MESA Models of Classical Nova Outbursts

Novae are cataclysmic variables driven by accretion of H-rich material onto white dwarfs (WDs) from their low-mass main-sequence or red-giant binary companions. In this work (Denissenkov et al. 2013, ApJ, 762, 8), we have used the state-of-the-art stellar evolution code MESA (**http://mesa.sourceforge.net**) to construct multi-cycle evolution sequences of novae with CO WD cores. We have explored a range of WD masses ($0.65M_{\odot}$, $0.85M_{\odot}$, $1.0M_{\odot}$, $1.15M_{\odot}$, and $1.2M_{\odot}$) and accretion rates (from $10^{-11}M_{\odot}$/yr to 10^{-9} $M_{\odot}$/yr) as well as the effect of different cooling times (different initial WD temperatures and luminosities) before the onset of accretion. In addition, we have studied the dependence on the elemental abundance distribution of accreted material and convective boundary mixing (CBM) at the core-envelope interface. In the first case, which is commonly accepted in 1D nova simulations, the CBM was mimicked by assuming that the accreted envelope had been pre-mixed with WD's material. In the second case, the CBM was implemented using a diffusion coefficient that was exponentially decreasing with a distance from the bottom of the convective envelope. This 1D approximation for CBM is supported by 3D hydrodynamic simulations of He-shell flash convection in AGB stars (Herwig et al. 2011, ApJ, 727, 89). Our nova models with such CBM display an enrichment of the accreted envelope with C and O from the underlying white dwarf that is commensurate with observations. We have compared our results with the previous work and investigated a new scenario for novae with the ^{3}He-triggered convection. We have found that ^{3}He can be produced in H-rich envelopes accreted with slow rates ($dM/dt < 10^{-10}$ $M_{\odot}$/yr) by cold ($T_{WD} < 10^{7}$ K) CO WDs, and that convection is triggered by ^{3}He burning before the nova outburst in this case.

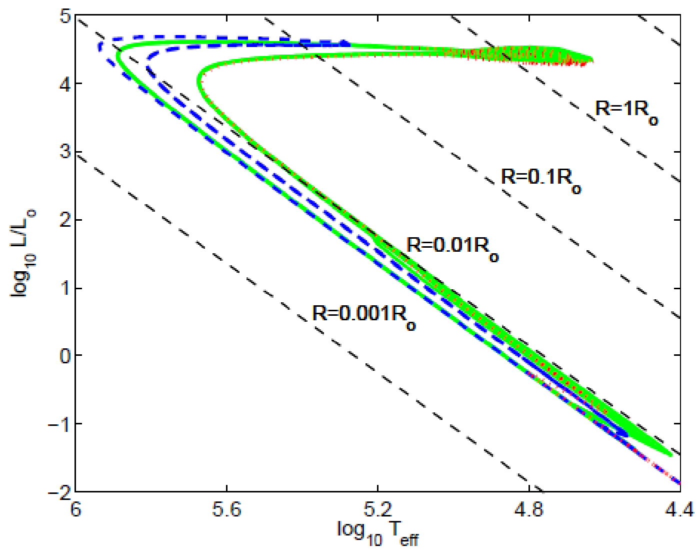

Figure 1: Evolutionary tracks of our CO nova models with $M_{WD} = 1.15$ $M_{\odot}$, $T_{WD} = 15$ MK (dotted red curve) or $T_{WD} = 30$ MK (solid green and dashed blue curves), and $dM/dt = 10^{-10}$ $M_{\odot}$/yr. The accreted material is a mixture of 70% solar and 30% WD's core compositions (dashed blue) or has the solar composition (dotted red and solid green).

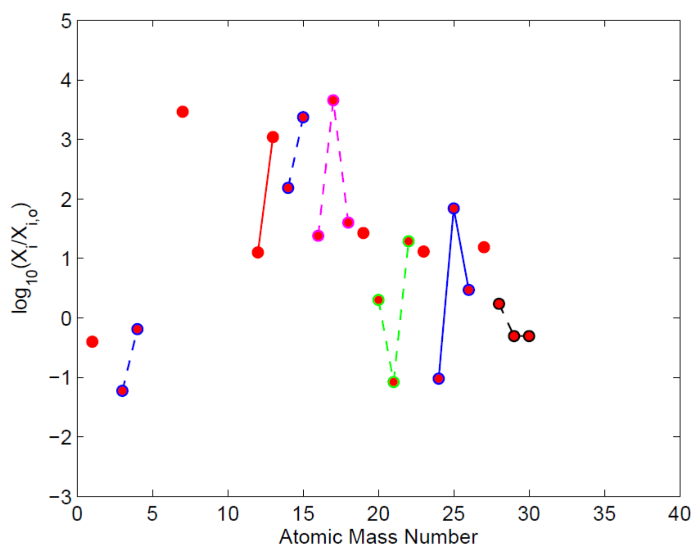

Figure 2: Solar-scaled mass-averaged abundances in the expanding envelope of a last model with $M_{WD} = 1.15$ $M_{\odot}$, $T_{WD} = 15$ MK and $dM/dt = 2\times10^{-10}$ $M_{\odot}$/yr. Our final abundances agree very well with those presented by José & Hernanz (1998, ApJ, 494, 680) in their Fig. 1 for a CO nova model with similar parameters.

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