Wolf-Rayet Phenomena in Massive Stars and Starburst Galaxies
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The stellar content of the Wolf-Rayet galaxy NGC 5253 from ISO-SWS spectroscopy

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1. Why mid-IR spectroscopy of Wolf-Rayet galaxies?

Wolf-Rayet galaxies are a subset of blue emission-line galaxies, whose spectra show the signature of large numbers of WR stars, with ages in the range 1–10×10^6 yr. Mid infra-red observations are well suited to the study of their hot, massive stars since this spectral region contains many fine-structure nebular lines which depend very sensitively on stellar content. The observations of *ISO* have opened-up this window, which we are exploiting through a Guest Observer program with the Short Wavelength Spectrometer (SWS), that includes NGC 5253, a nearby (4 Mpc) WR galaxy. NGC 5253 contains several young super-star clusters, no older than a few million years and has been the focus of many recent studies which have shown that the extinction is very high and patchy in the UV and optical. *ISO* observations of NGC 5253 are particularly important since the interstellar extinction at mid-IR wavelengths is low and because of its remarkably hot and young stellar population.

2. Hot clusters embedded in cooler emission

Our approach differs from previous investigations in that we are able to distinguish between the regions in which different infrared fine-structure lines form, using complementary ground-based observations from Beck *et al.* (1996). The high excitation nebular [S IV] emission is formed in the central super-star-nucleus, and lower excitation [Ne II] nebular emission originates from the clusters located in much larger galactic core. From our Brα flux, the $2''$ nucleus contains the equivalent of approximately 1000 O7V stars and the starburst is 2–3 Myr old; the older $20''$ core contains about 2500 O7V star equivalents, in agreement with the previous determination by Martin & Kennicutt (1995) from Hα. The Lyman ionizing flux of the nucleus is equivalent to the 30 Doradus region. These quantities are in good agreement with the observed mid-IR dust luminosity of 7.8×10^8 $L_\odot$.

We use photo-ionization modelling (Ferland 1996), including observed elemental abundances (Kobulnicky *et al.* 1997), coupled with the latest theoretical O-star flux distributions that account for non-LTE effects and stellar winds in

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low metallicity environments (Schaerer & de Koter 1997). Previous investigations of NGC 5253 (*e.g.*, Lutz *et al.* 1996) did not account for these factors, nor the spatial distribution of nebular emission, leading to imprecise results. For the compact nucleus we derive effective stellar temperatures and ionization parameters of $T_{\rm eff} \geq 38$ kK, $\log Q \simeq 8.25$, with the larger core less well constrained ($T_{\rm eff} \simeq 35$ kK, $\log Q \leq 8$). These results are supported by more sophisticated calculations using results from evolutionary synthesis models (Schaerer & Vacca 1998). We assess the contribution that Wolf-Rayet stars may make to highly ionized nebular lines (*e.g.*, [O IV]), and conclude that solely hot WR stars with weak stellar winds may provide the necessary hard ionizing flux distributions.

The observed structure of hot clusters embedded in cooler emission may be common in other dwarf starbursts, so that observing a galaxy solely with a single large aperture may result in confusion. Our results are discussed in greater detail by Crowther *et al.* (1999).

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References

Beck, S.C., Turner, J.L., Ho, P.T.P., Lacy, J.H., Kelly, D.M. 1996, ApJ 457, 610

Crowther, P.A., Beck, S.C., Willis, A.J., Conti, P.S., Morris, P.W., Sutherland, R.S. 1999, MNRAS 304, 654

Ferland, G.J. 1996, HAZY, University of Kentucky, Physics Dept Internal Report

Kobulnicky, H.A., Skillman, E.D., Roy, J.-R., Walsh, J.R., Rosa, M.R. 1997, ApJ 477, 679

Lutz, D., Genzel, R., Sternberg, A. *et al.* 1996, A&A 315, L137

Martin, C.L., Kennicutt, R.C. 1995, ApJ 447, 171

Schaerer, D., de Koter, A. 1997, A&A 322, 615

Schaerer, D., Vacca, W.D. 1998, ApJ 497, 618