N63A: A Supernova Remnant in a Cloudy Medium

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Abstract. Our recently obtained HST WFPC2 images of N63A reveal shocked cloudlets in the SNR interior. The study of N63A helps us understand the structure and evolution of SNRs in a cloudy medium.

1. N63A - A Puzzling SNR in an OB Association

N63A was one of the first three supernova remnants (SNRs) discovered in the LMC based on its strong, nonthermal radio emission. Its identification as a SNR was subsequently confirmed by its bright X-ray emission and high [SII]/Hα ratios. As shown by the X-ray contours in Fig. 1a, N63A is located in the northeastern quadrant of the H II region N63 associated with the OB association LH 83. The progenitor of the supernova was likely a member of LH 83 (van den Bergh & Dufour 1980). The currently most luminous star is an O7 V((f)) star with a mass of ~40 M☉ (Oey 1996). Therefore, the progenitor of N63A’s supernova was probably more massive than 40 M☉ and its main-sequence spectral type earlier than O7.

The spatial extent of N63A’s X-ray emission is similar to that of its radio emission, ~70″, and defines the size of the SNR. Within the SNR’s boundary, ground-based optical images show three bright nebular knots. Spectroscopic observations show that the two eastern knots have high [SII]/Hα ratios, indicating shock excitation, and that the western knot has a spectrum consistent with photoionization (Levenson et al. 1995). Besides these bright knots, no other optical features can be recognized as belonging to the SNR. The two [SII]-bright knots together extend over ~23″, much smaller than the SNR’s size. The absence of optical emission from the rest of the remnant cannot be caused by foreground obscuration, as A_v is generally <0.5 mag for stars in LH 83 (Oey 1996). Why is N63A’s optical emission region so much smaller than the SNR’s extent?
2. HST Images Reveal Shocked Clouds in N63

The Hubble Space Telescope (HST) WFPC2 images of N63A in the Hα and [SII] lines have revealed shocked clouds with sizes ranging from 5 pc down to 0.1 pc (Fig. 1b). N63A is clearly in a cloudy medium. The three bright nebular knots identified in ground-based images are well resolved in the WFPC2 images. The two eastern knots show distinct filamentary structures indicative of a compression by SNR shocks, while the western knot shows only diffuse ionized gas and dust clouds typical for H II regions. The two eastern knots might belong to the same cloud; their combined size is ~5 pc, comparable to the Orion Nebula.

Within the SNR boundary, numerous [SII]-bright cloudlets are detected. The high [SII]/Hα ratios indicate that these cloudlets have been shocked and are located in the SNR interior. Some cloudlets show a diffuse morphology with radial density gradients, suggestive of isotropic evaporation and implying that the magnetic field is either very weak or tangled. Some cloudlets contain multiple cores, each ~0.07 pc across. The rms densities of the cloudlets range from 150 to 700 H cm\(^{-3}\), and the masses range from 0.01 to ~1 M\(_{\odot}\).

ROSAT and ASCA observations of N63A were used to derive a SNR interior T\(_{e}\) of ~6 x 10\(^6\) K, N\(_{e}\) of ~5 cm\(^{-3}\), and a mass of ~160 M\(_{\odot}\). In such a hot medium, the evaporation timescale for the embedded cloudlets is a few x10\(^3\) yr, comparable to the dynamic age of N63A. It is conceivable that a significant amount of cloud mass has already been injected into the hot SNR interior through cloud evaporation.

References


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