Massive Star Outcomes: Core Collapse Events and Progenitors

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Extragalactic Transients Nov 20, 2007

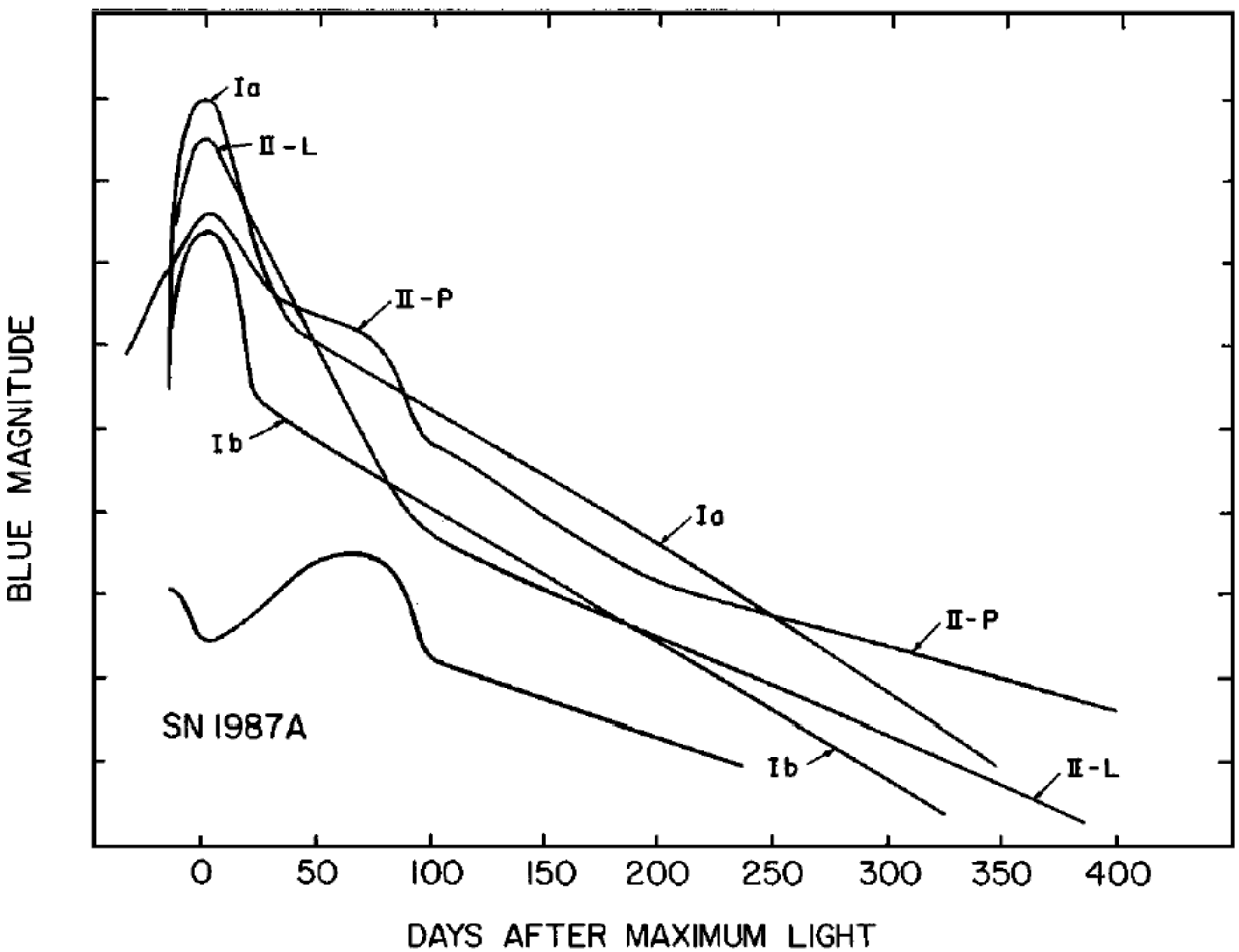

Figure 3 Schematic light curves for SNe of Types Ia, Ib, II-L, II-P, and SN 1987A. The curve for SNe Ib includes SNe Ic as well, and represents an average. For SNe II-L, SNe 1979C and 1980K are used, but these might be unusually luminous. From Wheeler 1990; reproduced with permission.

Dominant Case: Type IIP

Most likely the dominant outcome from the 10-25 M_sun stars, a few pieces of which we can understand analytically.. (Arnett 1980, Popov 1993, Nadyozhin 2003)

Smartt et al 2003

Detection of a Red Supergiant Progenitor Star of a Type II–Plateau Supernova

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We present the discovery of a red supergiant star that exploded as supernova 2003gd in the nearby spiral galaxy M74. The Hubble Space Telescope (HST) and the Gemini Telescope imaged this galaxy 6 to 9 months before the supernova explosion, and subsequent HST images confirm the positional coincidence of the supernova with a single resolved star that is a red supergiant of 8^{+4}_{-2} solar masses. This confirms both stellar evolution models and supernova theories predicting that cool red supergiants are the immediate progenitor stars of type II–plateau supernovae.

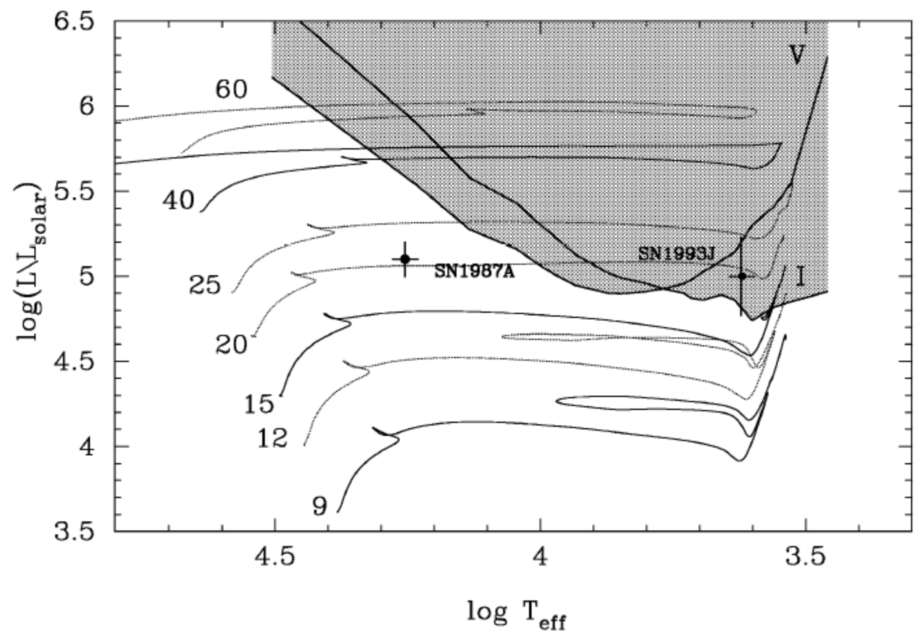


Figure 5. SN 2001du: Luminosity limits from pre-explosion images in *V* and *I* are plotted as thick solid lines. The shaded region is where a progenitor would have been detected in at least one filter. Overlaid are the evolutionary tracks as described in Section 3 for stars with main-sequence masses 9–60 $M_\odot$, for solar metallicity. The locations of the progenitors of SN 1987A and SN 1993J are also shown.

Li et al 2007 , ApJ, 661, 1013

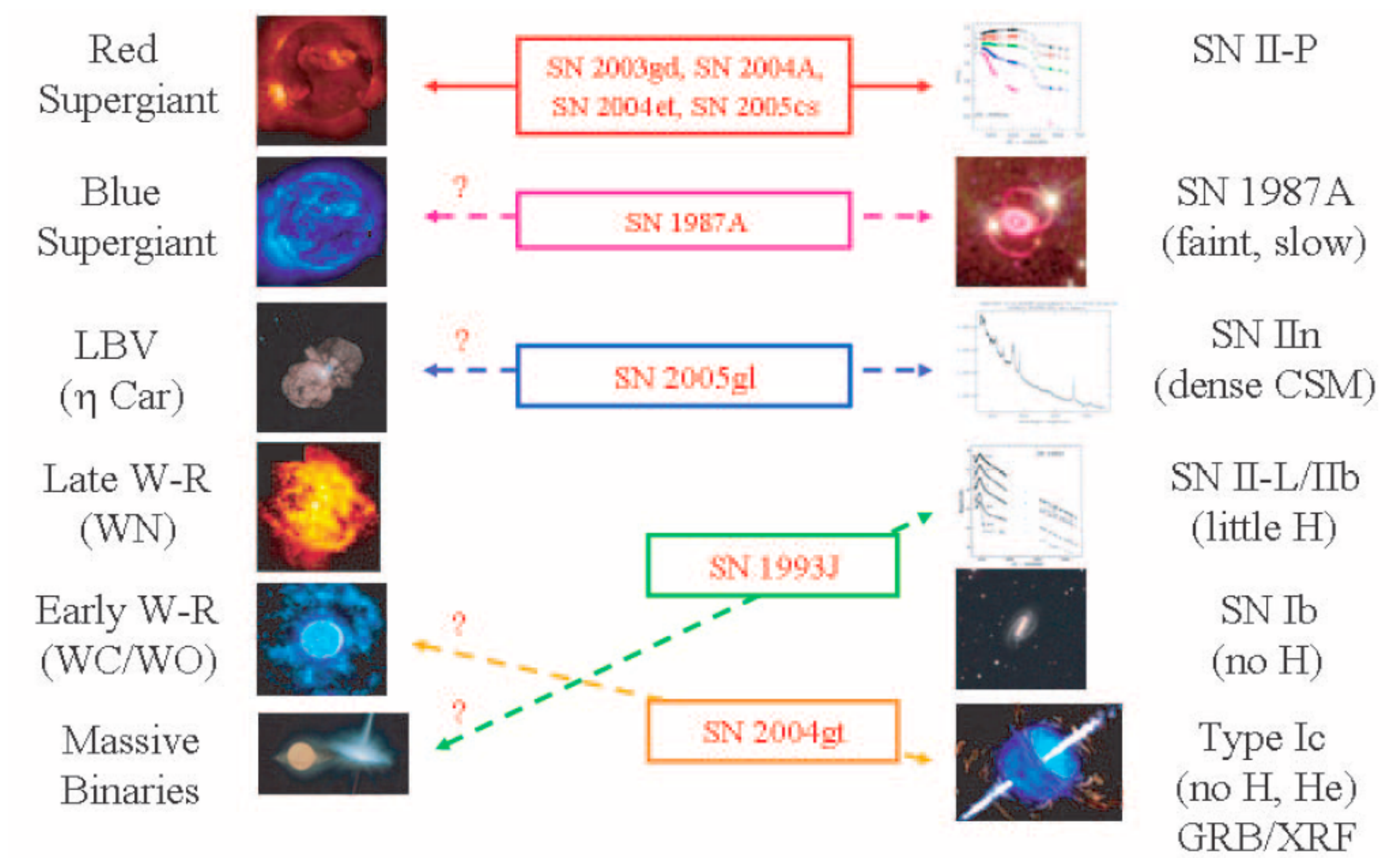
TABLE 7

Masses and Mass Limits for the Progenitors of Core-Collapse SNe

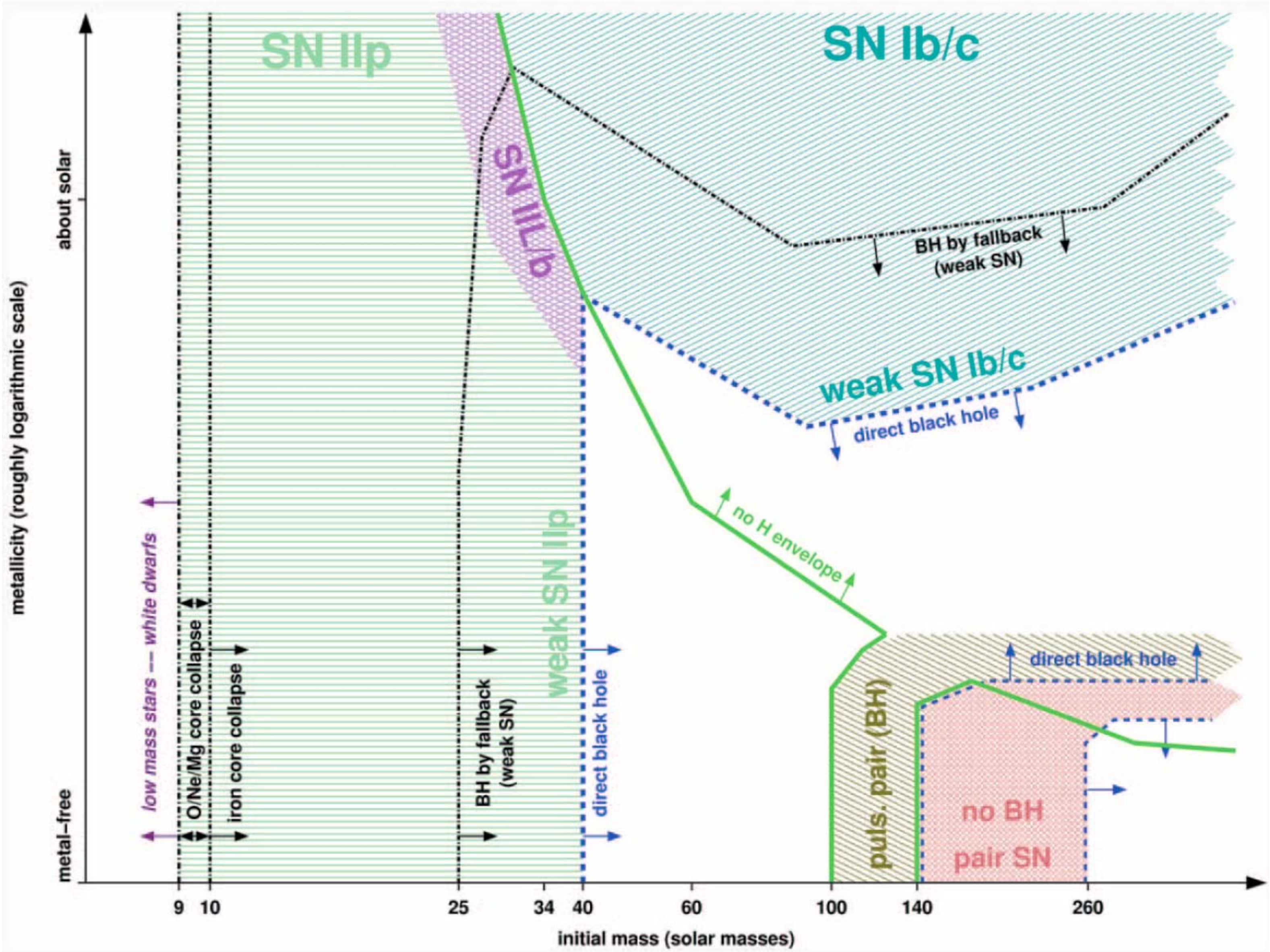
SN	SN type	Progenitor mass ($M_\odot$)	Progenitor Mass Limit	References
1987A	II-peculiar	~20		1, 2
1993J	IIb	~17		3, 4
1999ev	II-P	15–18		5
2003gd	II-P	6–12		6, 7
2004A	II-P	7–12		8
2004et	II-P	13–20		9
2005cs	II-P	7–13		10, 11
2006my	II-P	7–15		This paper
2006ov	II-P	12–20		This paper
2005gl	IIn? II-L?		40–80 $M_\odot$ LBV? CSC?	12
2004dj	II-P		~12–15 $M_\odot$? >20 $M_\odot$? (in CSC)	13, 14, 15
1999em	II-P		$\lesssim$15 $M_\odot$	16
1999gi	II-P		$\lesssim$12–20 $M_\odot$	17
2001du	II-P		$\lesssim$9–21 $M_\odot$	16, 18
1999an	II-P		$\lesssim$20 $M_\odot$	5
1999br	II-P		$\lesssim$12 $M_\odot$	5
2000ds	Ib/c		$\lesssim$7 $M_\odot$ RSG? WR?	5
2000ew	Ib/c		Low-mass RSG; WR?	5
2001B	Ib/c		$\lesssim$25 $M_\odot$ RSG? WR?	5
2004gt	Ib/c		~20–40 $M_\odot$? WR?	19, 20

References.—(1) Gilmozzi et al. 1987; (2) Sonneborn et al. 1987; (3) Aldering et al. 1994; (4) Van Dyk et al. 2002; (5) Maund & Smartt 2005; (6) Van Dyk et al. 2003c; (7) Smartt et al. 2004; (8) Hendry et al. 2006; (9) Li et al. 2005b; (10) Li et al. 2006; (11) Maund et al. 2005a; (12) Gal-Yam et al. 2007; (13) Wang et al. 2005; (14) Maíz-Apellániz et al. 2004; (15) Vinkó et al. 2006; (16) Smartt et al. 2003; (17) Leonard et al. 2002a; (18) Van Dyk et al. 2003b; (19) Gal-Yam et al. 2005; (20) Maund et al. 2005b.

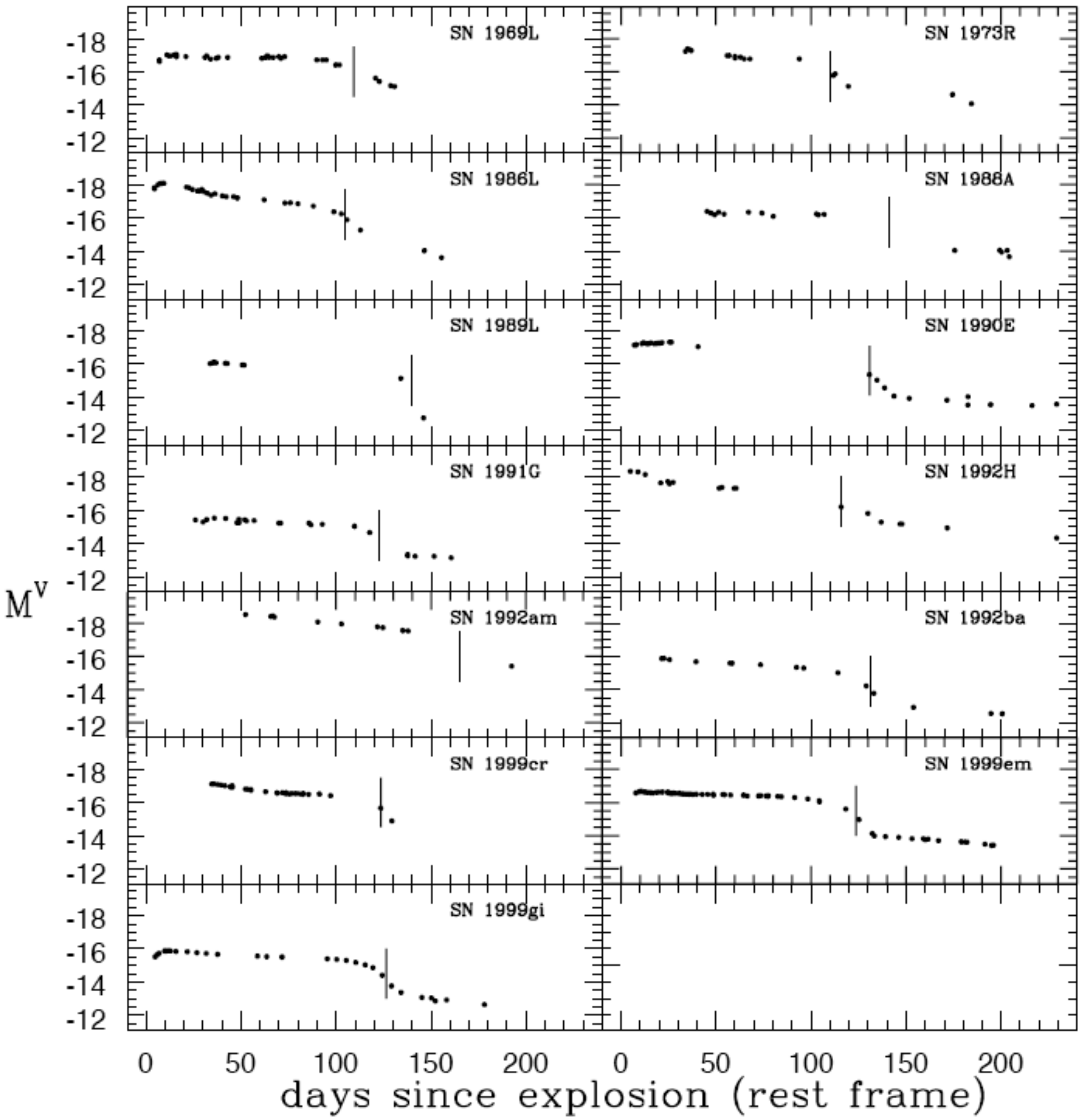
Gal-Yam et al


Red Supergiant
Blue Supergiant
LBV (η Car)
Late W-R (WN)
Early W-R (WC/WO)
Massive Binaries
SN 2003gd, SN 2004A, SN 2004et, SN 2005cs
?
SN 1987A
?
SN 2005gl
SN 1993J
?
?
SN 2004gt
SN II-P
SN 1987A (faint, slow)
SN IIn (dense CSM)
SN II-L/IIb (little H)
SN Ib (no H)
Type Ic (no H, He) GRB/XRF

Heger et al paper



Why are the peaks at -15 to -17?



1e41 erg/sec=-14

Lightcurve Fitting for 56Ni, Etot and M_ejected

Nadyoshin 2003

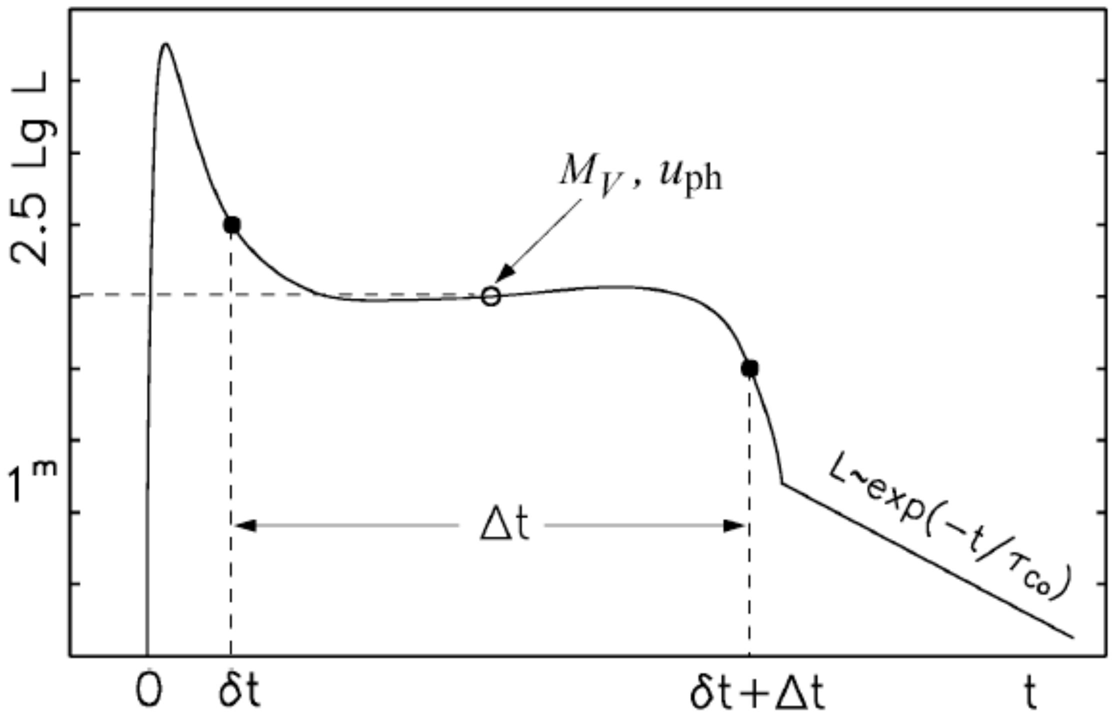
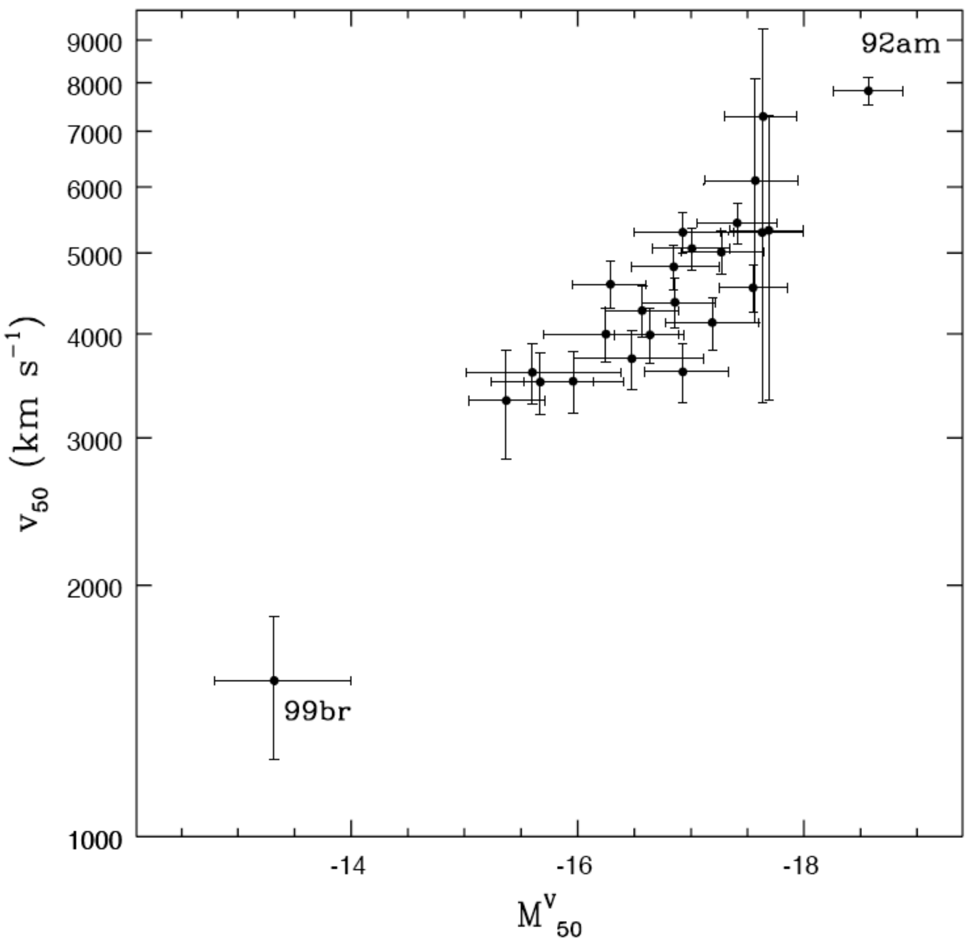


Figure 1. A schematic SNIIP light curve. The open circle marks the middle of the plateau and the two full circles show the plateau boundaries. The light curve tail powered by ^{56}Co decay is also shown ($\tau_{Co} = 111.3$ d).

Break for Popov Analytics

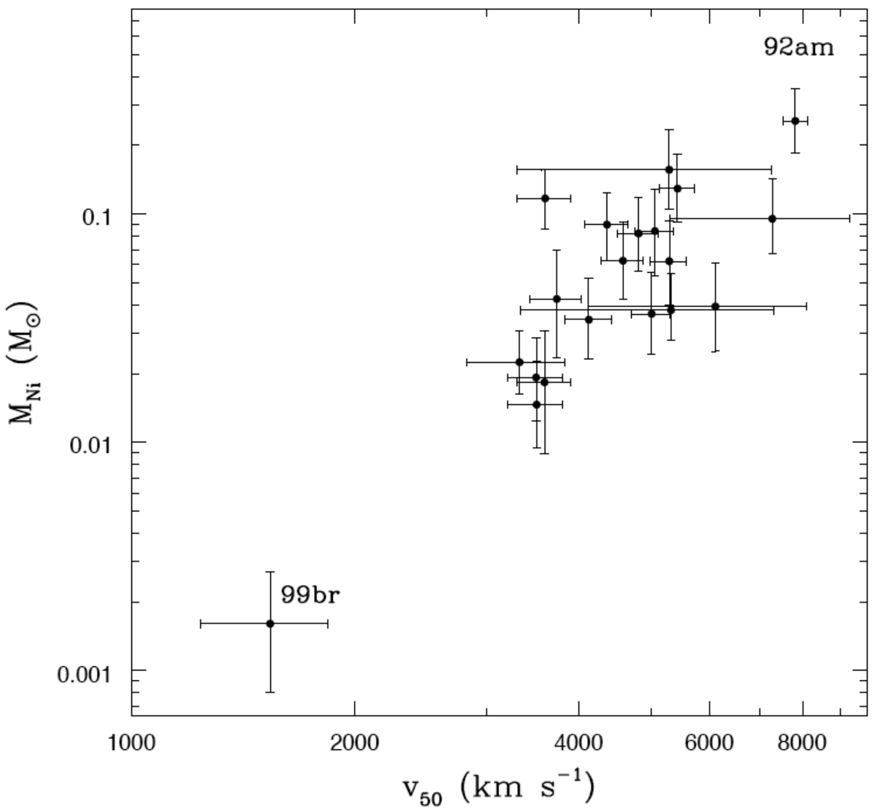
Velocity (at 50 days)-Plateau Brightness Relation for Type II-P's

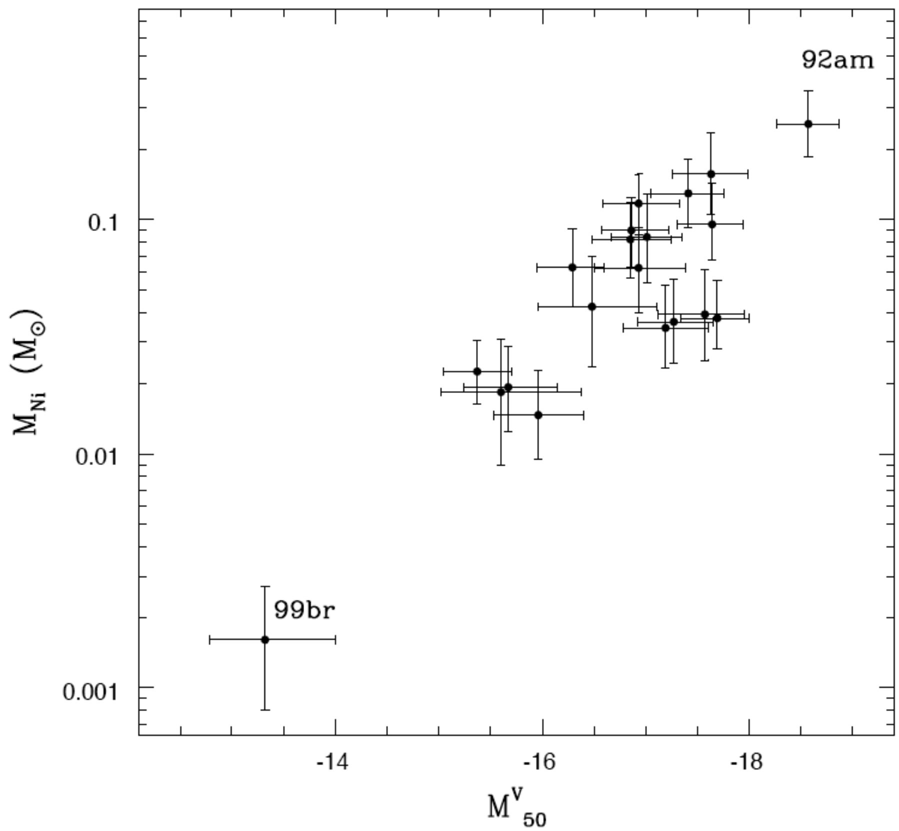


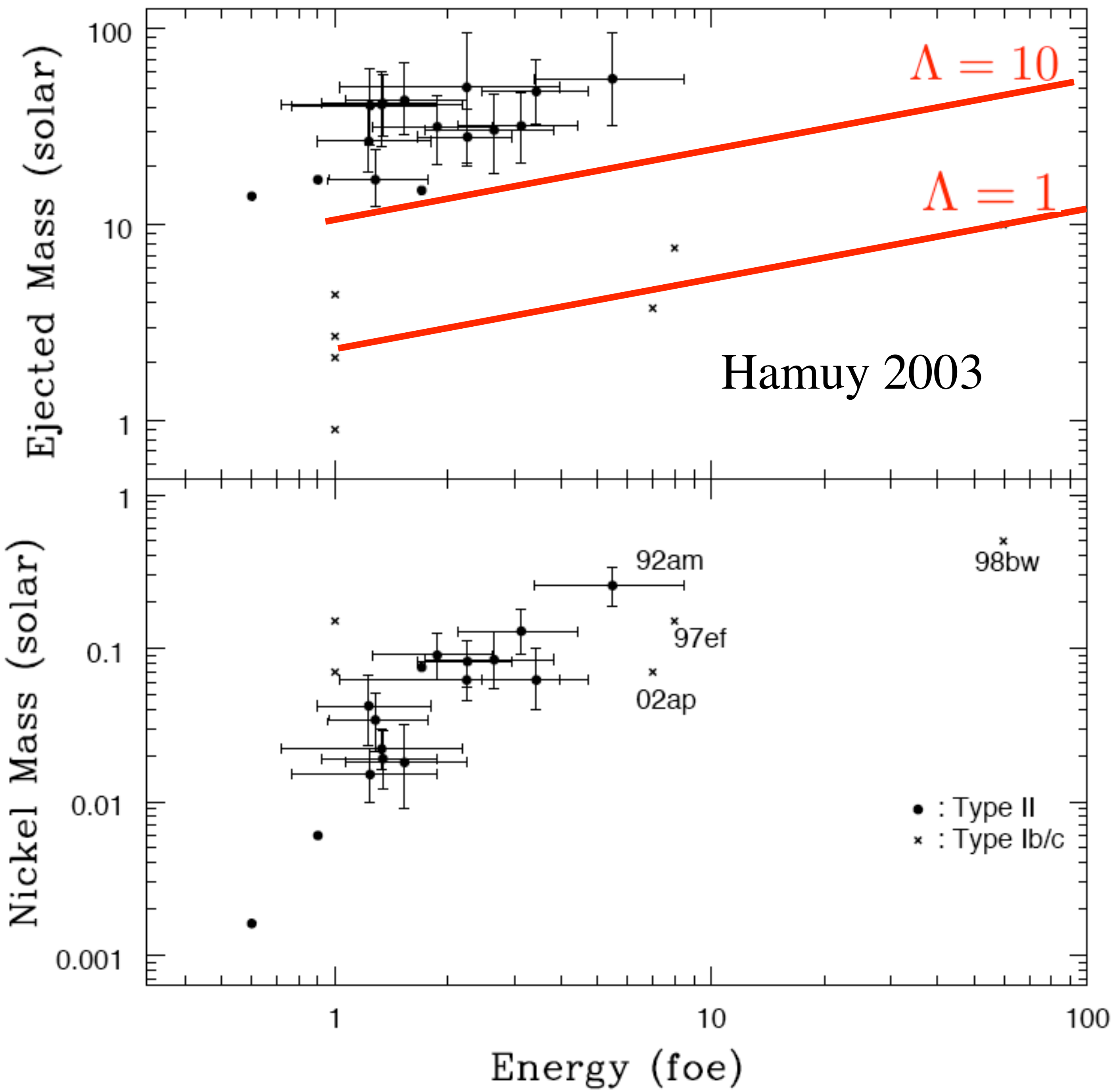
Hamuy 2003

Additional Relations for 56 Ni Masses

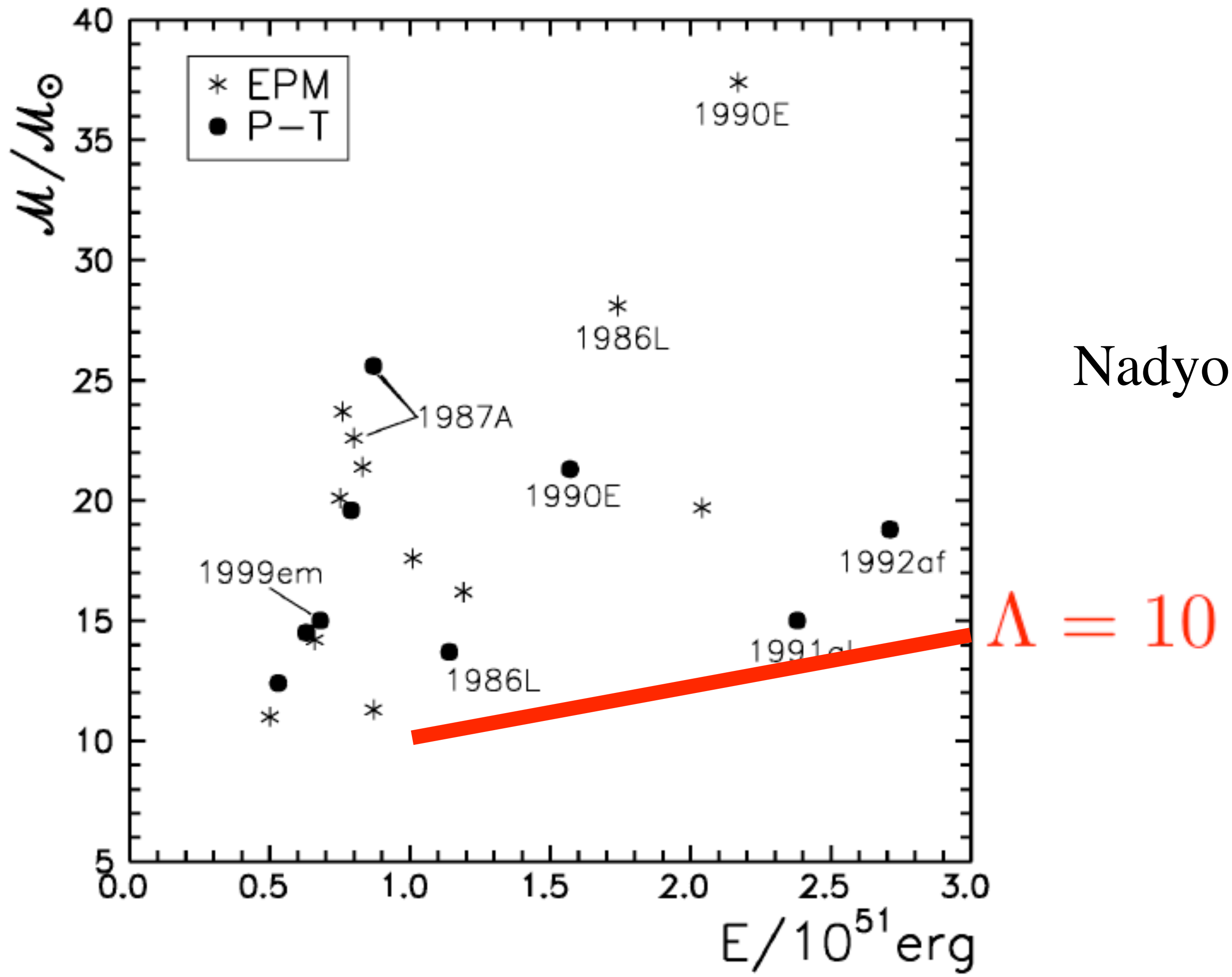
Hamuy 2003







Λ = 10
Λ = 1
Hamuy 2003
Ejected Mass (solar)
Nickel Mass (solar)
Energy (foe)
92am
98bw
97ef
02ap
● : Type II
× : Type Ib/c



Nadyoshin 2003

Figure 5. The explosion energy–envelope mass diagram for the case of EPM distances $D_{\rm EPM}$ from column 4 of Table 2 (asterisks; SNe 1991al and 1992af are excluded) and for the case of the plateau–tail distances $D_{\rm P-T}$ from column 2 of Table 3 (full circles). Some SNe are identified (see text).