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The masses of late-type WN stars

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Abstract. We present recent results for galactic WNL stars, obtained with the new Potsdam Wolf-Rayet (PoWR) hydrodynamic model atmospheres. Based on a combination of stellar wind modeling and spectral analysis we identify the galactic WNL subtypes as a group of extremely luminous stars close to the Eddington limit. Their luminosities imply progenitor masses around $120\,M_\odot$ or even above, making them the direct descendants of the most massive stars in the galaxy. Because of the proximity to the Eddington limit our models are very sensitive to the L/M ratio, thus allowing for a direct estimate of the present masses of these objects.

Keywords. stars: mass loss, stars: winds, outflows, stars: Wolf-Rayet.

In the recent re-analysis of the galactic WN sample with line-blanketed atmosphere models (Hamann *et al.* 2006) the WN stars turned out to form two distinct groups in the HR diagram, which are divided by their luminosities. Among these, the H-rich WNL stars, with luminosities above $10^6\,L_\odot$, are found to the right of the ZAMS, whereas early to intermediate subtypes show lower luminosities and hotter temperatures. The relatively large number of extremely luminous WNL stars already implies that many of these objects might be very massive stars in the phase of central H-burning.

Our hydrodynamic atmosphere models, on the other hand, imply that the formation of WR-type stellar winds is caused by the proximity to the Eddington limit (Gräfener & Hamann 2006; Gräfener, & Hamann 2005). In fact, our models reveal a rather strong dependence of the WR mass loss rates on the Eddington factor Γ_e or, equivalently, on the M/L ratio. Weak-lined WNL stars, with their relatively low mass loss rates, thus should have considerably higher M/L ratios than their strong-lined counterparts.

Detailed spectral modeling of weak-lined WNL stars in Carina OB 1 indeed indicates very high masses for these objects. Note, however, that the results depend on the adopted distance. For WR 22 (WN7h) we find a luminosity of $10^{6.3}\,L_\odot$ (for $m-M=12.1$) and a mass of $78\,M_\odot$, in agreement with the mass estimate by Rauw *et al.* 1996. For WR 25 (WN6ha) we determine values between $110\,M_\odot/10^{6.4}\,L_\odot$ (for $m-M=11.8$), and $210\,M_\odot/10^{6.7}\,L_\odot$ (for $m-M=12.55$). These masses are in agreement with H-burning stars in a late pase of their main-sequence evolution. Our models thus suggest an evolutionary sequence of the form O → WNL → LBV → WN → WC for very massive stars. Interestingly, WR 25 is the only evolved object in the young OB cluster Tr 16, apart from the LBV prototype η Car. Its location at the top of the main-sequence of this cluster, with a slightly lower luminosity than η Car (see Hillier *et al.* 2001), strongly supports its evolutionary stage as an LBV progenitor.

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