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# Using the X-ray Lightcurves of Young Supernovae to Probe the Stellar Environment and Supernova Progenitors

**Vikram V. Dwarkadas**

Dept of Astronomy and Astrophysics, U Chicago, 5640 S Ellis Ave
email: vikram@oddjob.uchicago.edu

**Abstract.** We have aggregated together data available in the literature, or analysed by us, to compute the lightcurves of most young supernovae (SNe) that have been detected in X-rays. Currently the database contains about 60 SNe spanning all the various types, but it is expanding rapidly. We use this library of lightcurves and spectra to explore the diversity of SNe, the characteristics of the environment into which they are expanding, and the implications for their progenitors. X-ray spectra can provide insight into the density structure, composition and metallicity of the surrounding medium, and the ionization level, through the spectra themselves as well as the X-ray absorption. Since core-collapse SNe expand mainly in environments created by the progenitor star mass-loss, this can provide crucial information about the nature of the progenitor star, and its mass-loss parameters in the decades or centuries before its death. In a few cases, via detailed modelling, we can distinguish the composition of the SN ejecta from that of the environment. X-ray observations therefore provide an invaluable probe into the stellar environments of core-collapse SNe, complementing data available at other wavelengths. We provide an overview of the X-ray lightcurves of various SN types, the implications for their environment, and clues to their progenitor stars.

**Keywords.** shock waves, stars: mass loss, supernovae: general, stars: winds, outflows, X-rays: general, X-rays: ISM

## 1. Introduction

Core-collapse SNe arise from massive stars, which lose a considerable amount of mass before they explode. This material accumulates in the surrounding medium, whose density is directly proportional to the mass-loss rate $\dot{M}$ and inversely to the wind velocity $v_w$. Thermal (bremsstrahlung) X-ray emission is proportional to the square of the density. Thus the X-ray lightcurve, if due to thermal emission, should reflect the radial structure of the ambient density profile, and correspondingly the mass-loss parameters of the progenitor star. Figure 1 shows the observed X-ray lightcurves of several SNe. Type IIP SNe are found to have the lowest X-ray luminosities of all types, and Type IIn SNe the highest, with other types lying somewhere in between. The low luminosity of IIPs suggests a maximum mass for the progenitor red supergiant (RSG) star of $\approx 19 M_{\odot}$ (Dwarkadas (2014)). If the emission from IIns is thermal, then this implies that many arise from stars with mass-loss rates $> 10^{-4}\, v_{w10}$ $\mathrm{M_{\odot}\ yr^{-1}}$, where $v_{w10}$ is scaled to 10 km s$^{-1}$. However, their lightcurves, and progenitor mass-loss rates, exhibit considerable diversity. One Type IIn has been suggested to have a Wolf-Rayet (W-R) star progenitor (Dwarkadas *et al.* (2010)). Type IIL's and IIbs exhibit wind mass-loss rates somewhat higher than those of IIP progenitors, suggesting that they arise from higher initial-mass RSGs, or have a binary companion that enhances the mass-loss rate. Ib/c SNe, if their emission was thermal, would require higher mass-loss rates than the IIns, given the high

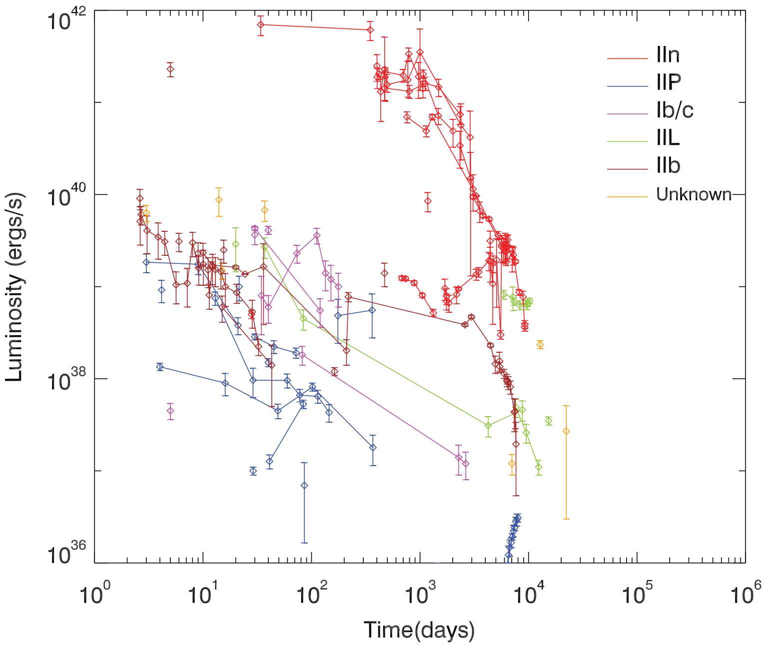


**Figure 1.** X-ray lightcurves of most observed SNe, grouped by type. Adapted from Dwarkadas & Gruszko (2012), with more SNe and additional datapoints.

wind velocities ($> 1000$ km s$^{-1}$) of their suggested W-R star progenitors. The likely alternative is a non-thermal origin to their emission, as has been previously proposed.

## References


Dwarkadas, V. V. 2014, *MNRAS*, 440, 1917
Dwarkadas, V. V. & Gruszko, J. 2012, *MNRAS*, 419, 1515
Dwarkadas, V. V., Dewey, D., & Bauer, F 2010, *MNRAS*, 407, 812


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