



# Pan-STARRS1 Discovery of Two Ultra-Luminous Supernovae at $z \sim 0.9$

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We present the discovery of two ultra-luminous supernovae (SNe) at  $z \sim 0.9$  with the Pan-STARRS1 Medium-Deep Survey. These SNe, PS1-10ky and PS1-10awh, are amongst the most luminous SNe ever discovered, comparable to the unusual transients SN 2005ap and SCP 06F6. Like SN 2005ap and SCP 06F6, they show characteristic high luminosities ( $M_{\text{bol}} \sim -22.5$  mag), blue spectra with a few broad absorption lines, and no evidence for H or He. We have constructed a full multi-color light curve sensitive to the peak of the spectral energy distribution in the rest-frame ultraviolet, and we have obtained time-series spectroscopy for these SNe. Given the similarities between the SNe, we combine their light curves to estimate a total radiated energy over the course of explosion of  $(0.9-1.4) \times 10^{51}$  erg. We find photospheric velocities of 12,000-19,000 km/s with no evidence for deceleration measured across  $\sim 3$  rest-frame weeks around light-curve peak, consistent with the expansion of an optically-thick massive shell of material. We show that, consistent with findings for other ultra-luminous SNe in this class, radioactive decay is not sufficient to power PS1-10ky, and we discuss two plausible origins for these events: the initial spin-down of a newborn magnetar in a core-collapse SN, or SN shock breakout from the dense circumstellar wind surrounding a Wolf-Rayet star.

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