Variety of Polarized Line Profiles in Interacting Supernovae

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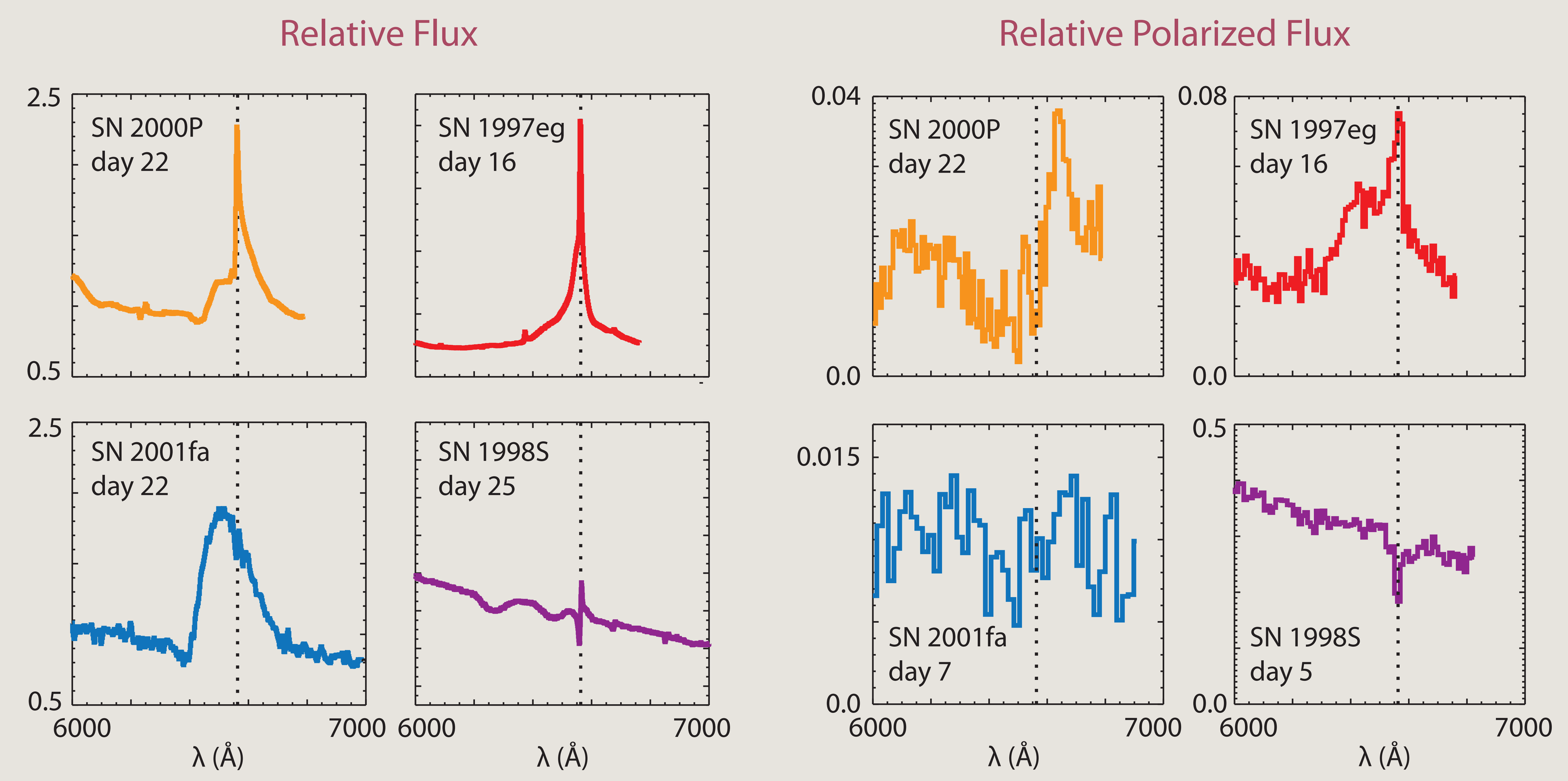
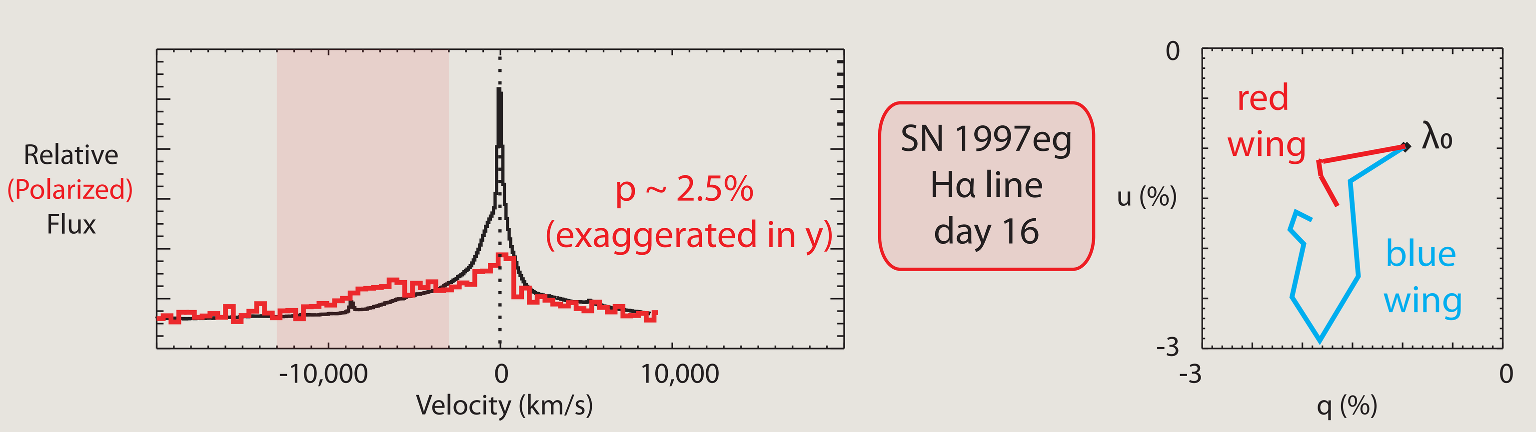
1. Some supernovae show signatures of interaction with dense pre-existing circumstellar material.



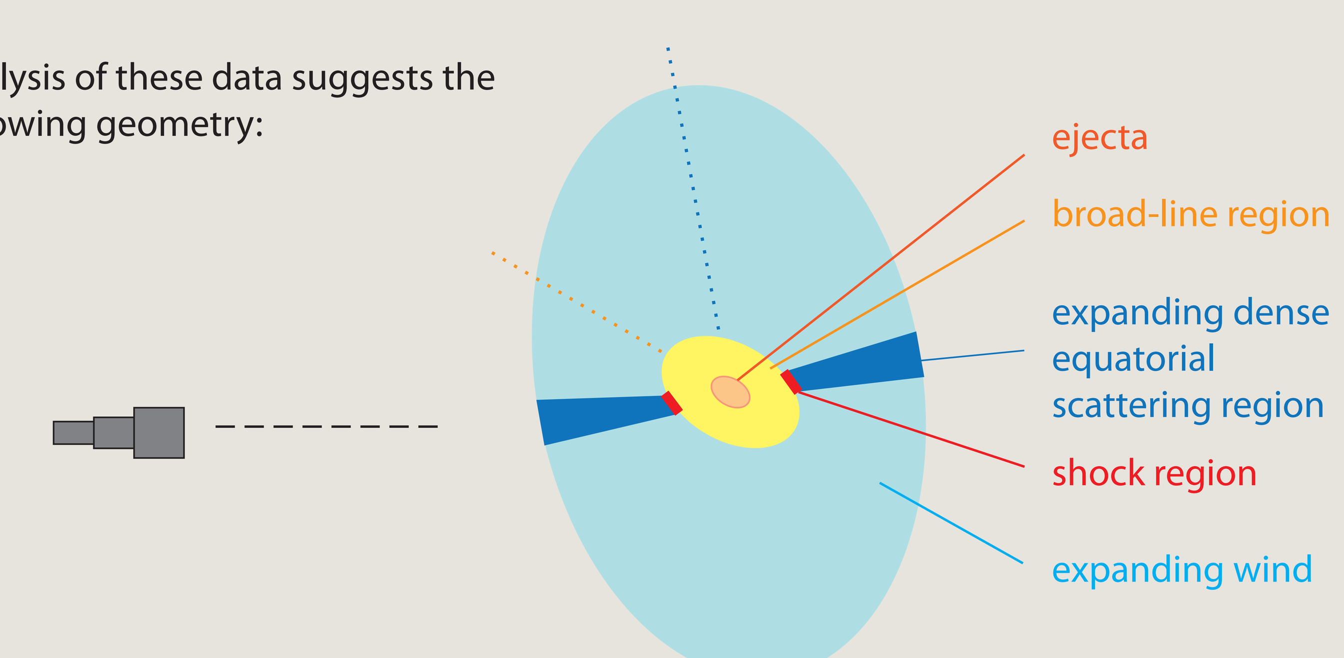
Hα line profiles of several SNe IIn at comparable epochs.
Both the flux and the polarized flux profiles vary widely between objects.

"Interacting supernovae" can be of any supernova subtype, but are most often called SNe IIn. These objects show strong, narrow hydrogen Balmer emission lines in their spectra. However, their behavior is otherwise heterogeneous, with wide variations in flux and polarization spectra, light curves, and radio/X-ray brightness. Such variations may reflect differing characteristics of the circumstellar material that produces the Balmer emission. Because the CSM is formed by pre-supernova stellar winds, analyzing these emission lines can yield details about the mass-loss history of supernova progenitors.

2. Analyzing polarized Hα line profiles gives clues to the circumstellar geometry of these objects.

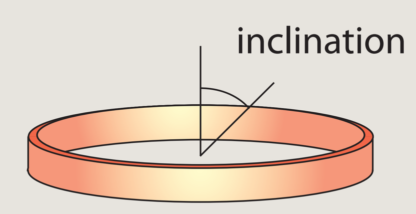


Analysis of these data suggests the following geometry:

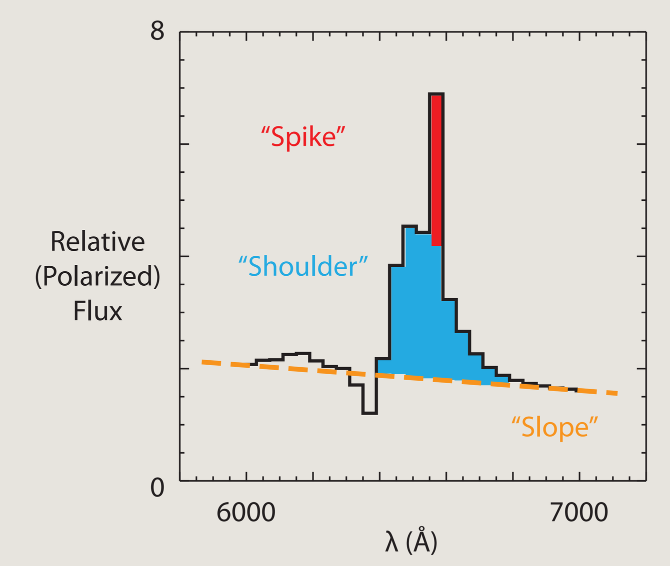


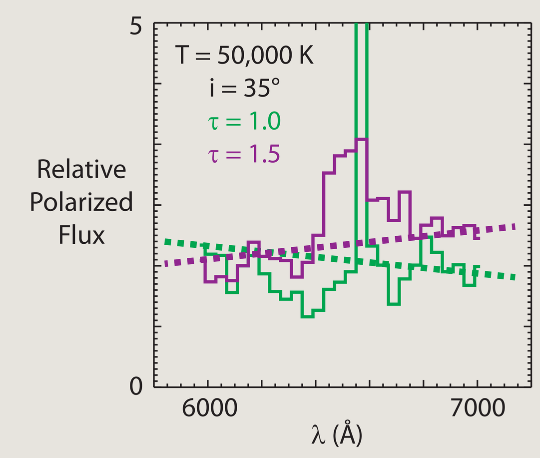
Spectropolarimetry distinguishes direct light from scattered light and constrains the shape and orientation of scattering regions. The example above is for the Type IIn SN 1997eg. Enhanced blue wings in the polarized Balmer lines suggest that the receding side of the expanding disk-like scattering region was obscured. Loop-like shapes in the Stokes *Q-U* plane (instead of straight lines or knots) across emission line profiles imply that the emission and scattering regions were misaligned to one another.

3. Numerical models provide diagnostics connecting line profiles to CSM characteristics.

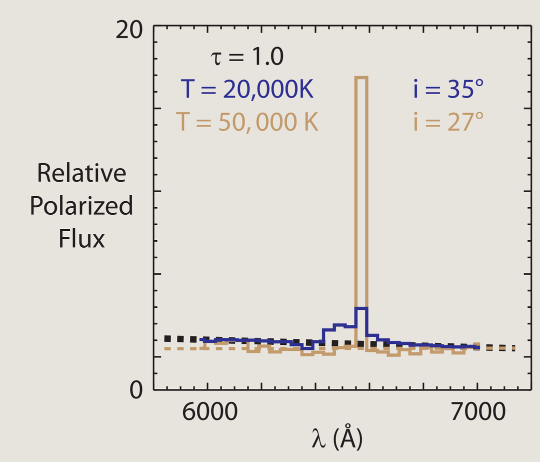


In the models shown here, the CSM is shaped like a toroidal shell with thickness 1/10 its radius. Data are binned to 40 Å. Both flux and polarized flux profiles show a "spike" at the rest wavelength superposed on a broader "shoulder" above the continuum "slope".

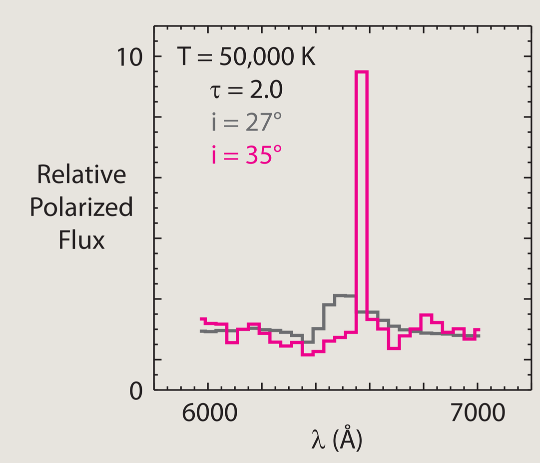




The slope is sensitive to optical depth for some viewing angles. Thus, if the viewing angle of the supernova can be inferred from other spectral information, the continuum slope near Hα could be used as an indicator of the optical depth of the CSM.



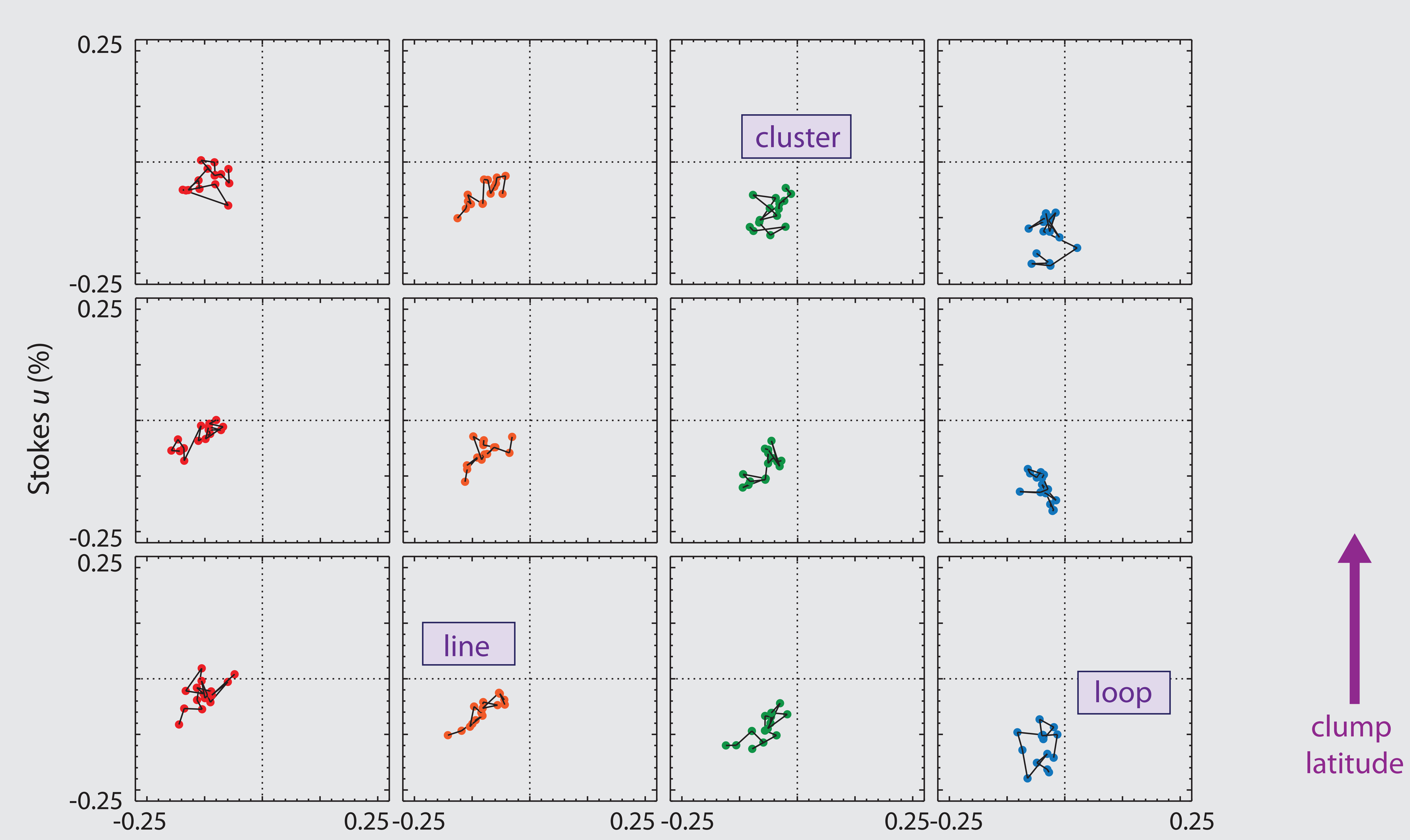
The height of the spike above the polarized continuum varies strongly with temperature for a given optical depth and intermediate viewing angles (i.e., not close to pole-on or edge-on). In these cases, measuring the polarized flux of the spike could provide an independent estimate of the CSM temperature.

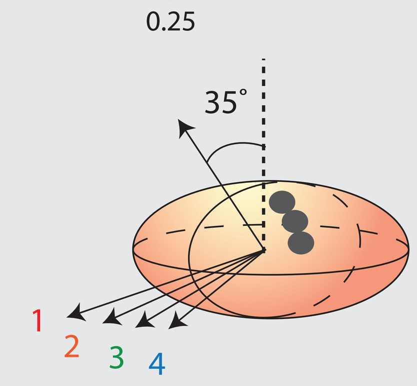


The ratio of the spike to the shoulder is a strong function of viewing angle for all optical depths. This diagnostic could thus be used to probe the orientation of the CSM to our line of sight.

I construct 3-D Monte Carlo radiative transfer models that predict the polarized line profiles arising from various ejecta-CSM scenarios. I then analyze the model profiles to develop diagnostics that will help interpret observational data, independent of interstellar polarization. In the example above, characteristics of the polarized line profile can be correlated with physical properties of the CSM.

4. Q-U traces contain detailed geometrical information about CSM asymmetries.





Sample model investigating *Q-U* traces created by a dense, Hα-absorbing clump above an ellipsoidal scattering region. Wavelength range is the same as in the above simulations; data are binned to 60 Å.

These models can also help explain the *Q-U* loops seen in a wide variety of SNe. *Q-U* loops, thought to arise from clumpy or highly asymmetrical CSM distributions, may contain clues to phenomena such as jets that are important for engine-driven explosions.

THE FINE PRINT:

SNe IIn spectra are from Filippenko, private communication.
SN 1997eg data are from Hoffman et al. 2008, ApJ, 688, 1186.

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