POSTER PAPERS 4.

Chairman : A. MAEDER

1. A.CAMPBELL and L.SMITH:
   A search for WR Stars in Giant Extragalactic Bursts of Star Formation.

2. M.KAUFMAN, R.C.KENNICUTT and R.N.BASH:
   Giant HII Regions in M81.

3. J.MELNICK, R. TERLEVICH and M. MOLES:
   Warmers: Massive Stars in the Nuclei of Galaxies.

4. G.BERTELLI, A.BRESSAN, C.CHIOSI, E.NASI and L.PIGATTO:
   Convective Overshooting: New Integrated Colours vs. Age Relations for Star Clusters.

5. C.CHIOSI and L.PIGATTO: The Distance Modulus of LMC.

6. Y.H.CHU: NGC 2070 and NGC 3603.

A SEARCH FOR WOLF-RAYET STARS IN GIANT EXTRAGALACTIC BURSTS OF STAR FORMATION

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It is well known that some giant extragalactic star-forming regions contain WR stars. D'Odorico, Massey, Rosa and coworkers found many examples in nearby galaxies of giant HII regions whose spectra show that they contain WN, and occasionally, WC stars. The dwarf emission-line galaxies He 2-10 (Allen *et al.* 1976) and Tol 3 (Kunth & Sargent 1981) have a strong broad emission feature near HeII 4686Å; in the latter object ∼150 WN stars are required to explain the observed equivalent width.

Giant star-forming regions ($\gtrsim 10^3$ O stars) are ideal laboratories in which to study the evolution of the most massive stars. We have begun a detailed optical/infrared investigation of a sample of "HII galaxies" (galaxies experiencing a relatively very luminous burst of star formation) with the objective of studying the occurence and evolution of WR stars as functions of the age, mass and abundance of the the ionizing cluster. Our sample consists of 15 HII galaxies observed at the AAT and a further 3 from the sample of Campbell *et al.* (1985), obtained at LCO: we have moderate dispersion, high (typically 30) continuum S/N spectrophotometry covering the wavelength range 3500-7000Å for a total of 20 starburst regions in these objects. We report here on our initial findings and concentrate on the four objects in which we have detected strong WR features.

The spectra are characterised by broad emission near HeII 4686Å and are shown in Fig. 1. The most conspicous WR features are seen in Mi 499 (= NGC 4385) which also shows broad NIII 4640Å emission of comparable strength ($W_\lambda \sim 4$Å) and width (FWHM ∼ 20Å) to HeII 4686Å. This feature is very similar to that discovered in NGC 300(7) by D'Odorico *et al.* (1983) and indicates a predominantly late WN population. The WC feature CIV 5800 is just detected at the 2σ level with a FWHM ∼ 40Å), indicating that early WC stars may also be present. Assuming a distance of 50 Mpc (from the emission-line redshift; $H_o = 50$ km s^{-1} Mpc^{-1}), we estimate that ∼ 1.5×10^4 late WN stars are required to produce the HeII emission flux of 1.5×10^{-14} ergs s^{-1} cm^{-2} in Mi 499.

The other three HII galaxies shown in Fig. 1 have a broad HeII 4686 feature (FWHM∼30Å; $W_\lambda \simeq 3$Å) but no NIII 4640Å emission, indicating that

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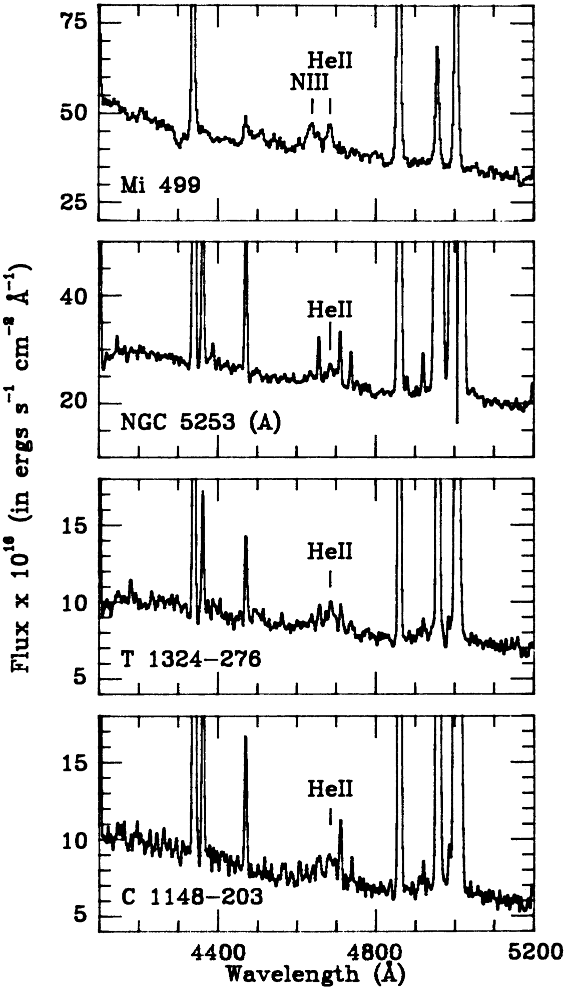

Fig 1: The 4 spectra containing WR stars

the WR stars are probably WN4-6, since this line is about a factor of 10 weaker than HeII 4686 in early WN stars. In addition, the CIV 5800 feature is not observed in these objects.

To begin to relate the presence of these WR features to physical properties of the HII galaxy, we have derived the gaseous O abundance relative to that in the solar neighbourhood (sn) (Shaver *et al.* 1983), using the measured T_e and a typical N_e of 100 cm^{-3}. Where [OIII] 4363 is not observed (in regions of moderate age or high O abundance), T_e cannot be measured, and we were not able to determine O/H in such objects. The O abundance may be estimated indirectly (for $O/H \gtrsim 0.7 O/H_{sn}$) from the flux of [OIII] 4959, 5007Å relative to that of Hβ; using the calibration of Edmunds & Pagel (1984 and references therein), we derive an abundance for Mi 499 of ∿ $1.5 O/H_{sn}$. We have divided the objects arbitrarily into 3 abundance groups, as indicated by the symbols in Fig. 2. The WR containing objects have abundances throughout the range ($0.15 O/H_{sn} < O/H < 1.5 O/H_{sn}$) covered by our sample. The only object which may contain WC stars, Mi 499, has an unusually high gaseous abundance.

Fig. 2 shows the distribution of the objects in the log (4*[OIII] 4959/ [OII] 3727), log ($W_{H\beta}$) plane. As the ionizing cluster evolves and its integrated spectral energy distribution changes, an HII galaxy moves from upper right to lower left in this diagram, thus providing an age estimator (Terlevich *et al.* 1985). The WR-containing objects are grouped in a narrow age range (∿3-4 Myr) with the exception of Mi 499, whose position in the diagram indicates an age of $\gtrsim$ 6Myr.

We have both broad-band (JHK) and narrow-band (2.3μ, CO index) infrared photometry for the 2 bursts in Tol 3, the brightest burst in

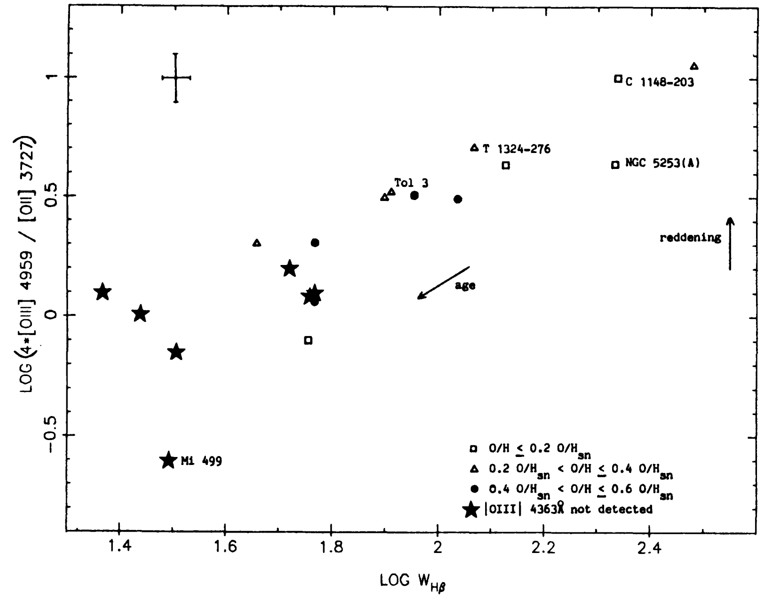

Fig. 2: The distribution in the log |OIII|/|OII|, log $W_{H\beta}$ plane.

T 1457-262 and the 2 brightest knots in the nucleus of NGC 5253. A large CO index or, less directly, aperture photometry, indicates that red supergiants (RSG) are present in NGC 5253 (B). T1457-262 (A) and Tol 3 (SE) (Campbell & Terlevich 1984). Similarly, RSGs are not present in NGC 5253 (A) and Tol 3 (NW). The 4 objects in Fig. 1, Mi 499, C 1148-203, NGC 5253 (A) and T 1324-276, together with Tol 3 (NW), are known to contain WN stars. At comparable continuum S/N, no WR stars are detected in Tol 3 (SE), NGC 5253 (B) and T 1457-262 (A). The data therefore suggest that, as found in the Galaxy (e.g. Maeder *et al.* 1980), RSG and WR stars do not occur (at the same time) in the same star-forming regions. A more detailed analysis, now underway, is required to explain how this phenomenon is related to the physical properties of the cluster such as age, mass and abundance.

REFERENCES

Allen,D.A., Wright,A.E. & Goss,W.M., 1976, *Mon.Not.R.astr.Soc.*,177, 91
Kunth,D. & Sargent,W.L.W., 1981, *Astron.Astrophys.*,101, L5
Campbell,A.W. & Terlevich,R.J., 1984, *Mon.Not.R.astr.Soc.*,211, 15
Campbell,A.W., Terlevich,R.J. & Melnick,J., 1985, in preparation.
D'Odorico,S., Rosa,M. & Wampler,E.J., 1983, *Astron.Astrophys.Suppl.*,53, 97
Edmunds,M.G. & Pagel,B.E.J., 1984, *Mon.Not.R.astr.Soc.*,211, 507
Maeder,A., Lequeux,J. & Azzopardi,M., 1980, *Astron.Astrophys.*,90, L17
Shaver,P.G., McGee,R.X., Danks,A.C. & Pottasch,S.R., 1983, *Mon.Not.R.astr.Soc.*,204, 53
Terlevich,R.J., Melnick,J. & Campbell,A.W., 1985, in preparation