WR analysis

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Wolf-Rayet (WR) stars are massive stars with strong, hydrogen-deficient winds. Their spectral analysis requires adequate numerical simulations. Modeling such expanding atmospheres is a difficult task because of the extreme non-LTE situation, the need to account for complex model atoms, especially for the iron-group elements with their millions of lines, and because of the supersonic expansion. Adequate codes have been developed successfully e.g. by the Munich group (Puls, Pauldrach), Hillier (CMFGEN) and in Potsdam (PoWR). While early work was based on the assumption of a smooth and homogeneous spherical stellar wind, the need to account for clumping became obvious about ten years ago. A relatively simple first-order clumping correction was readily implemented into the model codes. However, its simplifying assumptions are severe.

Recently we developed a more realistic treatment, which accounts for optically thick clumps by a statistical treatment. The porosity effect on continuum opacity was shown to facilitate the emergence of X-rays. When clumps are optically thick at line frequencies, strong spectral features become generally weaker. This holds also for resonance lines. The recently reported discrepancy between the Hα line and the P V resonance doublet in O star spectra can be perfectly reconciled without a further reduction of the mass-loss rate and correspondingly stronger clumping. It is not yet known to which extend "macroclumping" affects WR spectra and their analysis.

Mass-loss from O and WR stars is driven by the momentum transfer from UV photons to the ions of heavy elements. This has been worked out in hydrodynamically self-consistent models for O stars, however on the expense of approximations in the radiative transfer. For WR stars such models used to fall short in explaining the high mechanical momentum of their strong winds. Only recently, we combined the PoWR code with the hydrodynamic equations and obtained self-consistent WR models, showing that the previous shortfalls were due to deficiencies in the radiative-transfer treatment.

The PoWR models were employed for analyzing a comprehensive sample of Galactic WN stars. The results show, more clearly than in previous work, the separation of the WN stars in two distinct groups. The late-type WN stars are very luminous, contain more or less atmospheric hydrogen and are probably hydrogen-burning stars which never crossed the HR diagram to the red side. The hydrogen-free early-type WN stars are less luminous and stem from progenitors of lower initial mass after an excursion to the cooler part of the HRD. Hence most WNE stars have not evolved from WNL. We compared our analytic results with a population synthesis, based on Geneva evolutionary models with and without rotation, and found that the agreement is not yet satisfactory.