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Type Ia Supernovae Strongly Interacting with Their Circumstellar Medium

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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 IIn 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 Hα emission (with widths of ∼2000 km s^{-1}) and exhibit large Hα/Hβ 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 Hα 75–100 days past maximum brightness. The absolute magnitudes of SNe Ia-CSM are found to be -21.3 mag $\leqslant M_R \leqslant -19$ 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

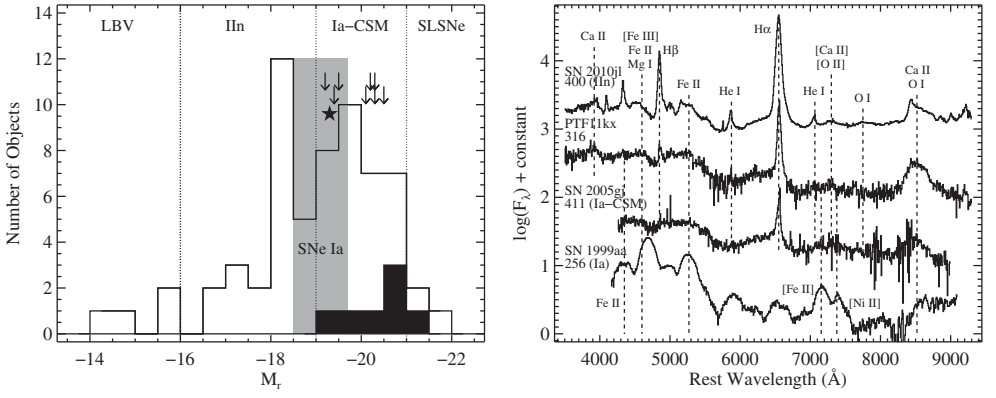

Figure 1. (left panel) Histogram of peak absolute r-band magnitude of 63 SNe IIn. The gray shaded region is the range of "typical" SNe Ia; the black, filled histogram shows seven recently discovered SNe Ia-CSM, the downward-pointing arrows are eight older SNe Ia-CSM, and the star is PTF11kx. (right panel)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