On the Expansion Rate and Age of the Supernova Remnant G266.2–1.2 (Vela Jr.)

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1. Introduction

The shell-type supernova remnant G266.2–1.2 was discovered in the ROSAT all-sky survey data and, based upon its equatorial coordinates, named RX J0852.0–4622 (Aschenbach, 1998). To the extent that it is possible to distinguish the emission of photons cm$^{-2}$ s$^{-1}$ keV$^{-1}$ arcmin$^{-2}$, the location of CXOU J085201.4–461753 (Pavlov et al., 2001) was used to measure the radius of expansion. The cyan arc is a segment of a circle that has a radius of $0.850^{+0.012}_{-0.012}$ (see Fig. 1) in the parameter space defined by the radial offset $\Delta \theta$ and the scaling factor $\theta$. The solid black and dotted red contours are the results obtained before and after, respectively, the mean $\Delta \theta$ and $\theta$ registration adjustments are included. The stars indicate the best-fit values of $\Delta \theta$ and $\theta$. The evidence of expansion in region A (i.e. the evidence that $\Delta \theta > 0$) is significant at nearly the 4$\sigma$ confidence level.

2. Data Analysis

Table 1: Expansion results

<table>
<thead>
<tr>
<th>Region</th>
<th>Region B</th>
<th>Region C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial offset $\Delta \theta$ [arcsec]</td>
<td>0.8442$^{+0.0042}_{-0.0042}$</td>
<td>0.8447$^{+0.0047}_{-0.0047}$</td>
</tr>
<tr>
<td>Azimuth $\theta$ [deg]</td>
<td>320.0$^{+0.5}_{-0.5}$</td>
<td>322.5$^{+0.5}_{-0.5}$</td>
</tr>
<tr>
<td>Model parameters:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radial offset $\Delta \theta$ [arcsec]</td>
<td>0.8442$^{+0.0042}_{-0.0042}$</td>
<td>0.8447$^{+0.0047}_{-0.0047}$</td>
</tr>
<tr>
<td>Scale factor $\theta$</td>
<td>0.864$^{+0.012}_{-0.012}$</td>
<td>0.864$^{+0.012}_{-0.012}$</td>
</tr>
<tr>
<td>Expansion:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time difference $\Delta t$ [yr]</td>
<td>5.652</td>
<td>5.652</td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.864$^{+0.012}_{-0.012}$</td>
<td>0.864$^{+0.012}_{-0.012}$</td>
</tr>
<tr>
<td>$\theta$ [deg]</td>
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</tr>
</tbody>
</table>
| The statistical uncertainties are listed at the 68.3% confidence level. These values are based on the sizes of and numbers of events in source free portions of the regions. A 20% uncertainty in the shock radius is assumed because the location at which the progenitor exploded is unknown.

3. Discussion

To obtain a constraint on the age of G266.2–1.2, we used the hydrodynamic models of Truelove & McKee (1999). Since the physical conditions—the initial kinetic energy ($E_{ke}$), mass ($M$), and mass density distribution ($n_{0}$) are uncertain, a five-dimensional grid in $E_{ke}$, $M$, $n_{0}$, $n_{0}$, and $n_{0}$ was used with 81 values of $E_{ke}$, $M$, $n_{0}$, $n_{0}$, and $n_{0}$, with values of $n_{0}$ and $n_{0}$ and $n_{0}$ for $E_{ke}$, $M$, and $n_{0}$, and values of $n_{0}$ and $n_{0}$ and $n_{0}$ for $E_{ke}$, $M$, and $n_{0}$, and values of $n_{0}$ and $n_{0}$ and $n_{0}$ for $E_{ke}$, $M$, and $n_{0}$. The hydrodynamic analysis does not provide a significant constraint on the distance. An analysis of previously published distance estimates constrains the distance to be between about 0.5 and 1.0 kpc (Allen et al., 2014). We adopt the distance of the closer of two groups of material in the Vela Mecu-lar Foundation (i.e. $E_{ke}$ is the distance of the remnant. This distance is consistent with the progenitor having been a member of the Vela OB1 association (Eggen, 1982).

4. Conclusions

• An analysis of the data for two Chandra observations of G266.2–1.2 indicates that it has expanded by $2.0^{+0.6}_{-0.5}$ arcsec over a period of 5.652 yr (i.e. $2.0^{+0.6}_{-0.5}$ arcsec yr$^{-1}$) and that the expansion rate is $\theta = 0.42^{+0.10}_{-0.05}$ arcsec yr$^{-1}$. This rate is half the rate reported for an XMM-Newton data ($5.7^{+1.2}_{-1.0}$ arcsec over 6.5 yr from 2001 to 2007 or $0.95^{+0.25}_{-0.20}$ arcsec yr$^{-1}$, Kasuda, Tsunami & Mori, 2008).

5. Acknowledgements

G.S.A. is supported by contract SVS-73016 between MIT and the Smithsonian Astrophysical Observatory. The Smithsonian Astrophysical Observatory is operated on behalf of NASA under contract NAS8-03060. This research has made use of data products from the Chandra Data Archive, the Two Micron All Sky Survey, and the USNO-B1.0 catalog. The analyses described herein were performed using the software packages CIAO, provided by the Chandra X-ray Center, the software package ISIS (Houck & Denicol, 2000), the scripting language S-Lang, and the models of the XSPEC spectral-fitting package.

References


Figure 1: A 1–5 keV image of the northwestern rim of G266.2–1.2 from the Chandra observation. The cyan asterisk is the location of the aim point. The image has been smoothed using a two-dimensional Gaussian function with $\alpha_{x} = \alpha_{y} = 10$ pixels = 1.92 arcsec. The color is a linear function of the flux and varies from about $1 \times 10^{-7}$ to less than $1 \times 10^{-7}$ or more (dark blue) to $1 \times 10^{-7}$ to more (white) units of photons cm$^{-2}$ s$^{-1}$ pixel$^{-1}$. The magenta lines mark the boundary of the region that was observed in both 2003 and 2008. The yellow circles encompass registration sources 1 and 2. The green annular wedges mark the boundaries of regions A and B, which were used to measure the rate of expansion. The cyan arc is a segment of a circle that has a radius of $0.85^{+0.01}_{-0.01}$ and that is centered on the location of CXOU J085201.4–461753 (Pavlov et al., 2001).

Figure 2: Top panel: Radial profiles for region A (see Fig. 1). The black curve is the number of events in each radial bin from the 2008 dataset. Here, the bins are 1 pixel (0.492 arcsec) wide. The dotted vertical line at $\theta = 0.864^{+0.012}_{-0.012}$ is the radius at which the number of events in 2008 is halfway between the peak of the black curve and the nominal number of background events. The blue and red curves are scaled versions of the 2003 profile before and after, respectively, it has been radially shifted by 2.0 arcsec. Bottom panel: The differences between the black profile and the blue and red profiles divided by the 2$\sigma$ statistical uncertainties.

Figure 3: The 1-, 2-, and 3$\sigma$ confidence contours for region A (see Fig. 1) in the parameter space defined by the radial offset $\Delta \theta$ and the scaling factor $\theta$. The solid black and dotted red contours are the results obtained before and after, respectively, the mean $\Delta \theta$ and $\theta$ registration adjustments are included. The stars indicate the best-fit values of $\Delta \theta$ and $\theta$. The evidence of expansion in region A (i.e. the evidence that $\Delta \theta > 0$) is significant at nearly the 4$\sigma$ confidence level.

Figure 4: The distribution of the ages of the 57.4 million plausible hydrodynamic scenarios. No age is less than 2.2 yr or greater than 8.4 yr. If the lowest 5% and highest 5% of the distribution are ignored, then the plausible ages are between about 2.4 and 5.1 yr (i.e. between the dotted vertical lines). By more than a factor of 1.5. In the unlikely case that G266.2–1.2 was produced by a Type Ia event, the expected age range is within the range of plausible ages. The hydrodynamic analysis does not provide a significant constraint on the distance. An analysis of previously published distance estimates constrains the distance to be between about 0.5 and 1.0 kpc (Allen et al., 2014). We adopt the distance of the closer of two groups of material in the Vela Mecular Foundation (i.e. $E_{ke}$ is the distance of the remnant. This distance is consistent with the progenitor having been a member of the Vela OB1 association (Eggen, 1982).