

Type Ia Supernovae Strongly Interacting with Their Circumstellar Medium

Jeffrey M. Silverman¹, Peter Nugent², Avishay Gal-Yam³,
 D. A. Howell⁴, Mark Sullivan⁵ and Alex Filippenko⁶

¹Astronomy, University of Texas at Austin, Austin, TX, United States
 email: jsilverman@astro.as.utexas.edu

²Lawrence Berkeley National Lab, Berkeley, CA, United States

³Weizmann Institute of Science, Rehovot, Israel

⁴Las Cumbres Observatory Global Telescope Network, Goleta, CA, United States

⁵University of Southampton, Southampton, United Kingdom

⁶University of California - Berkeley, Berkeley, CA, United States

Abstract. A rare subclass of Type Ia supernovae (SNe Ia) shows evidence of strong interaction with a hydrogen-rich circumstellar medium (CSM); these objects are referred to as SNe Ia-CSM. PTF11kx began life as a SN Ia, but after a month it began to show indications of significant interaction with its CSM. This well-studied object solidified the connection between SNe Ia-CSM and more typical SNe Ia, despite their spectral similarity to Type II_n SNe (which likely come from massive star progenitors, as opposed to the white dwarf progenitors for the SNe Ia-CSM). The spectra of all ~ 20 known SNe Ia-CSM are dominated by H α emission (with widths of ~ 2000 km s⁻¹) and exhibit large H α /H β intensity ratios; moreover, they have an almost complete lack of He I emission (see left panel of Figure 1). They also show possible evidence of dust formation through a decrease in the red wing of H α 75–100 days past maximum brightness. The absolute magnitudes of SNe Ia-CSM are found to be -21.3 mag $\leq M_R \leq -19$ mag (see right panel of Figure 1), and they also show ultraviolet emission at early times and strong infrared emission at late times (but no detected radio or X-ray emission). Finally, the host galaxies of SNe Ia-CSM imply that these objects come from a relatively young stellar population.

Keywords. supernovae: general, stars: circumstellar matter

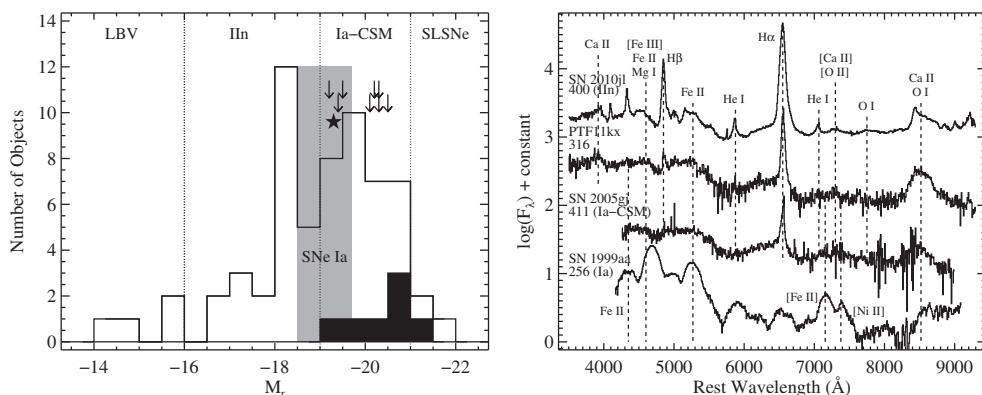


Figure 1. (left panel) Histogram of peak absolute r -band magnitude of 63 SNe II_n. The gray shaded region is the range of “typical” SNe Ia; the black, filled histogram shows seven recently discovered SNe Ia-CSM, the downward-pointing arrows are eight older SNe Ia-CSM, and the star is PTF11kx. (right panel) Spectra of PTF11kx and SN 2005gj (SNe Ia-CSM), SN 2010jl (SN II_n), and SN 1999aa (SN Ia). Spectra are labeled with rest-frame age relative to maximum brightness; major spectral features are also labeled.