*Wolf-Rayet Phenomena in Massive Stars and Starburst Galaxies*
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# Gas and hidden star formation in NGC 5253

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**Abstract.** We confirm the presence of compact H II regions in the center of the starburst in NGC 5253 through the detection of optically thick free-free emission. The number of O-type stars implied by the excitation of these nebulae is nearly two orders of magnitude larger than what is indicated by the radio continuum fluxes. The compact H II regions are located 70 pc to the north of the location of the Wolf-Rayet feature. Implied extinctions are extremely high. Not all WR galaxies can be identified as such due to extinction.

## 1. Introduction

NGC 5253 is a dwarf I0/S0 galaxy with an intense nuclear starburst of IR luminosity $3 \times 10^9$ $L_\odot$ (Beck *et al.* 1996), comparable to the starburst in the nearby large spiral galaxy M 83, although N 5253 is much smaller, having only a percent or so of the mass of M 83. The detection of the Wolf-Rayet feature (Walsh & Roy 1989; Kobulnicky *et al.* 1997) and the lack of strong synchrotron emission (Beck *et al.* 1996; Turner, Ho & Beck 1998) suggest that the starburst is very young. Numerous large super star clusters (SSCs), possible precursors to globular clusters, are found within the starburst region. The mechanism of star formation and its trigger (perhaps an accretion event) are relevant to the understanding of how star formation develops in low metallicity, low mass galaxies.

The radio continuum data were taken with the A-configuration of the *VLA* at 1 cm and 2 cm in April, 1998. The synthesized beamsizes are $0''.24 \times 0''.093$, p.a. −8 at 1 cm; and $2''.6 \times 1''.0$, p.a. 2 at 2 cm. Absolute positional accuracy is better than $0''.01$. Absolute fluxes were calibrated using 3C 286, and are good to better than a few percent.

## 2. Results

We detect the central radio continuum source in NGC 5253 at both 1 cm and 2 cm in these very small beams. There is a noticeable NS extension to the 2-cm map which reflects an intrinic NS extension. There is also a smaller nebula $0''.2$ east of the main radio source. The coordinates of the main continuum source are $\alpha = 13^h\, 39^m\, 55^s.934$, $\delta = -31^\circ\, 38'\, 24''.36$ (J2000). The intrinsic source size, deconvolved from the beam, is $0''.12 \times 0''.086$, or 1.6 pc × 1.2 pc ($d = 2.8$ Mpc). The brightness temperature implied by the 12 mJy flux is 2100 K. Since the observed electron temperature is 12 000 K, we infer that the optical depth of



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the radio emission is 0.2, indicating that $\nu_t \simeq 22$ GHz, an emission measure of $3 \times 10^9$ cm$^{-6}$ pc, and an rms electron density of 4–5 $\times 10^4$ cm$^{-3}$. This source has not been seen in lower resolution images (Beck *et al.* 1996; Turner *et al.* 1998), since even at spatial resolutions of a few parsecs, confusion with synchrotron emission is a serious problem.

Because the radio free-free emission is optically thick, we cannot estimate the Lyman continuum rate based on the radio fluxes. However, since we do resolve the region, and since we know the emission measure, we can infer a minimum rate of UV photons required to ionize the region from its size (Turner *et al.* 1998). We obtain $N_{\rm Lyc} \simeq 10^{53}$ s$^{-1}$, or 8000 O6 stars. This is fifty times larger than $N_{\rm Lyc}$ estimated from the radio free-free flux, and 3000 times higher than obtained from $H_\alpha$ fluxes (Calzetti *et al.* 1997). Since we do not have a good measure of the dimensions of the nebula, this number is uncertain by factors of a few. However it is safe to say that the number of O-type stars in this starburst could easily be 1–3 orders of magnitude large than either optical or radio ionization estimates.

The emission measures of this nebula indicate that there is high density gas within the starburst. At minimum the density is $\sim 10^{4-5}$ cm$^{-3}$. If the nebula is pressure-confined, the surrounding neutral gas density could easily be much higher. Given the high densities and the 35 magnitudes of extinction estimated toward the central source by Calzetti *et al.* (1997), it is quite likely that there are molecular clouds in the region. Yet there is no CO detected here (Turner, Beck & Hurt 1997; Meier *et al.* in these Proceedings). CO is likely to be a very poor tracer of $H_2$ in this galaxy due to its low metallicity and high radiation fields (Israel *et al.* 1986; Lequeux *et al.* 1994). The high extinctions imply that optical tracers of young star formation activity, such as the WR feature, may not be ubiquitous features of the youngest starbursts.

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