Spectral analysis of early-type stars using a genetic algorithm based fitting method

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We present the first automated fitting method for the quantitative spectroscopy of O- and early B-type stars with stellar winds. The method combines the non-LTE stellar atmosphere code {\sc fastwind} from Puls et al.\ (2005) with the genetic algorithm based optimizing routine {\sc pikaia} from Charbonneau (1995), allowing for a homogeneous analysis of upcoming large samples of early-type stars (e.g.\ Evans et al.\ 2005). In this first implementation we use continuum normalized optical hydrogen and helium lines to determine photospheric and wind parameters. We have assigned weights to these lines accounting for line blends with species not taken into account, lacking physics, and/or possible or potential problems in the model atmosphere code. We find the method to be robust, fast, and accurate. Using our method we analysed seven O-type stars in the young cluster Cyg OB2 and five other Galactic stars with high rotational velocities and/or low mass loss rates (including 10~Lac, ζ~Oph, and τ~Sco) that have been studied in detail with a previous version of {\sc fastwind}. The fits are found to have a quality that is comparable or even better than produced by the classical ``by eye'' method. We define errorbars on the model parameters based on the maximum variations of these parameters in the models that cluster around the global optimum. Using this concept, for the investigated dataset we are able to recover mass-loss rates down to $\sim$ 6×10^{-8} $M_{\odot}{\rm yr}^{-1}$ to within an error of a factor of two, ignoring possible systematic errors due to uncertainties in the continuum normalization. Comparison of our derived spectroscopic masses with those derived from stellar evolutionary models are in very good agreement, i.e.\ based on the limited sample that we have studied we do not find indications for a mass discrepancy. For three stars we find significantly higher surface gravities than previously reported. We identify this to be due to differences in the weighting of Balmer line wings between our automated method and ``by eye'' fitting and/or an improved multidimensional optimization of the parameters. The empirical modified wind momentum relation constructed on the basis of the stars analysed here agrees to within the error bars with the theoretical relation predicted by Vink et al.\ (2000), including those cases for which the winds are weak (i.e.\ less than a few times 10^{-7} $M_{\odot}{\rm yr}^{-1}$).

Reference: A\&A in press
Status: Manuscript has been accepted

Weblink: http://xxx.lanl.gov/abs/astro-ph/0506751

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