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Imaging and spectroscopy of the LMC He II nebula N 44C and its ionizing star

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Abstract. We present results from new *HST* imaging and spectroscopy of the peculiar Large Magellanic Cloud H II region N 44C and its ionizing star. While this nebula exhibits strong He II recombination emission, the source of the He^+ ionizing photons has not been found. The UV spectrum of the ionizing star suggests an approximate spectral class of O7–O8; the UV Si IV , He II , and N IV features do not show P-Cygni profiles, indicating that the ionizing star is not a supergiant. No companion star has yet been detected. Ground-based and *HST* optical spectroscopy of the ionized gas shows that the nebular abundances of C, N, O and He are not anomalous relative to other LMC H II regions, suggesting that no previous WR/SN companion has disappeared. Echelle spectroscopy has also ruled out the presence of high velocity shocked gas. Deep *ROSAT* imaging shows no X-ray point source in this location. The "fossil X-ray binary" hypothesis of Pakull & Motch (1989) remains the best explanation for the ionization of this nebula; however, convincing evidence for this hypothesis remains elusive.

1. Introduction

A handful of H II regions with strong He II recombination emission have been discovered over the past decade (Garnett *et al.* 1991). The He II emission is peculiar because of the high photon energies ($h\nu \geq 54$ eV) required to further ionize He^+. NLTE stellar atmosphere models predict that a star capable of ionizing helium to this state must have $T_{\rm eff} \gtrsim 60\,000$ K. Most of these H II regions discovered to have their own "He II regions" appear to be associated with Wolf-Rayet stars or massive X-ray binary systems. However, Stasińska *et al.* (1986) found that the central engine ionizing N 44C in the LMC appears to be a normal O star.

A number of theories have been proposed to solve the problem of N 44C. The He II observed in the optical spectrum of the nebula may be accounted for by a $T_{\rm eff} \simeq 50\,000$K O-type supergiant near the Eddington-limit. Radiative shocks have also been proposed as the source of the high ionization. Pakull & Motch (1989) have suggested that the high degree of ionization found in this

nebula could be caused by a fossil X-ray binary which has turned off within the last century.

2. Observational data

Narrow-band (44Å) images of N 44C in Hβ, [O III], He II and continuum were obtained with the *CTIO* 0.9m in 1991. We also obtained *HST*-WFPC2 images in F502N, F656N and F547N. Optical long-slit spectra of the N 44C nebula were taken using the RC spectrograph on the *CTIO* 4.0m telescope and with the *HST*-FOS. A UV spectrum of "Star 2", the only apparent ionizing source in N 44C, was obtained with *HST*-GHRS. An echellogram and *ROSAT* X-ray image were provided by Magnier *et al.* (1996).

3. Results

- N 44C is an LMC H II region with its own 3 pc diameter He II region; the source of the He^{+2} ionizing photons is unknown.
- The central star within N 44C is classified as an O7-O8 main sequence star based on the absence of Si IV and C IV P-Cygni features in its UV spectrum.
- Analysis of *CTIO* and *HST*-FOS spectra reveal a chemical composition similar to that typically found in the LMC; this rules out the hypothesis that a previous WR/SN has produced the high level of ionization.
- Echelle spectroscopy rules out the existence of high velocity gas, excluding shock ionization as the source for the He II emission.
- *ROSAT* X-ray imaging shows no point source in this region; no X-ray binary system is detected to low limits. This does not exclude the possibility that a "fossil" X-ray binary system is responsible for the high ionization level.
- Analysis of the ionic ratios found in the gas and further analysis of the stellar spectrum, will aid in the modelling of the central ionizing source.

References

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