Tools for Astrophysics: MESA and NuGrid

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Stellar Evolution and Post-Processing Nucleosynthesis Computations With

MESA and NUGRID

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MESA

- MESA is a collection of Fortran-95 Modules for Experiments in Stellar Evolution

- It is free for download from the website http://mesa.sourceforge.net that also explains how to install and run the code

- The main MESA module star can be used for one-dimensional stellar evolution simulations of almost any kind; other MESA modules provide star with state-of-the-art numerical algorithms, atmospheric boundary conditions, and modern input physics

- Parameters for a MESA star run are specified in the inlist file that contains three Fortran-95 parameter namelists: star_job, controls, and pgstar.

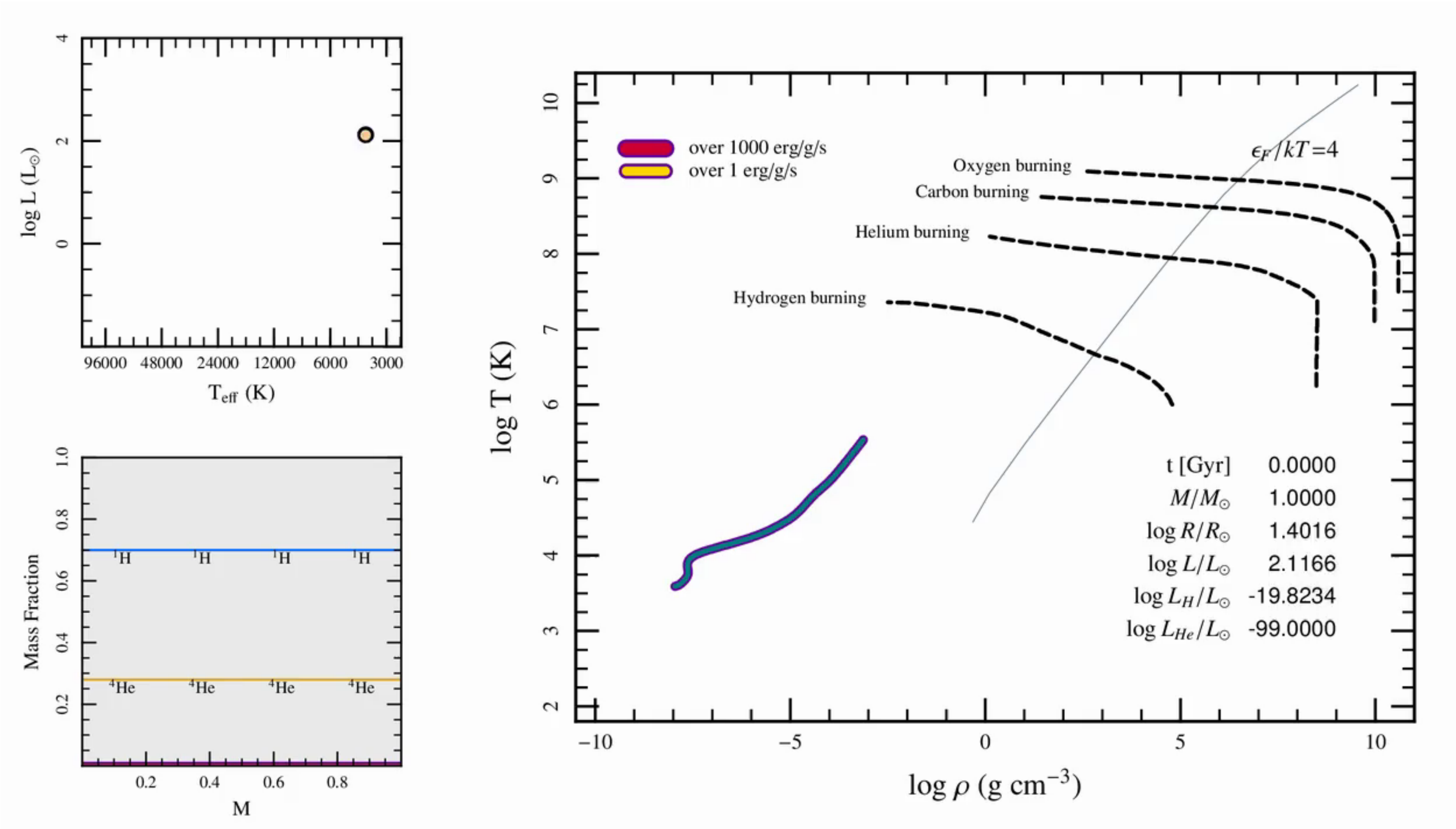
- All of the MESA star parameters already have reasonable default values with which standard stellar evolution simulations can be done

- Initial mass and chemical composition of a star, and a condition when to stop the simulations can be changed in the controls namelist

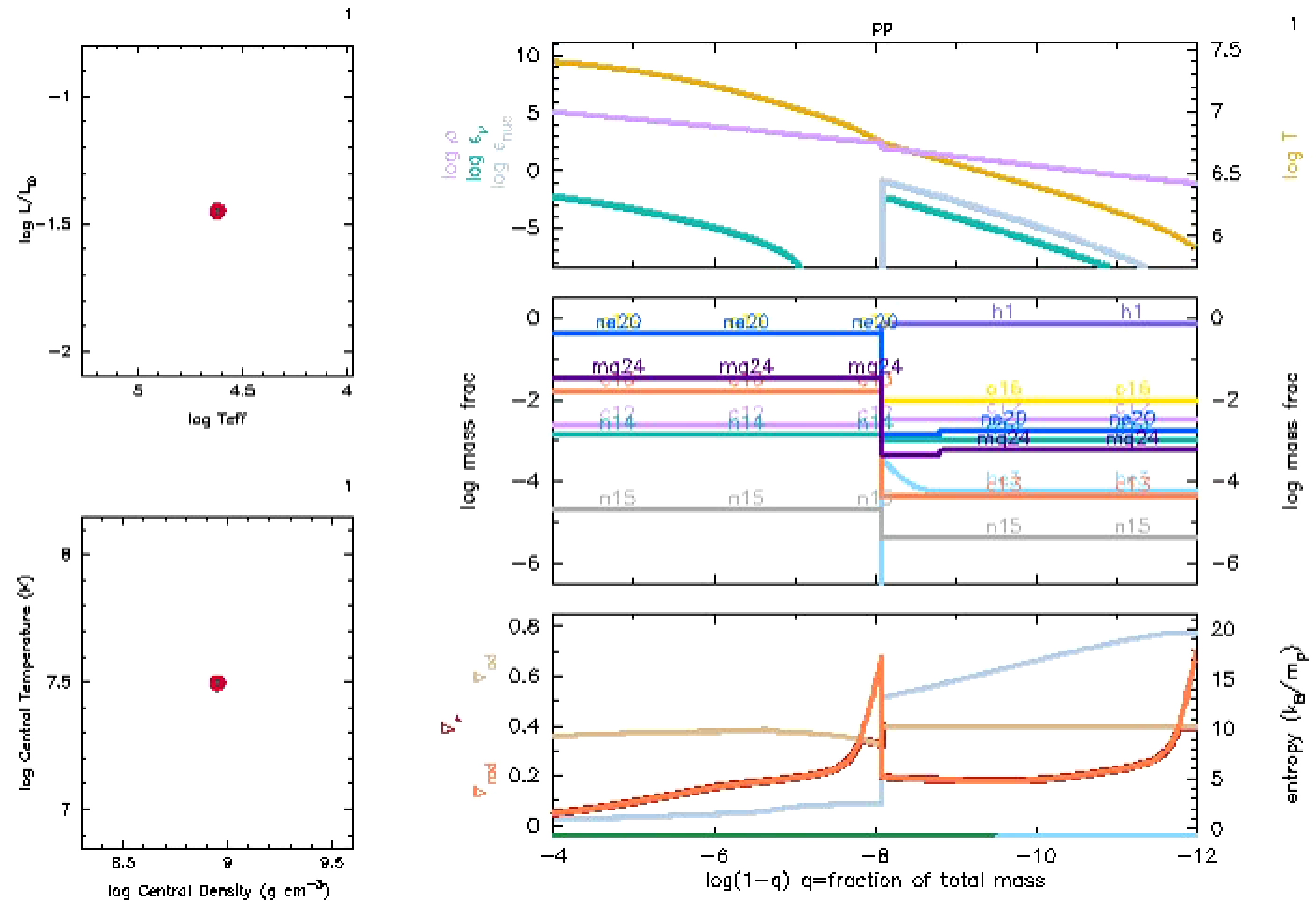
- For more details and references, read the paper version of this MESA/NuGrid tutorial, e.g. at http://astrowww.phys.uvic.ca/~dpa/

- The following slides will illustrate applications of MESA and NuGrid for simulations of stellar evolution and nucleosynthesis

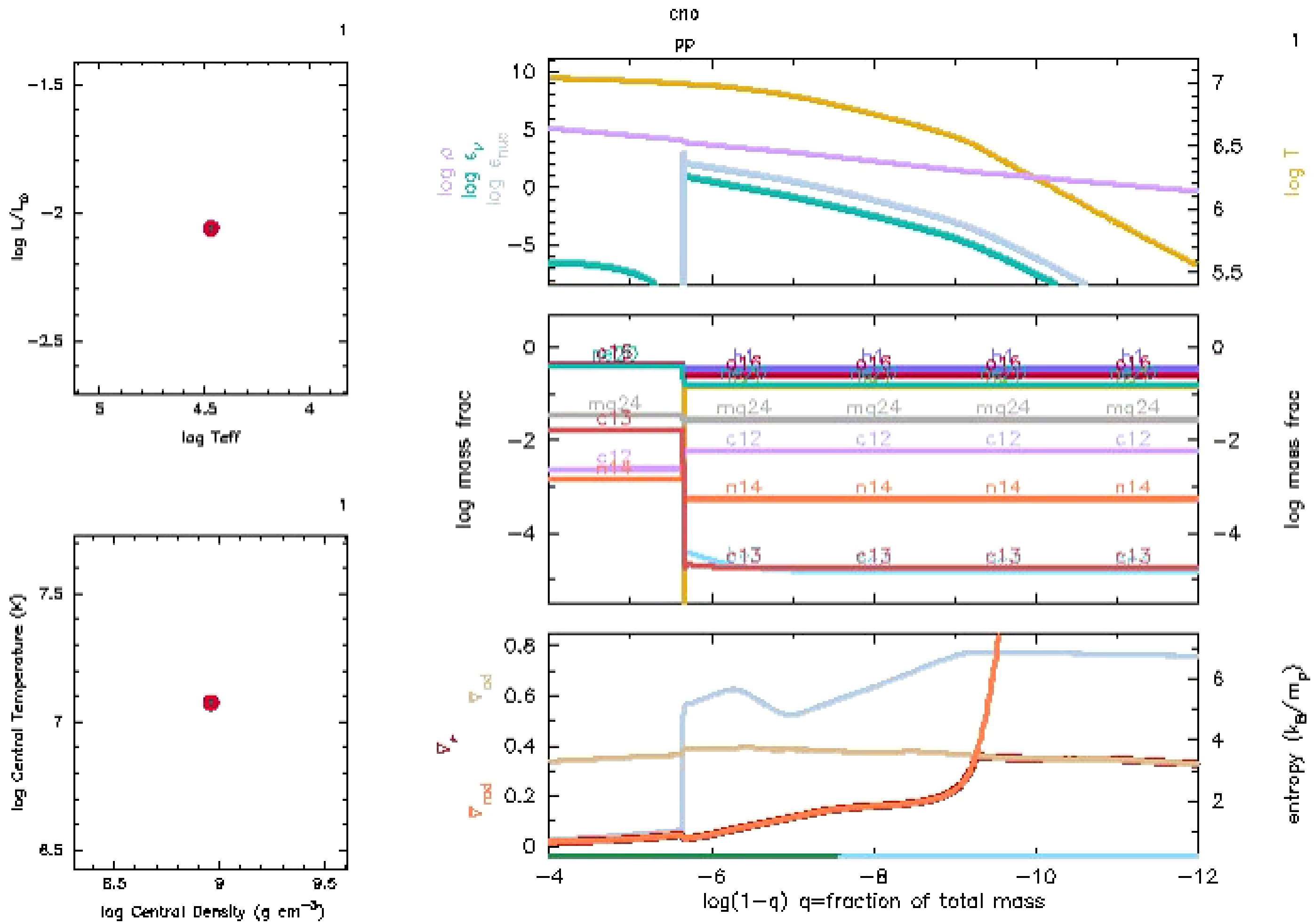
MESA star can compute without any interruption the evolution of a solar-type star from the pre-MS phase through the He-core flash and thermal pulses on the AGB towards white-dwarf cooling (the movie from the MESA website)



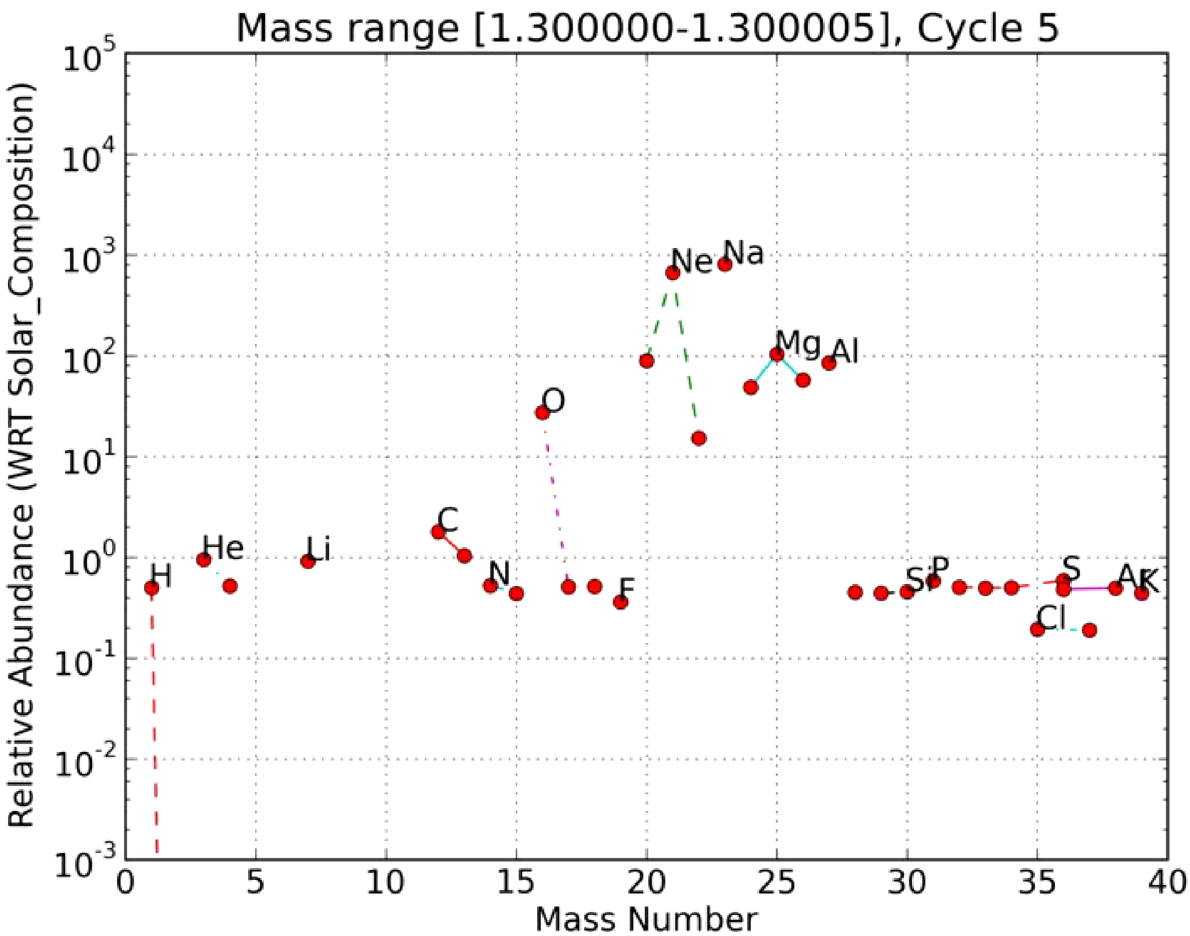
The multi-cycle nova outbursts occurring on the 1.3M$_\odot$ ONe white dwarf with T=30 MK for the mass accretion rate 10^{-10} M$_\odot$/yr; the excess of L over L_{edd} is assumed to be transformed into the kinetic energy of mass loss; there is no convective boundary mixing



The nova outburst on the $1.3M_{\odot}$ ONe WD with T=12MK for $dM/dt=2\times10^{-10}M_{\odot}/yr$; the WD accretes a mixture of equal amounts of its core and solar-composition materials; this nova model is similar to those considered in other publications



MESA star can output stellar models in a format readable by the NuGrid multi-zone code MPPNP that can use them for post-processing nucleosynthesis computations; NuGrid tools include Python scripts that produce plots like those shown on the next two slides



Variations of the relative abundances of stable isotopes in the envelope of the nova model shown on the previous slide

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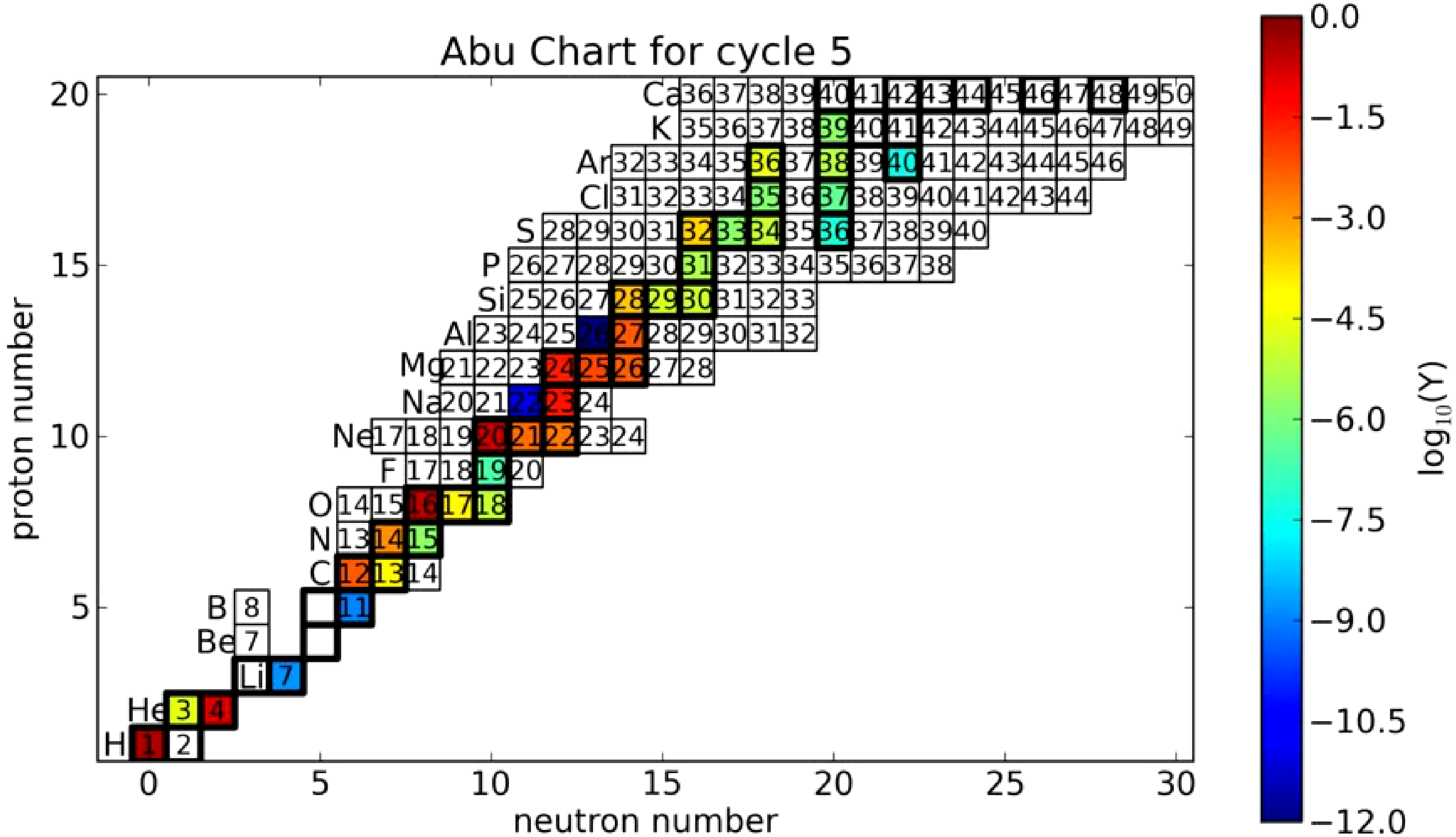

Variations of the isotope abundances in the envelope of the same nova model displayed on a chart of nuclides

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