Clumping in Hot Star Winds
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Clumping in Galactic WN stars: a comparison of mass loss rates from UV/optical & radio diagnostics

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The mass loss rates and other parameters for a large sample of Galactic WN stars have been revised by Hamann et al. (2006), using the most up-to date Potsdam Wolf-Rayet (PoWR) model atmospheres. For a sub-sample of these stars exist measurements of their radio free-free emission. After harmonizing the adopted distance and terminal wind velocities, we compare the mass loss rates obtained from the two diagnostics. The differences are discussed as a possible consequence of different clumping contrast in the line-forming and radio-emitting regions.

The Potsdam Wolf–Rayet model atmospheres were applied by Hamann et al. (2006) (HGL06) to analyze the UV/optical spectra of Galactic WN stars. Radio continuum emission measurements are available for 12 of these stars (Wendker 1995; Leitherer et al. 1997; Cappa et al. 2004), leaving out known binary systems. For 10 more stars only upper limits of their radio emission could be estimated. We derive mass loss rates with the relation from Wright & Barlow (1975) for free-free emission. Multiple radio measurements were averaged for WR 87, WR 89 and WR 105. The free-free Gaunt factor $g_{\rm ff}$ is calculated following Leitherer & Robert (1991) with a constant electron temperature $T_{\rm e} = 10000$ K. The mean molecular weight μ is taken from our analysis (HGL06) and the mean number of electrons per ion is $\gamma = 1$ – exept for WR 2 and WR 3 where our models indicate that He remains fully ionized. Terminal velocities v_∞ and distances d are taken from HGL06 for consistency.

While UV/optical lines are formed in regions between $1 \ldots 10\ R_*$, the radio emission emerges from $\approx 1000\ R_*$. The empirical mass loss rates from both diagnostics scale with the adopted clumping contrast ($\dot{M} \propto D^{-1/2}$) at their corresponding formation radius. The UV/optical mass loss rates from HGL06 were derived under the assumption of clumping ($D_{\rm opt} = 4$), whereas the radio mass loss rates are derived for an unclumped plasma ($D_{\rm radio} = 1$).

We find that the mass loss rates from the two diagnostics agree remarkably well (see Fig. 1), the average difference in $\log \dot{M}$ being only $\Delta \log \dot{M}$(opt-radio) $= -0.05 \pm 0.10$. This average difference would vanish completely when choosing $D_{\rm opt} = 3.2 \times D_{\rm radio}$. For OB stars, Puls et al. (2006, and this volume) found a higher degree of clumping in the line-forming region, relative to the radio regime.

There are evidences (from electron-scattering line wings) that the clumping contrast in the line-forming region of WR stars is $D_{\rm opt} = 4 \ldots 10$, typically. This implies, together with our present result, that density imhomogeneities are not entirely smoothed out in the radio-emitting region.

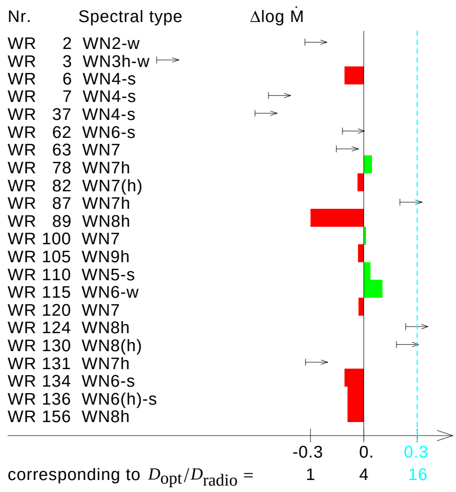

Figure 1: Analysed sample of WN stars

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