MESA Summer School 2013: Helium Burning Stars Mini-Lab

Lecturer: Lars Bildsten, TA: Bill Wolf

Objectives

In this short exercise, we'll investigate the properties of the Helium-burning zero-age main sequence (ZAMS). Then, we'll look at what happens as these stars leave the ZAMS and what becomes of their He-depleted cores. You should be able to start from a nearly blank inlist. Copy a work directory over form `mesa/star/work` and clear out the `star_job` and `controls` namelists. These exercises won't require more than a few commands to get going, so you should be able to make your own inlists with a little help.

Part 1

Instructions

- Pick a random number between zero and one and use it to determine the mass of your star uniformly between 0.2 $M_\odot$ and 4.0 $M_\odot$.
- Starting from the pre-main sequence, evolve a pure helium star of your mass until the He ZAMS. That is, stop and save a model when $L_{\rm nuc} \approx L$ or when the central helium abundance has dropped by $\approx 10\%$.
- From your He ZAMS model, tell us the mass of your star, and L, $T_{\rm eff}$, T_c, ρ_c (central temperature and density), and the mass of the convective core. Send these six pieces of data to Bill Wolf at `wmwolf@physics.ucsb.edu`.

Inlist Hints

As always, look for useful options/switches in `mesa/star/defaults/star_job.defaults` for the `&star_job` namelist and `mesa/star/defaults/controls.defaults` for the `&controls` namelist.

- You need to create a model from the pre-main sequence. Look for help in `star_job.defaults`
- You need to make the star be pure helium. Check out the `relax_Y` options in `star_job.defaults`. If you use those, be sure to set `initial_Y` and `initial_Z` to zero, too.
- Be sure to set your initial mass to the one you determined randomly.
- The run should end when Helium burning has become the dominant source of luminosity. You can use an energy-generation rate criterion or a central abundance criterion. See the `when to stop` section of `controls_default.defaults` for some options.
- When you've reached your stopping condition, either save a model to load in part 2 or remember the photo number and restart from it for part 2.

Part 2

Instructions

You'll need to use the model you created in part 1. Either load the model you saved from part 1 or change your inlist and restart from the last photo. If you were unable to produce a model in part 1, use one of the pre-made models provided to you. Then, do the following:

- Take the model you created in Part 1 and run it until the core is exhausted of helium.
- Report the time taken to burn all of the helium (from ZAMS, not from the pre-main sequence).
- Report the C-O mix in the center at this time. That is, what are the central mass fractions of `c12` and `o16` in the core when the helium is exhausted?
- Send your mass and these data to Bill Wolf at `wmwolf@physics.ucsb.edu`.
- Once the core has burned out, keep running it to see *if* you get helium to burn in the shell just above the C-O core.

Inlist Hint

The stopping condition is now exclusively a central abundance condition. You'll need to use the `xa_central_abundance` business documented in `controls.defaults` under `when to stop`.