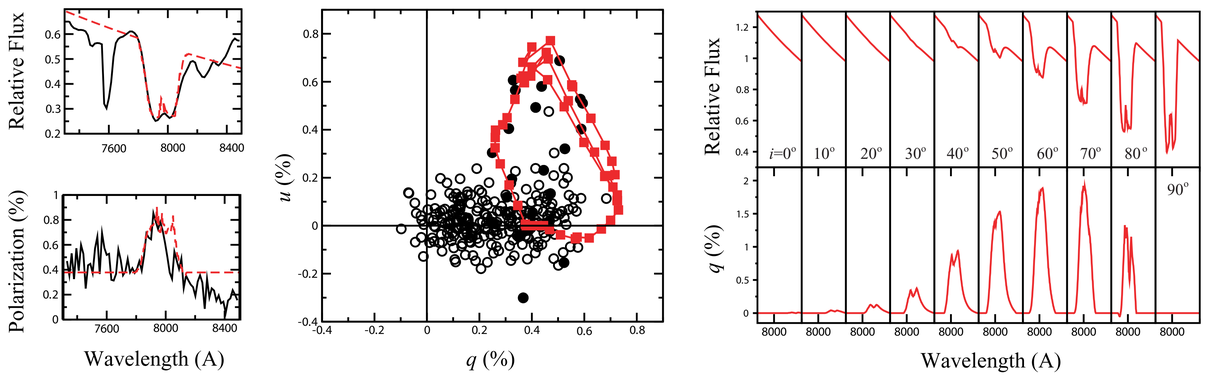
Background and Previous Work

Our group is a new collaboration between groups at UC Berkeley and LBNL that brings together a cutting-edge campaign of spectropolarimetric SN observations and a suite of versatile modeling tools, including spectrum synthesis and Monte Carlo radiative transfer codes. Detailed modeling of both observational data and theoretical explosion scenarios can combine the two lines of inquiry and lead to a new understanding of SN ejecta, including the mechanisms of core collapse, the nature of SN progenitor systems, the characteristics of SN environments, and the extent to which ejecta asphericity may affect the determination of cosmological parameters.

In a recent spectrum synthesis study, Thomas et al. (2004) found that both 1-D models with multiple shells and a 3-D model with a line-of-sight clump could fit the complex high-velocity CaII infrared spectral features of SN 2000cx, an unusual Type Ia SN. Spectropolarimetric data could help distinguish between fits to the flux spectrum.



Thomas et al. 2004, ApJ, 601, 1019



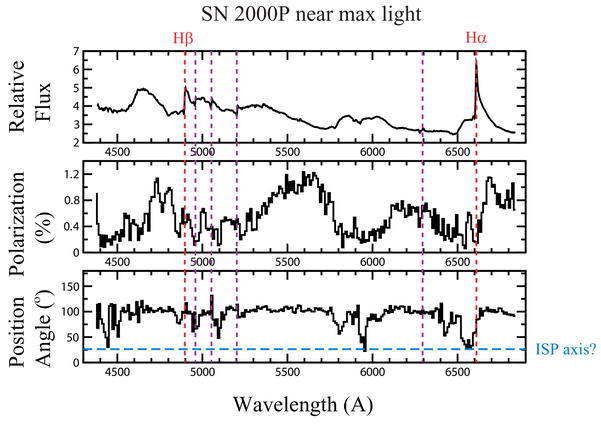
Kasen et al. 2003, ApJ, 593, 788

Kasen et al. (2003) investigated several ejecta models and their ability to fit the flux and polarization profiles of the high-velocity CaII IR triplet in the normal Type Ia SN 2001el. They found a clumped shell model was more effective than either a spherical shell, an ellipsoidal shell, or a toroid in reproducing the line profiles. Predicted spectra from this model, shown at upper right, suggest that large polarization features can exist for certain lines of sight even when the flux spectrum is relatively featureless. These authors have also modeled the flux and polarization predictions of a model in which the presence of a nearby companion star gives rise to a conical hole in the ejecta (astro-ph/0311009). These models can easily be applied to existing SN spectropolarimetry.

Current Projects

Models of SNe Type IIn

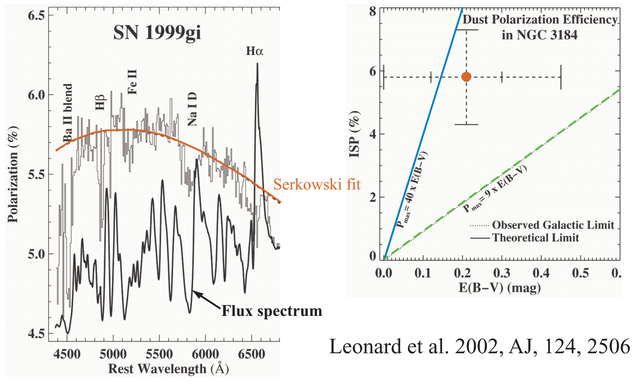
Spectra of Type IIn supernovae indicate intense interaction between the SN ejecta and a dense circumstellar medium. Modeling of this interaction can reveal the characteristics of this CSM and lead to insights into the progenitor's mass-loss history. SN 2000P has many intriguing features, including distinct line polarization effects (often offset from the lines in the flux spectrum), changes in polarization at constant PA, and a potential secondary axis indicated by the similar PA's of several different lines.



SN 1998S, another Type IIn, also shows large line polarization features and a well-defined position angle. A study by Leonard et al. (2000) identified several possible values for the interstellar polarization contribution, based on different assumptions about the intrinsic polarization of the broad lines, narrow lines, and continuum. They preferred choice (a) at right, and suggested the CSM is distributed in a disklike or ringlike geometry around the supernova. Other choices imply different geometrical configurations; polarimetric modeling can help distinguish between the ISP choices.

Properties of the ISM in other galaxies

The Type IIp SN 1999gi showed a large continuum polarization with a Serkowski-law shape, but very little reddening. Observations of ISM probe stars indicate that this polarization arises not in the Milky Way, but in the host galaxy, NGC 3184, which seems to have a very high dust polarization efficiency. Similar analyses and modeling applied to other SNe can probe the ISM in other galaxies.

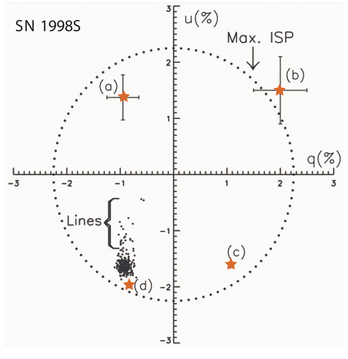


Leonard et al. 2002, AJ, 124, 2506

Polarization classification of SNe

Atlas of polarization features of ejecta models

Leonard et al. 2000, ApJ, 536, 239



Also ask me about...

- structure & spectropolarimetry of β Lyr
- polarization models of binary-disk systems
- polarization variations of HAeBe binaries
- polarization models of η Car
- Lyα illumination of T Tauri disks