Optically Thick Winds of Novae

Jason P. Aufdenberg
Department of Physics and Astronomy, Arizona State University, Tempe, AZ 85287-1504 USA

Peter H. Hauschildt, C. Ian Short
Department of Physics and Astronomy & Center for Simulational Physics, University of Georgia, Athens, GA 30602-2451 USA

Sumner G. Starrfield
Department of Physics and Astronomy, Arizona State University, Tempe, AZ 85287-1504 USA

Abstract. We present the latest improvement to the stellar wind module (Aufdenberg, 2000) of the multi-purpose radiative transfer and stellar atmosphere code PHOENIX. We are able to simulate the structure and spectrum of an optically thick stellar wind for use in the analysis of classical novae in outburst, luminous blue variables, and Wolf-Rayet stars. The spherically symmetric relativistic radiative transfer equation is solved in the co-moving frame and non-LTE metal line-blanketing is included in both the construction of the temperature structure and the synthetic spectrum. The temperature structure is iteratively converged under the condition of energy conservation. As an example, we show a comparison of our optically thick wind model to observations of Nova Vel 1999. The STIS spectrum (Shore et al. 1999) and V-band flux (Sargent 1999) of Nova V382 Velorum are better reproduced by adopting a wind/beta-law form for the velocity field rather than a ballistic/linear velocity law.

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References

Seargent, D. A. J. 1999, IAU Circular No. 7184

1Current address: Harvard-Smithsonian Center for Astrophysics, 60 Garden St MS 15, Cambridge, MA 02138 USA
Figure 1. The STIS UV spectrum and V-band flux of Nova Vel 1999 compared to model atmospheres with linear (standard nova model, dashed line) and beta-law (wind model, dotted line) velocity fields. Both models represent fairly well the UV flux distribution, however while the beta-law model is consistent with the observed V magnitude, the linear velocity law synthetic spectrum is nearly 5 times brighter than the observed visual continuum.

Figure 2. A comparison of the model atmosphere structures for the synthetic spectra in Fig. 1. The figure shows the run of velocity (left axis) and temperature (right axis) with radius. Both models have the same mass-loss rate (\(\dot{M} = 10^{-4} M_\odot \text{ yr}^{-1}\)), with model temperatures of 18 kK (linear) and 45 kK (beta-law). The linear model, with a larger effective opacity due to the desaturation of lines (effectively higher \(\beta\)) away from the terminal velocity, becomes optically thick at a much larger radius (factor of \(\approx 10\)) than the beta-law model. In the beta-law model the smaller radius of the UV photosphere is offset by the higher temperatures at these depths, and the two models match in the UV. The visual continuum, with a color temperature of roughly 9000 K, forms at a radius \(\sim 2\) times larger in the linear model, thereby producing too much flux in the V-band.