TWO POSSIBLE WIND MODELS FOR WOLF-RAYET STARS

T. Nugis
W. Struve Astrophysical Observatory of Tartu
Estonia, USSR

Frequently the models proposed to explain some observational data are in conflict with the other observational data. Our purpose was to find out the empirical models of the envelopes of WN5 and WN6 stars which are not in conflict with the continuum runs in the IR spectral region and with the emission line intensities and profiles. In our recent study (Nugis, 1984) we proposed for Wolf-Rayet stars the spherically symmetric outflow model having an increasing velocity zone (with some coronal heating near the stellar surface) which is followed by the decreasing velocity zone extending up to the distance where the matter starts flowing with constant velocity. Let us call this model the AD-model (Acceleration-Deceleration).

The analysis of theoretical line intensities of HeI and HeII found by us by solving the statistical equilibrium equations for level populations at different distances from the stellar surface (by using the Sobolev escape probability method (Sobolev, 1960)), has confirmed that from spherically symmetric outflow models only the AD-model agrees with the observed line spectra of WN5 and WN6 stars. The intensity ratios suggest that HeI lines are effectively formed at distances $R > 4R_*$ (R_* is the stellar radius). In the case of monotonically increasing or constant velocity flows the optical depths of HeI lines are small at such distances and therefore no strong absorption components can be obtained in calculations. The agreement with the observed HeI spectrum can be obtained only in the case of the AD-type models (from spherically symmetric flows).

The specific feature of HeII line spectra of WN5 and WN6 stars is that lower members of the Pickering series have no apparent absorption components although from the line intensity ratios it can be concluded that the line optical depths for them must be greater than unity, provided the level populations have a normal run in the sense that the Menzel coefficients b_n are approaching unity from above ($b_k/b_i < 1$ if $i < k$ and $i < n_o$, where n_o is the principal quantum number beginning from which $b_n \approx 1$). Usually Menzel coefficients have a normal run. The only possibility to get agreement with observations is the case when $S_L > I_\nu^*$ at high expansion velocities (in the case of Planckian approximation to

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the stellar radiation: $S_L/I_\nu^* = (\exp(h\nu/kT_*)-1)/(b_i/b_k\exp(h\nu/kT_e)-1))$. This condition cannot be fulfilled as it appeared from our present calculations for the models having comparatively low T_* values ($T_* \approx 30000$ - 50000), even if $T_e > T_*$. This condition was not fulfilled also in the calculations by Castor and Van Blerkom (1970) for $T_e > T_*$ models. Our calculations showed that the condition $S_L > I_\nu^*$ can be fulfilled for the Pickering lines in the HeIII zone of WN5 and WN6 stars if we assume that the coronal heating takes place only in the thin region close to the stellar surface and that due to this heating the radiation power of the core in the first series continuum increases.

If we want to have a model without decelerating flow region, then we must give up the assumption of spherical symmetry. Let us consider the flow, which is on a large scale average, spherically symmetric. In our "alternative" model the radial matter streams from different spherical zones on the stellar surface are moving outward at periodically different speeds ($v(r,\varphi) = v(r,\varphi+n\varphi_o)$, where φ is the latitudinal angle of the spherical zone on the stellar surface). If φ_o is small, then the line-of-sight velocities above the stellar disk may be very different even at a comparatively large distance from the star. To get the agreement with the observed line spectrum of HeI it is yet necessary that the matter streams from different spherical zones on the stellar surface (with $\Delta\varphi < \varphi_o$) would be compressed into a smaller opening angle beginning at some distance from the star. The proposed "alternative" model is only a schematic empirical model. The estimates show that the mass loss rates and the optical depths of the envelopes in electron scattering of this model are smaller as compared to the case of the spherically symmetric AD-model. This "alternative" model belongs to the category of alternative models proposed for the atmospheres of Wolf-Rayet and O stars by Underhill (1983).

The crucial test for our models ought to be far IR spectrophotometry. The presence in the far IR spectral region of the lines of high ionization potential ions, such as of NV, favours the second model ("alternative" model) because in the case of a spherically symmetric model one cannot see at long wavelengths the regions of the envelope which are situated close to the stellar surface.

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