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The Properties of Hypernovae SNe 1997ef and 1998bw

Paolo A. Mazzali^{1,2}, Koichi Iwamoto³, Takayoshi Nakamura¹, Ken'ichi Nomoto¹ (¹Dept. of Astronomy and Research Centre for the Early Universe, University of Tokyo, ²Osservatorio Astronomico, Trieste, Italy, ³Dept. of Physics, Nihon University)

We discuss the properties of the very energetic Type Ic Supernovae 1997ef and 1998bw. SN 1998bw was discovered as the optical counterpart of GRB 980425, raising interest in a possible SN/GRB connection. Both SNe 1997ef and 1998bw are characterised by their large luminosity and the very broad spectral features.

We modelled simultaneously the light curve and the spectral evolution of these SNe. Their observed properties can be explained if they are very energetic SN explosions, originating probably from the core collapse of the bare CO cores of massive stars. We find for SN 1998bw a kinetic energy $E_k = 6 \times 10^{52}$ erg and an ejecta mass $M_{ej} = 11M_{\odot}$, and for SN 1997ef $E_k = 8 \times 10^{51}$ erg and $M_{ej} = 8M_{\odot}$. Also, these SNe produced large masses of ^{56}Ni , which powers their light output: $0.8M_{\odot}$ for SN 1998bw and $0.15M_{\odot}$ for SN 1997ef. These values are much larger than in normal SNe Ic: an object like SN 1994I had $E_k = 10^{51}$ erg, $M_{ej} = 2.5M_{\odot}$ and produced $0.07M_{\odot}$ of ^{56}Ni , like most core-collapse SNe. Because of their large explosion energies, we call objects like SNe 1997ef and 1998bw 'hypernovae'. The progenitor masses may have been $\sim 40M_{\odot}$ for SN 1998bw and $\sim 30M_{\odot}$ for SN 1997ef, compared to $\sim 15M_{\odot}$ for SN 1994I.

At late times, both the light curve and the spectra suggest that the explosion may have been asymmetric. This would reduce the estimate of E_k somewhat, and may help us understand the claimed connection with GRB's. At least one other object like SN 1997ef has also been observed, SN 1998ey.