Profile Analysis of Polarized Lines in Interacting Supernovae

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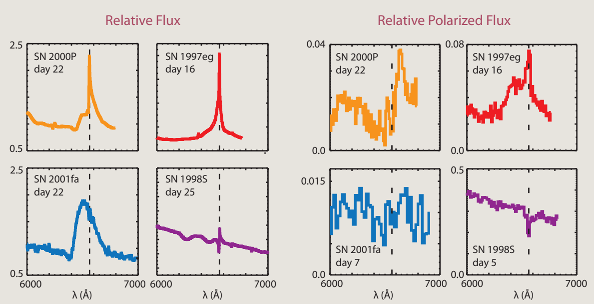
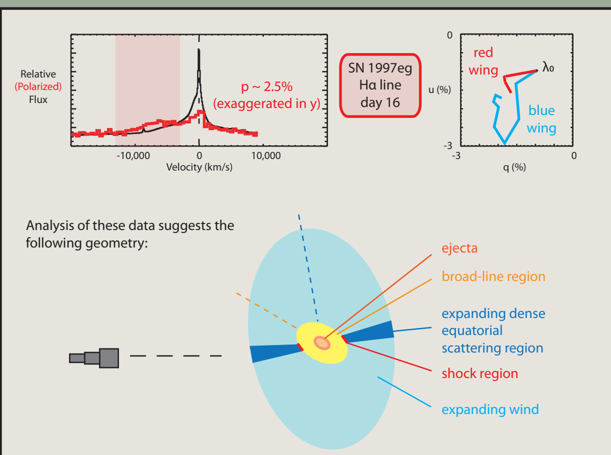
1. Some supernovae show signatures of interaction with dense pre-existing circumstellar material.



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

These "interacting supernovae" are also called Type IIn supernovae. They normally show strong, narrow hydrogen Balmer emission lines in their spectra. However, the category is heterogeneous, with wide variation in flux and polarization spectra, light curves, and radio/X-ray brightness among these objects. Such variations may reflect differing characteristics of their circumstellar material. Because this CSM is formed by pre-supernova stellar winds, studying interacting supernovae can probe the mass-loss history of the most massive stars.

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



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 suggested that the receding side of the expanding disk-like scattering region was obscured. Loop-like shapes (instead of straight lines or knots) across emission line profiles in the Stokes *q-u* plane implied that the emission and scattering regions were misaligned to one another.

THE FINE PRINT:

SNe IIn spectra are from Filippenko, private communication. SN 1997eg data are from Hoffman et al. 2008, ApJ, 688, 1186. HST image credits: (SN 1987A) C. Burrows, ESA/STScI, and NASA; (He2-104) R. Corradi, M. Livio, U. Munari, H. Schwarz, and NASA; (WR 124) Y. Grosdidier, A. Moffat, G. Joncas, A.Acker, and NASA.

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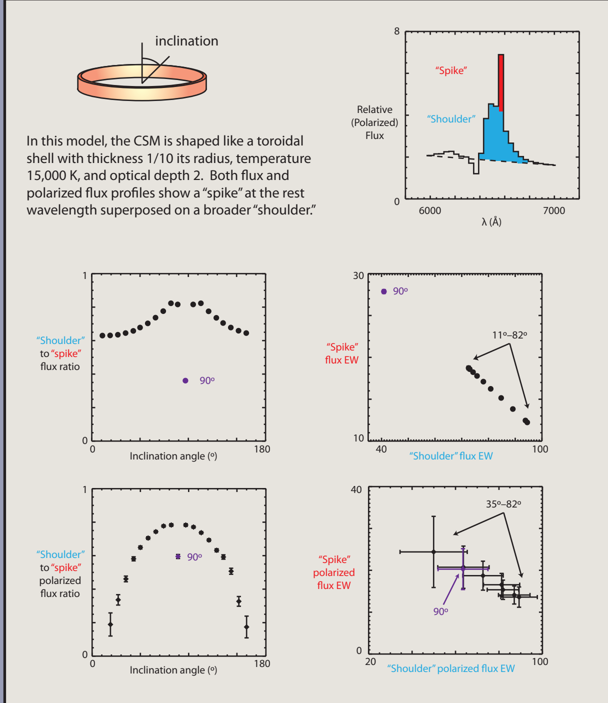
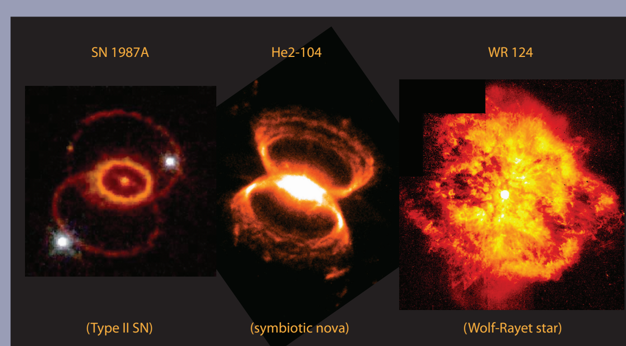
3. Numerical models provide diagnostics connecting line profiles to CSM characteristics.



In this model, the CSM is shaped like a toroidal shell with thickness 1/10 its radius, temperature 15,000 K, and optical depth 2. Both flux and polarized flux profiles show a "spike" at the rest wavelength superposed on a broader "shoulder."

Monte Carlo radiative transfer models predict the total and polarized flux profiles arising from various ejecta-CSM scenarios. Analysis of the model profiles can lead to the discovery of diagnostics that will help interpret observational data. In the example above, different viewing angles give rise to differing ratios and equivalent widths of the "shoulder" and "spike" in both flux and polarized flux. Measuring these quantities in an observed spectrum could thus yield a value for the inclination of the system if the basic CSM geometry were known, as in SN 1997eg.

4. Comparing CSM geometries with those of massive stars can link SNe with progenitors.



A better understanding of the structures surrounding interacting SNe will allow us to draw connections with massive star wind geometries. For example, misaligned components like those in SN 1997eg may imply a progenitor with unstable, convection-driven mass loss. Further studies combining polarimetry with numerical modeling promise to illuminate the nature of stellar mass loss at cosmological distances and in a variety of galactic environments.

For detailed references and acknowledgments, please see other side...

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SN 1997eg

Hoffman, J.L., Leonard, D.C., Chornock, R., Filippenko, A.V., Barth, A.J., & Matheson, T. 2008, "The Dual-Axis Circumstellar Environment of the Type IIn SN 1997eg," ApJ, 688, 1186

Modeling of the circumstellar material around supernovae

Hoffman, J.L. 2007, "Polarized Line Profiles as Diagnostics of Circumstellar Geometry in Type IIn Supernovae," in Revista Mexicana de Astronomía y Astrofísica Conference Series 30 (Circumstellar Media and Late Stages of Massive Stellar Evolution), eds. G. García-Segura & E. Ramirez-Ruiz (Ensenada: UNAM), 57

Acknowledgments

Image credits:

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