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 morphology 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?

<table>
<thead>
<tr>
<th>Low Mass Type Ia</th>
<th>High Mass Type Ib or II</th>
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<tbody>
<tr>
<td>Kepler (1604)?</td>
<td>Cas A (~1680)</td>
</tr>
<tr>
<td>Tycho (1572)</td>
<td>RCW103 (~0)</td>
</tr>
<tr>
<td>AD1006 (1006)</td>
<td>E0102-723</td>
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<tr>
<td>0519-690 (350-1500)</td>
<td>Puppis A</td>
</tr>
<tr>
<td>SN1885 in M31 (1885)</td>
<td>3C58(1181)</td>
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<td></td>
<td>Crab(1054)</td>
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<tr>
<td></td>
<td>G11.2-0.3(386)</td>
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<td></td>
<td>W44 Vela</td>
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<td></td>
<td>0540-693 (~0)</td>
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<td>N157B</td>
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<td>IC443</td>
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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
  \[ R \propto t^{0.9} \]
- --

Environment

- Isolated object but often complex circumstellar medium
- Pre-explosion mass loss
- Pre-explosion mass loss

Figure 1. Properties of young SNRs

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