Neutron Star Envelope

This test is to show how to make a neutron star envelope in `MESA`. There are ten inlists that are run consecutively, and if they have run successfully, the terminal output at the end of the run should read `''finished all inlists for neutron_star_envelope''`.

`MESA` cannot compute the core of a neutron star, so this only sets up an envelope with an "empty" core with mass, radius, and luminosity as its only parameters. Each inlist has its own specific purpose, which is explained below.

inlist_ns1: This first inlist loads a pre-saved white dwarf model (`1.000_Tc_7.6.mod`), changes the nuclear reaction network (`new_net_name = 'cno_extras_plus_fe56.net'`), and increases the tau factor (`set_to_this_tau_factor = 75`) to ignore the most of the atmosphere of the star.

inlist_ns2: This removes a big part of the inner mass (`remove_inner_fraction_q = 0.9`), then runs for 50 steps.

inlist_ns3: This removes more of the inner mass (`remove_inner_fraction_q = 0.99`), then runs for 50 steps.

inlist_ns4: This removes more of the inner mass (`remove_inner_fraction_q = 0.99`), then runs for 50 steps while accreting pure ^{56}Fe on the surface (`set_to_xa_for_accretion = .true. ; set_nzlo = 1 ; set_nzhi = 99999 ; accretion_species_id(1) = 'fe56'`).

inlist_ns5: This removes more of the inner mass (`remove_inner_fraction_q = 0.999`), then runs for 50 steps.

inlist_ns6: This removes more of the inner mass (`remove_inner_fraction_q = 0.999`), then runs for 50 steps.

inlist_ns7: This sets the mass of the "empty" core (`relax_M_center = .true. ; new_mass = 1.4`), then runs for 50 steps.

inlist_ns8: This sets the radius of the "empty" core (`relax_R_center = .true. ; new_R_center = 1d6 ! in cm`), then runs for 50 steps.

inlist_ns9: This sets the luminosity of the "empty" core (`relax_L_center = .true. ; new_L_center = 1e34 ! in ergs/second`), then runs for 50 steps.

inlist_ns10: This turns on ^{4}He accretion (`mass_change = 1.7e-10 ! Msun/year`), then runs for 50 steps.

The end result is, as expected, an envelope of mostly iron with a small amount of helium on the surface, as can be seen in the abundance profile to the left (figure 1). The plot on the right (figure 2) shows that the model is still adjusting to all the changes, with luminosity falling more than an order of magnitude in 15 minutes.

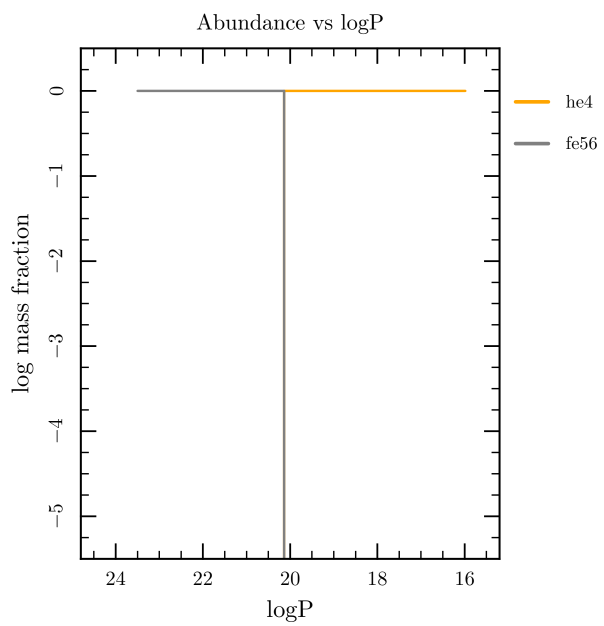

Figure 1: Abundance profile showing iron and helium envelope

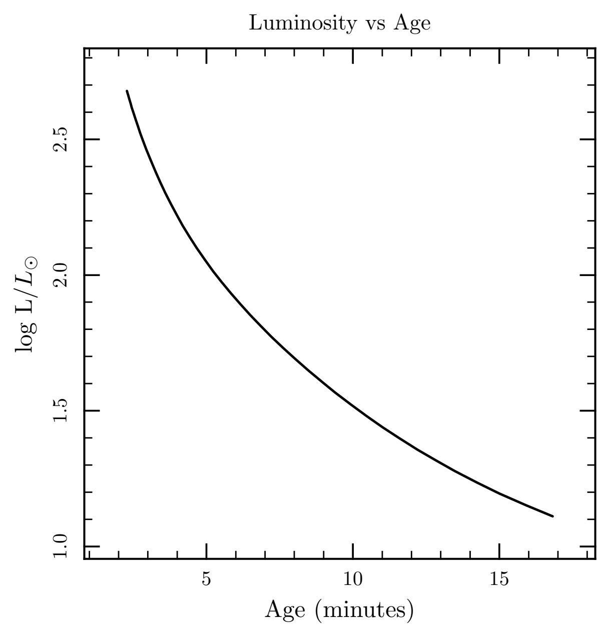

Figure 2: Luminosity plot shows model is still adjusting to changes

This final plot (figure 3) is meant to show a few internal MESA variables, such as the size of the time-step, the number of zones, and the number of retries against the model number in order to give some understanding of how hard MESA is working throughout the run and where some areas of problems/interest might be.

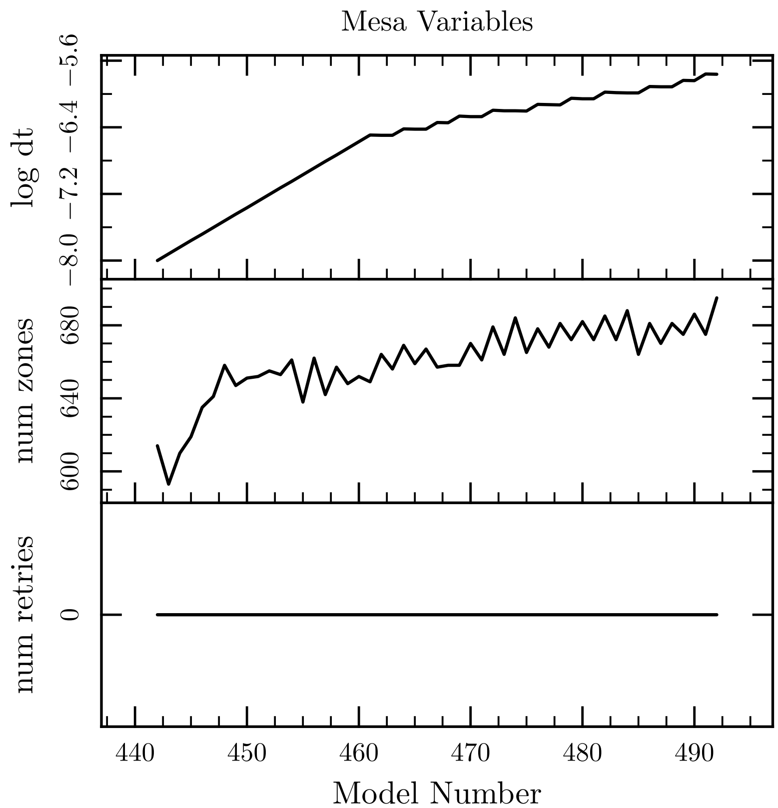

Figure 3: MESA variables plotted against model number show how hard MESA is working