ANALYSIS OF THE OPTICAL SPECTRA OF WOLF-RAYET GALAXIES

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Wolf-Rayet (W-R) galaxies are a subset of emission-line galaxies in whose integrated spectra a broad (i.e., stellar in origin) He II λ 4686 emission feature has been detected. This line is a prominent emission feature in the spectra of WN stars. The presence of 10^2 to 10^5 W-R stars in these galaxies has been inferred from a comparison of the luminosity and equivalent width of this feature in the integrated galaxy spectra with those of the corresponding line in the spectra of Galactic and LMC WN stars. Most W-R galaxies exhibit other properties indicative of a very young starburst population, such as a relatively "blue" continuum and a strong nebular emission line spectrum due to photoionization by large numbers of hot, early-type stars. Their spectra are therefore very similar to to those of giant H II regions. There are currently about 40 W-R galaxies known.

As part of a systematic study of the properties of these galaxies, we have obtained moderate resolution ($\sim$ 3.5 Å) and S/N ($\sim 15-30$) optical spectra of ten W-R galaxies. The spectra were acquired during two observing runs on the 4-m telescope at CTIO and cover the wavelength ranges $\sim$ 3120 to $\sim$ 5400 Å and $\sim$ 4500 to $\sim$ 7000 Å.

The nebular emission lines have been used to determine reddenings, temperatures ($T_e \sim 12{,}000$ K), densities ($N_e \sim 200$ cm^{-3}), and total ionizing fluxes in these galaxies. The observed emission line ratios are found to be similar to those of H II and starburst galaxies. In all ten of the W-R galaxies the He II λ4686 feature is resolved, with a typical FWHM $\sim$ 15 Å. The spectra of several W-R galaxies exhibited a broad N III λ4638 emission feature as well. Both lines are characteristic of the spectra of Galactic and LMC WN stars. A few objects exhibit a broad emission feature of C IV λ5808, indicative of the presence of WC stars. Using the strength of the He II λ4686 feature, we have estimated the number of WN stars present in these galaxies to be $\sim 100-3000$. We have accounted for the contribution from the WN stars to the total ionizing flux and determined the WN/O star number ratios in these galaxies from the relative strengths of the stellar He II λ4686 and nebular $H\beta$ emission lines. We find ratios in the range $\sim 0.06-1.0$, much larger than those predicted by standard hot-star evolution models. This result suggests that the upper end of the initial mass functions in W-R galaxies may be very flat, the starburst episodes may be very short compared to massive star lifetimes, or the nebular regions may not be completely optically thick to Lyman continuum photons. Because evolutionary models indicate that the W-R phase lasts only ten percent of the O star main sequence lifetime, emission-line galaxies containing large numbers of W-R stars may represent the youngest phases of the starburst phenomenon, in which massive star formation is still occurring or has only recently ended ($\lesssim$ few $\times 10^6$ years ago).

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