Mass loss from inhomogeneous hot star winds
II. Constraints from a combined optical/UV study

J.O. Sundqvist(1), J. Puls(1), A. Feldmeier(2), S.P. Owocki(3)

1 - UniversitÃ¤tssternwarte MÃ¼nchen, Germany; 2 - Institut fÃ¼r Physik und Astronomie, Potsdam, Germany; 3 - University of Delaware, Bartol Research Institute, Newark, USA

Context: Mass loss is essential for massive star evolution, thus also for the variety of astrophysical applications relying on its predictions. However, mass-loss rates currently in use for hot, massive stars have recently been seriously questioned, mainly because of the effects of wind clumping. Aims: We investigate the impact of clumping on diagnostic ultraviolet resonance and optical recombination lines often used to derive empirical mass-loss rates of hot stars. Optically thick clumps, a non-void interclump medium, and a non-monotonic velocity field are all accounted for in a single model. The line formation is first theoretically studied, after which an exemplary multi-diagnostic study of an O-supergiant is performed. Methods: We used 2D and 3D stochastic and radiation-hydrodynamic wind models, constructed by assembling 1D snapshots in radially independent slices. To compute synthetic spectra, we developed and used detailed radiative transfer codes for both recombination lines (solving the `formal integral') and resonance lines (using a Monte-Carlo approach). In addition, we propose an analytic method to model these lines in clumpy winds, which does not rely on optically thin clumping. Results: The importance of the `vorosity' effect for line formation in clumpy winds is emphasized. Resonance lines are generally more affected by optically thick clumping than recombination lines. Synthetic spectra calculated directly from current radiation-hydrodynamic wind models of the line-driven instability are unable to in parallel reproduce strategic optical and ultraviolet lines for the Galactic O-supergiant LCep. Using our stochastic wind models, we obtain consistent fits essentially by increasing the clumping in the inner wind. A mass-loss rate is derived that is approximately two times lower than what is predicted by the line-driven wind theory, but much higher than the corresponding rate derived when assuming optically thin clumps. Our analytic formulation for line formation is used to demonstrate the potential importance of optically thick clumping in diagnostic lines in so-called weak-winded stars and to confirm recent results that resonance doublets may be used as tracers of wind structure and optically thick clumping. Conclusions: We confirm earlier results that a re-investigation of the structures in the inner wind predicted by line-driven instability simulations is needed. Our derived mass-loss rate for LCep suggests that only moderate reductions of current mass-loss predictions for OB-stars are necessary, but this nevertheless prompts investigations on feedback effects from optically thick clumping on the steady-state, NLTE wind models used for quantitative spectroscopy.

Reference: Accepted for publication in Astronomy and Astrophysics, pre-print available on astro-ph.
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1101.5293

Comments:

Email: jon@usm.uni-muenchen.de