Wolf-Rayet Phenomena in Massive Stars and Starburst Galaxies
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Ejected nebulae as probe of Wolf-Rayet Lyman-continua

Anna Pasquali[1], Paul A. Crowther[2], Werner Schmutz[3], and D. John Hillier[4]

[1]*ST-ECF/ESO, Karl-Schwarzschild-Strasse 2, D-85748 Garching bei München, Germany*
[2]*Department of Physics & Astronomy, UCL, Gower Street, London WC1E 6BT, UK*
[3]*Institute für Astronomie, ETH Zentrum, Häldeli-Weg 15, Zürich CH-8092, Switzerland*
[4]*Department of Physics and Astronomy, University of Pittsburgh, 3941 O'Hara Street, Pittsburgh PA 15260, USA*

Abstract. We present the first results from our analysis of WR model atmospheres in the UV domain. Specifically, we test the model atmospheres derived for WR 124 and WR 18 from the Hillier & Miller (1998) and Schmutz (1997) codes through photo-ionization modelling of the associated nebula or H II region. Both codes assume non-LTE and line-blanketing, while photon-loss is implemented only in Schmutz (1997) code. The comparison of the predicted nebular properties with observations indicates that: *(i)* line-blanketing is essential in reconciling the stellar and nebular properties of WR stars; and *(ii)* in the case of WR 18 the inclusion of photon-loss produces a slightly more ionized nebula than observed. However, the effect of different model properties such as mass-loss rate has still to be investigated.

1. Introduction

Hot, massive stars emit the majority of their flux below 912 Å. Unfortunately, this range is not directly observable, except for very bright OB stars at negligible interstellar reddening. Therefore, the UV domain at $\lambda < 912$ Å can be investigated only indirectly, *i.e.*, by fitting the modelled spectral energy distribution to the observed spectrum of the star from near-UV to IR wavelengths. Alternatively, since the observed properties of the associated nebulae depend on the UV flux distribution of their central stars, it is possible to use a grid of model atmospheres to obtain the temperature of the ionizing star by the nebular characteristics. Here we propose a different technique: we test the model atmosphere from the analysis of the stellar spectrum through photoionization modelling of the associated nebula or H II region (CLOUDY, Ferland *et al.* 1997). In particular, we test the current generation of line-blanketed model atmospheres for Wolf-Rayet stars by Hillier & Miller (1998) and Schmutz (1997), the two sets being different in that Schmutz (1997) code includes photon-loss. For this purpose we have selected two WR stars with the best studied associated nebulae: WR 124 in M1-67, and WR 18 in NGC 3199. These nebulae have been previously studied by Esteban *et al.* (1991, 1992) who derived plasma properties and chemical abundances.

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2. The results

Our preliminary results are summarized in Table 1, where we list the most relevant observed and predicted quantities for the nebulae associated with WR 124 and WR 18.

Table 1. Observations and predictions for WR nebulae.

	T_e (K)	n_e (cm^{-3})	S^{2+}/S^+	O^{2+}/O^+
M1-67: observed	6200	1050	1.7	< 0.03
M1-67: unblanketed	9800	1050	44.7	7.4
M1-67: Hillier & Miller	6100	1050	1.6	10^{-8}
NGC 3199: observed	9800	102		2.3
NGC 3199: Hillier & Miller	9500	102		2.3
NGC 3199: Schmutz	9300	102		5.0

2.1. WR 124 and M1-67

Both the unblanketed and blanketed models (derived by fitting the optical spectrum) give for WR 124 $T_{\rm eff} = 33\,000$ K and $\log(L/L_\odot) = 5.3$. However, the photoionization properties they predict for M1-67 through CLOUDY are significantly different. While the line-blanketed atmosphere is able to reproduce the observed nebular properties rather well, the unblanketed model completely fails to match the oxygen O^{2+}/O^+ balance, producing a more ionized nebula than observed.

2.2. WR 18 and NGC 3199

Hillier & Miller and Schmutz models of WR 18 agree in $T_{\rm eff}$ (83 000 K), but differ in $\log(L/L_\odot)$, being 5.3 and 5.4 respectively. Their predictions are in reasonable agreement with the observed nebular fluxes of NGC 3199, although the inclusion of photon-loss yields a harder flux distribution, enhancing the predicted ionization-balance of the nebula.

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