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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 [S II]/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 $\sim$40 $M_\odot$ (Oey 1996). Therefore, the progenitor of N63A's supernova was probably more massive than 40 $M_\odot$ 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, $\sim 70''$, 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 [S II]/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 [S II]-bright knots together extend over $\sim 23''$, 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?*

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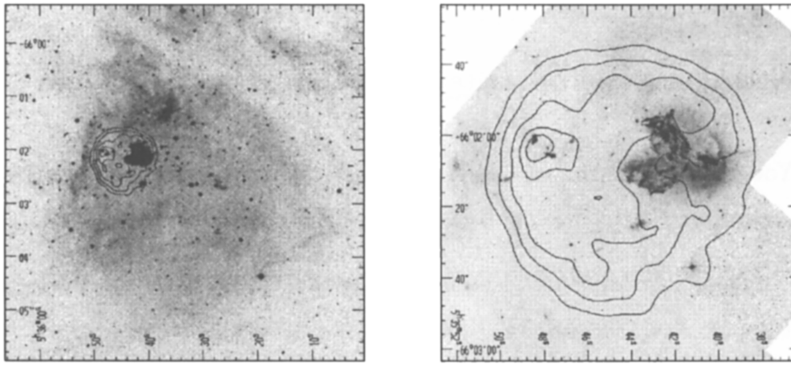

Figure 1. (a) Hα image of N63 overlaid by X-ray contours. (b) HST WFPC2 Hα image of N63A overlaid by X-ray contours.

2. HST Images Reveal Shocked Clouds in N63

The Hubble Space Telescope (HST) WFPC2 images of N63A in the Hα and [S II] 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 [S II]-bright cloudlets are detected. The high [S II]/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 $\sim 6\times10^6$ 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 $\times10^3$ 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.

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