A 0.5 MS CHANDRA OBSERVATION OF THE O-RICH SNR G292.0+1.8

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YOUNG CORE-COLLAPSE SNRS

- O-rich SNR: fast moving O-rich optical ejecta knots

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<tr>
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<th>Cas A</th>
<th>G292.0+1.8</th>
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<tbody>
<tr>
<td><strong>Age</strong></td>
<td>~320 yrs</td>
<td>~3,000 yrs</td>
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<tr>
<td><strong>Radius</strong></td>
<td>~2.5’</td>
<td>~4’</td>
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<tr>
<td></td>
<td>~2.4 pc @ 3.4 kpc</td>
<td>~7.7 pc @ 6 kpc</td>
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G292.0+1.8 : THE TEXTBOOK EXAMPLE OF YOUNG CORE-COLLAPSE SNR

- An active **pulsar** and its **wind nebula**
- Fast moving **stellar ejecta** enriched in light elements like Oxygen, Neon and Magnesium.
- Evidence for blast wave interaction with **circumstellar material**
Chandra view of G292.0+1.8 (background: DSS)
An invaluable opportunity for the study of nucleosynthesis and the shock evolution of core-collapse SNRs
First Chandra observation (ACIS-S3) in AO1 (40 ksec): GTO target.

Deep (~500 ksec) Chandra observation (ACIS-I) in AO7: GO Large Project (PI: Sangwook Park)

- John P. Hughes (Rutgers), Patrick O. Slane (CfA), David N. Burrows (Penn State), B. M. Gaensler (U. of Sydney), Parviz Ghavamian (STScI)
1. NATURE OF THE AMBIENT MEDIUM

- Young C-C SNRs are expected to expand inside the wind.
- The shocked ambient gas of the SNR expanding in the wind ($\rho \propto r^{-2}$) shows different radial structure from those expanding in the uniform medium.

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<tr>
<th>at CD</th>
<th>Density</th>
<th>Temperature</th>
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<tbody>
<tr>
<td>Uniform (s=0)</td>
<td>0</td>
<td>$\infty$</td>
</tr>
<tr>
<td>Wind (s=2)</td>
<td>$\infty$</td>
<td>0</td>
</tr>
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Self-Similar solution by Chevalier (1982)
regions are selected with minimal ejecta contamination

single plane-parallel shock model (vpshock)

sub-solar metal abundances

The structure of shocked ambient gas is consistent with models of the remnant expanding in the circumstellar wind.

The estimated wind density ($n= 0.1 \sim 0.3 \text{ cm}^{-3}$) at the current outer radius ($\sim 7.7 \text{ pc}$) suggests a slow wind from a red supergiant star.

- $\dot{M} : 2\sim5 \times 10^{-5} \, M_\odot \, \text{yr}^{-1}$ \(v_w = 10 \text{ km s}^{-1}\)
- $M_w = 15 \sim 40 \, M_\odot$

The overall kinematics of G292.0+1.8 are consistent with the remnant expanding inside the RSG wind.
Our results provide a direct evidence that G292 is expanding inside the dense RSG wind from the progenitor star.
2. SPATIAL DISTRIBUTION OF SHOCKED EJECTA EMISSION

- Equivalent-width (EQW) map of individual lines shows different spatial distribution.

- In NW, ions with high ionization potentials (IP) are found outside those with lower IP. It traces the radial variation of the ionization time scale.

- The observed trend can be explained by a reverse shock propagating inwards (as in E0102.2-7219, Gaetz et al 2000)

(Lee et al. in prep.)
EXPLOSION ASYMMETRY?

- The asymmetric distribution of ionization states is likely due to the asymmetric nature of the explosion.
- The location of the explosion center seems controversial (Winkler et al., 2008; H.-G. Lee 2009)
DISTRIBUTION OF SILICON

Silicon in Cas A (Hwang et al. 2004)
3. PULSAR & PWN

- Our deep ACIS-I observation reveals faint emission suggestive of a jet/torus structure.

- **Contrast** to the strong tendency toward spin-kick alignment claimed by Ng & Romani (2007)
Our Chandra observation of G292.0+1.8 shows a consistent picture of late-stage evolution of massive star, where it loses a significant amount of its initial mass as stellar wind and undergoes an asymmetric explosion to leave a neutron star with high spatial velocity.