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Supernova remnants and their progenitors

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Abstract. Young supernova remnants (SNRs) show obvious differences that can be related to characteristics of the progenitors and supernova types as tabulated in Fig. 1. Questions remain.

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Questions include: why do some Type Ia supernova remnants show a definite gap between the leading-shock rim and the main shell (e.g., Tycho), while others show a single continuous shell out to the sharp rim (SN 1006)?

Why do some SNe leave only a cooling neutron star with no pulsar wind nebula (PWN) (Cas A), or erratic point X-ray sources (RCW 103), while others have pulsars? Is it the magnetic field, spin rate or what?

What physical conditions can discriminate between mixed morpology remnants with internal thermal X-rays (W 44) and those with more standard shells (Vela)? Is it just the surrounding medium?

The composite SNR G11.2−0.3 has been identified with SN 386. It contains a central pulsar with a period of 65 ms and a calculated spin-down age about three times longer than the age since its explosion. In contrast, the Crab Nebula, an extended pulsar wind nebula with no apparent shell, has a close match between the two ages. Is the presence or absence of a shell related to differences in the moment of inertia of the neutron star?

Why do some composite SNRs (MSH 15−56) show a radio pulsar wind nebula somewhat offset from the center, and then a point X-ray source with an apparent X-ray PWN out near the shell and not necessarily aligned with the radio PWN?

	Low Mass Type Ia	High Mass Type Ib or II		
Examples (approximate explosion date if known)	Kepler (1604)? Tycho (1572) AD1006 (1006) 0519-690 (350-1500) SN1885 in M31 (1885)	Cas A (~1680) RCW103 (~0) E0102-723 Puppis A	3C58(1181) Crab(1054)	G11.2-0.3(386) W44 Vela 0540-693 (~0) N157B IC443
Morphology	Reasonably round shells	Broken up shells, shrapnel	Only pulsar wind nebula	Composite PWN plus shell
Compact core	--	Cooling neutron star, no pulsar wind nebula	Pulsar plus pulsar wind nebula (PWN)	
Spectral results optical X-ray	Balmer dominated, N,S Thermal Fe, Si, S	O (FMKs), N (QSFs) Fe, metals	Ni, N, S Power law (synchrotron) in PWN	
Pre point-blast expansion	Near point blast $R \propto t^{0.5}$	Near free expansion $R \propto t^{0.9}$	--	
Emvironment	Isolated object but often complex circumstellar medium	Pre-explosion mass loss	Pre-explosion mass loss	

Figure 1. Properties of young SNRs