Reflections and Fringes:
How Can We Link Polarimetry with Interferometry to Illuminate Circumstellar Material?

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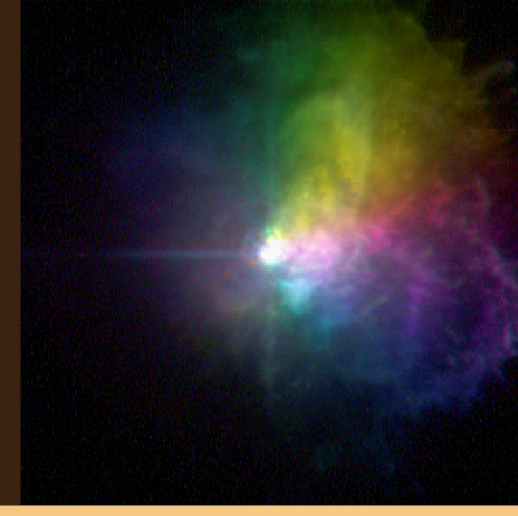
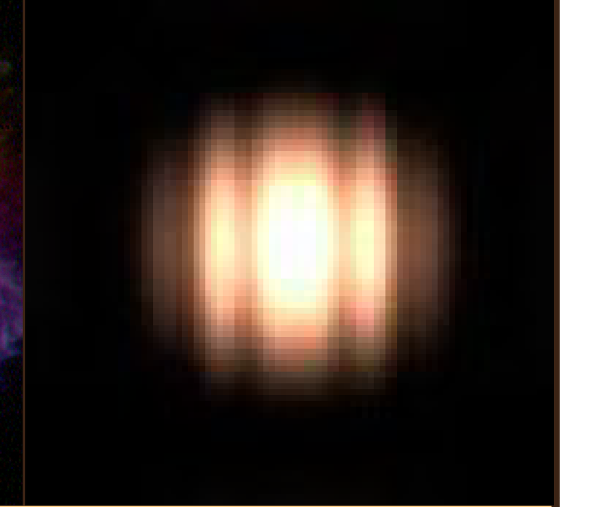
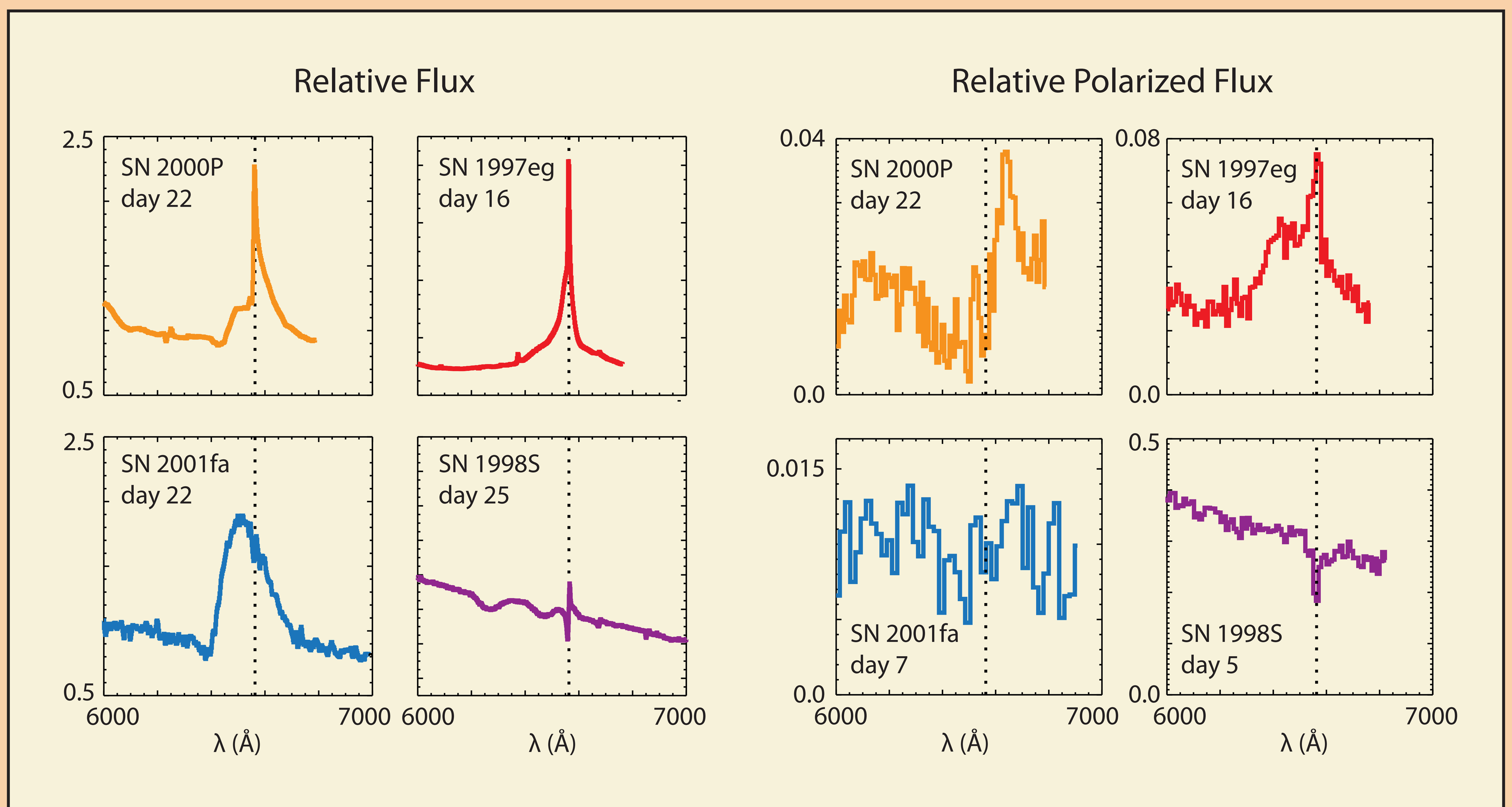




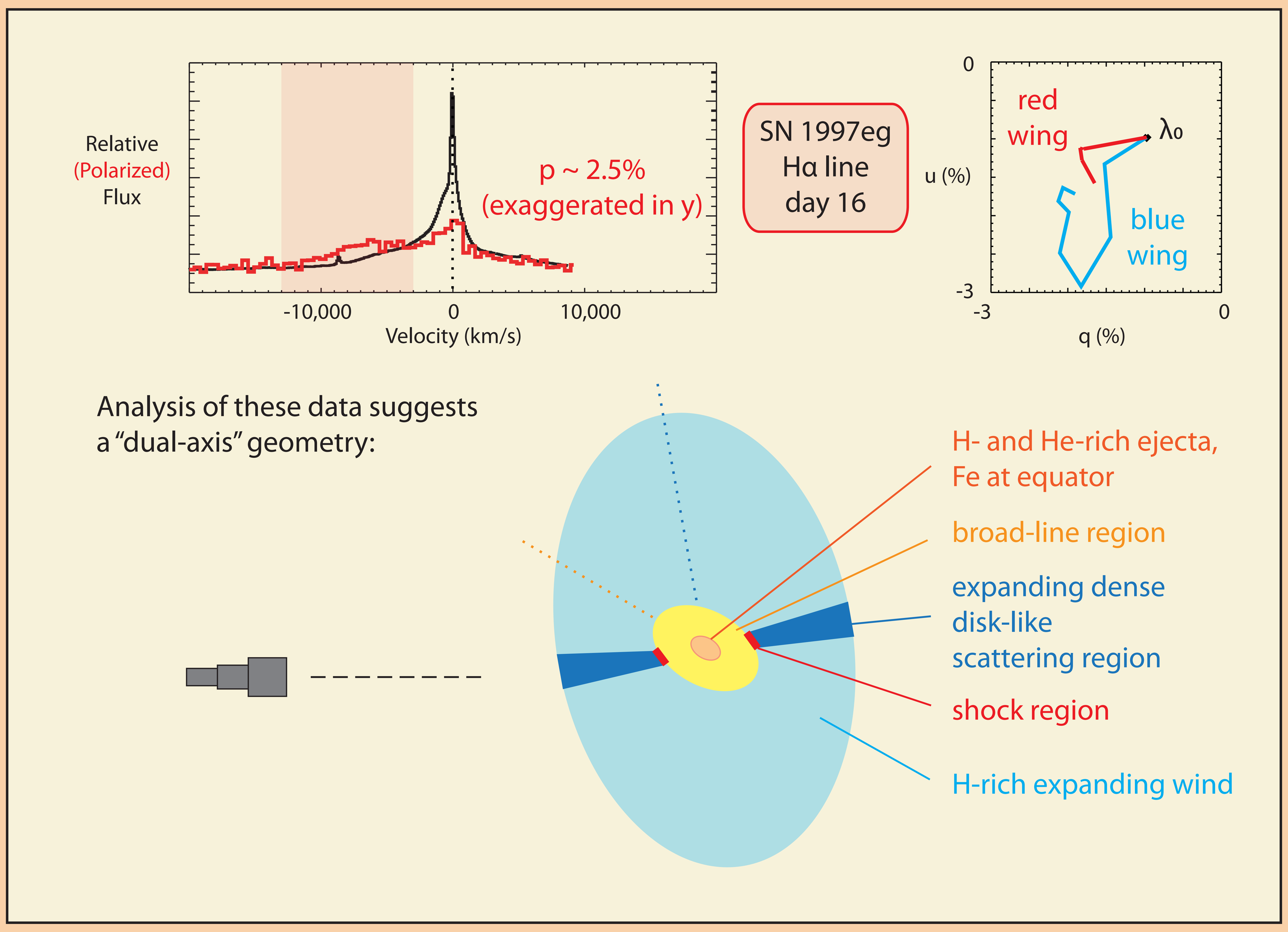
1. Some core-collapse supernovae are surrounded by dense pre-existing circumstellar material.



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

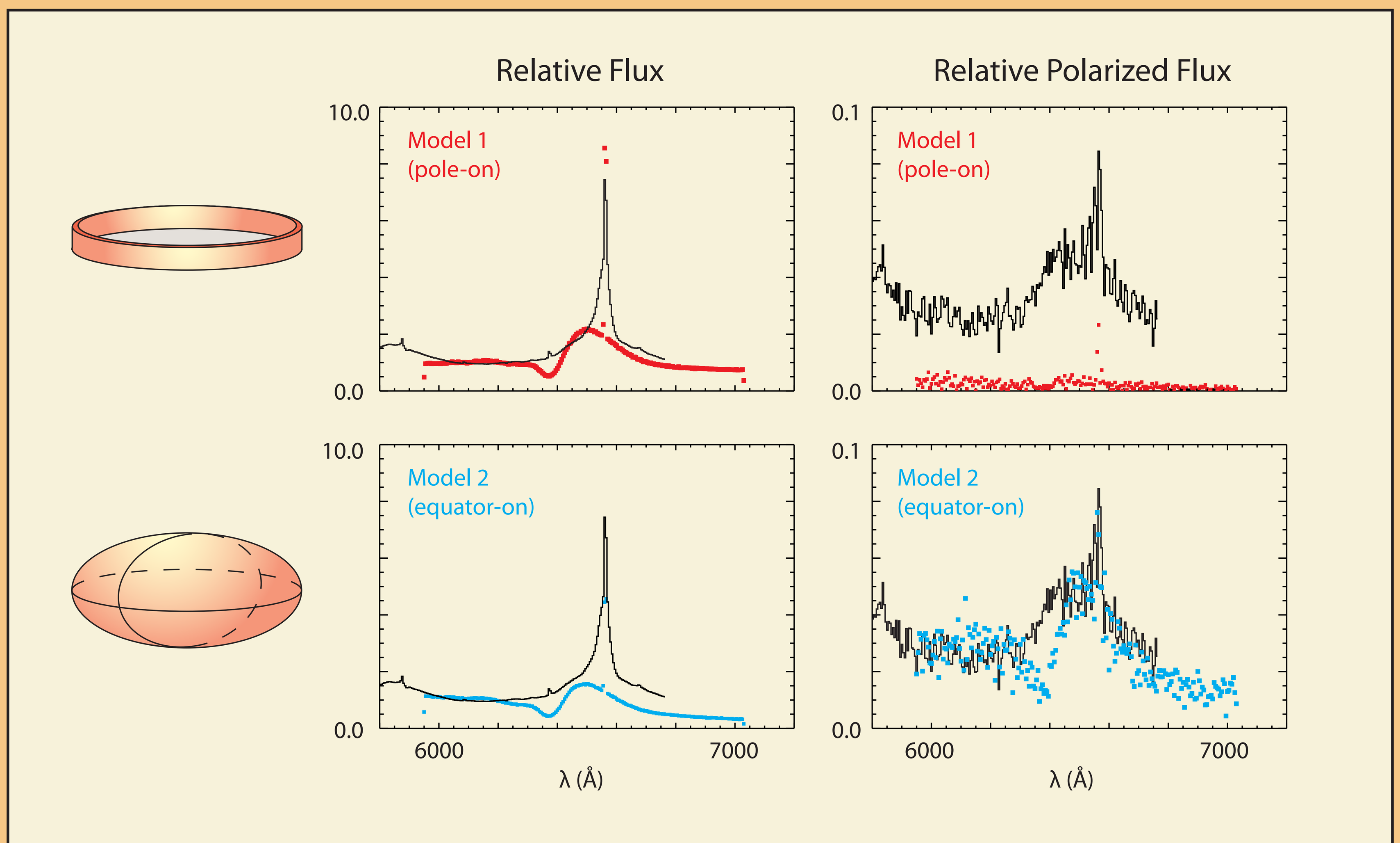
These "interacting supernovae," also called Type IIn supernovae, show strong, narrow hydrogen Balmer emission lines in their spectra. However, the category is heterogeneous, with wide variation in flux and polarization spectra, light curves, and radio/X-ray brightness among these objects. Such variations 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 line profiles gives clues to the circumstellar geometry of these objects.



Spectropolarimetry distinguishes direct light from scattered light and constrains the shape, orientation, and composition of scattering regions. In 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. These spectropolarimetric signals are observable at extragalactic distances. Can we combine them with interferometry to "calibrate" them using similar, resolved CSM structures in Galactic massive stars?

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

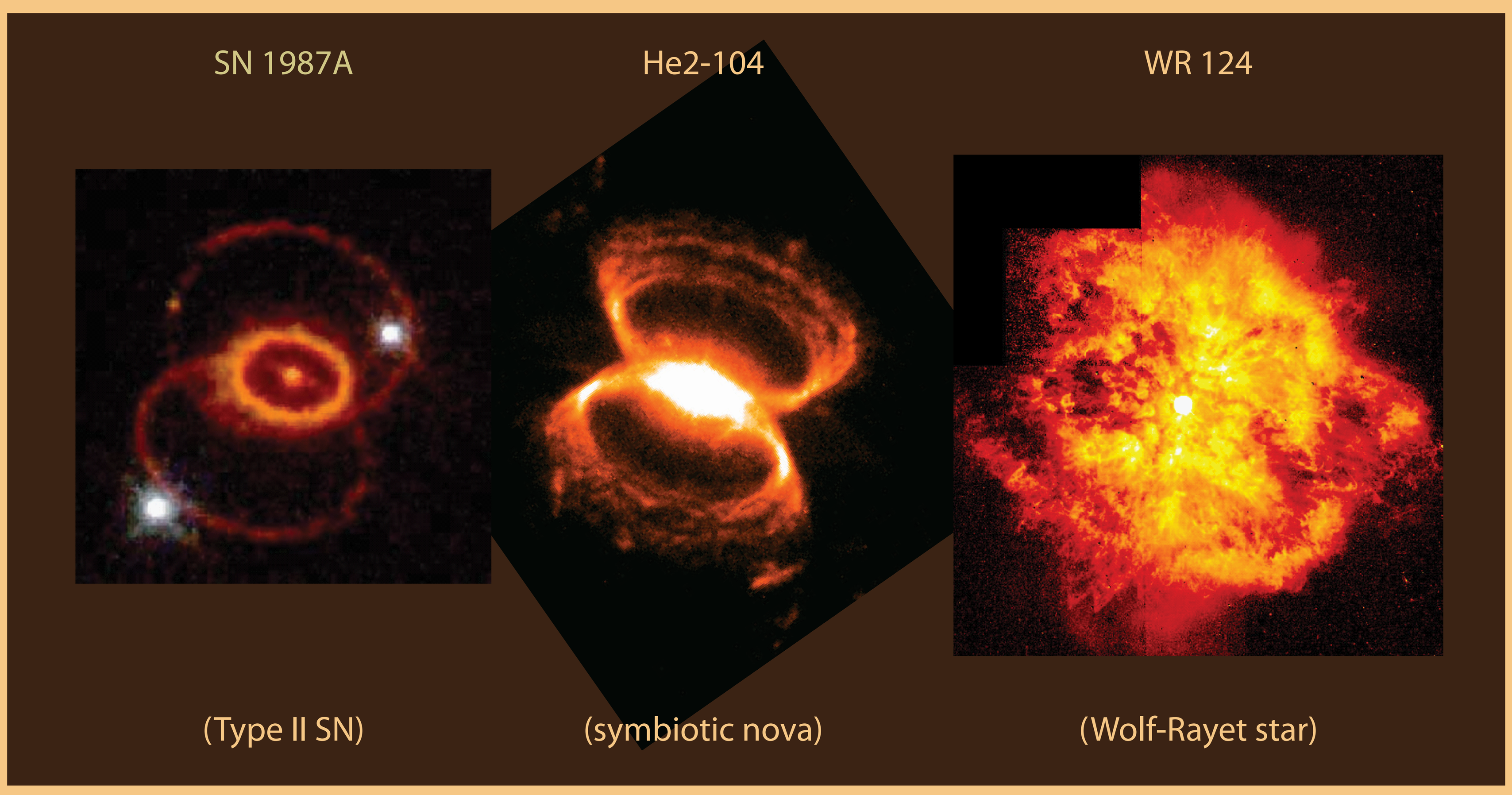


Flux (left) and polarized flux (right) profiles of the Hα line in SN 1997eg at day 16 (black lines) compared with two models created by SLIP (colored points). Model 1 has a toroidal CSM with optical depth of 0.5 and temperature of 10,000 K, seen nearly pole-on. It fits the flux profile well but produces too little polarization. Model 2 has an ellipsoidal CSM with optical depth of 1 and temperature of 20,000 K, seen equator-on. It fits the polarized flux well but does not match the flux "spike".

Monte Carlo radiative transfer models created by my SLIP code predict the total and polarized flux profiles arising from different CSM geometries. In the example above, the Hα line profile of SN 1997eg in total light is well fitted by a model with a circumstellar toroidal shell, but this model does not fit the polarized line profile. Another model with an ellipsoidal CSM fits the polarized line shape but not its profile in total light. The difference in viewing angle between these two "partial best fit" models supports the picture of multiple axes in SN 1997eg.

Construction of these models is simple and requires no symmetry in the input CSM geometry. This numerical tool can link interferometric and spectropolarimetric observations by analyzing the polarimetric signatures of CSM configurations around nearby stars resolved with interferometry. We can then search for these signatures in extragalactic SNe.

4. Interferometric measurements of nearby winds could help us identify the progenitors of these SNe!



A better understanding of the wind structures surrounding potential SN progenitors in our own galaxy, revealed through interferometry, will allow us to draw connections with the CSM geometries inferred at large distances. For example, misaligned components like those in SN 1997eg may imply a progenitor with unstable, convection-driven mass loss. Developing spectropolarimetric diagnostics of interferometrically observed geometries using the SLIP code could create a CSM "distance ladder" with the potential to illuminate the nature of stellar mass loss at cosmological distances and in a variety of galactic environments.

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THE FINE PRINT:

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