Brown Dwarf

This test is to show that a 0.02 $M_\odot$ brown dwarf can form and cool peacefully if left alone for billions of years. To check if this test ran successfully, log[g] and effective temperature values at five different ages throughout its evolution are compared to the calculations of Baraffe et al (2003)[1]. If they match close enough you should see this terminal output at the end of the run: "all values are within tolerance".

This test case creates a brown dwarf of 0.02 $M_\odot$ from a pre-main sequence model with an initial core temperature of 200,000 K and evolves it for 10 Gyr. It sets the initial mass to 0.03 $M_\odot$ before relaxing it down to 0.02 $M_\odot$ (`new_mass = 0.02`).

The brown dwarf stays fully convective throughout the entire evolution, and, therefore, the abundances of the elements (figure 1), given in log mass fraction, are constant in q, where q is the fraction of star mass interior to outer boundary of each zone, moving outward from the core.

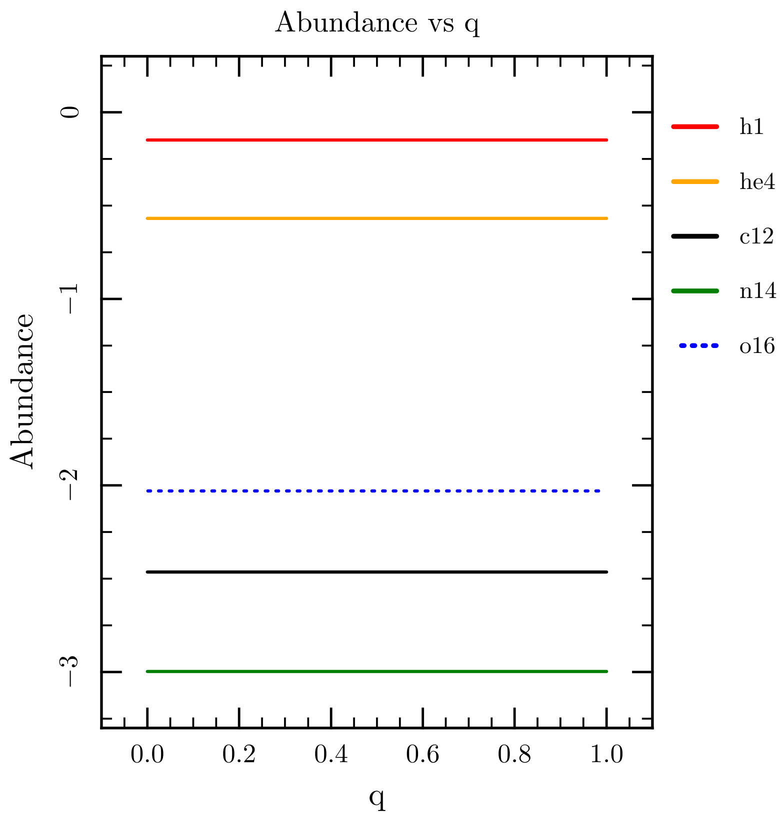

Figure 1: Abundance profile

[1]Baraffe, I., Chabrier, G., Barman, T. S., Allard, F., & Hauschildt, P. H. 2003, A&A, 402, 701

Here on the H.R. Diagram (figure 2) we see decreasing luminosity throughout the evolution, but a temporary increase in effective temperature early in its evolution. The brown dwarf contracts, as shown in the plot to the right (figure 3).

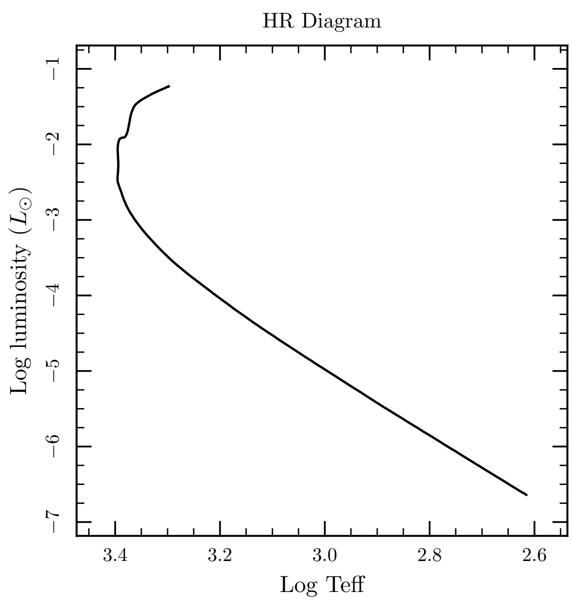

Figure 2: H.R. Diagram where the evolution track goes from top to bottom

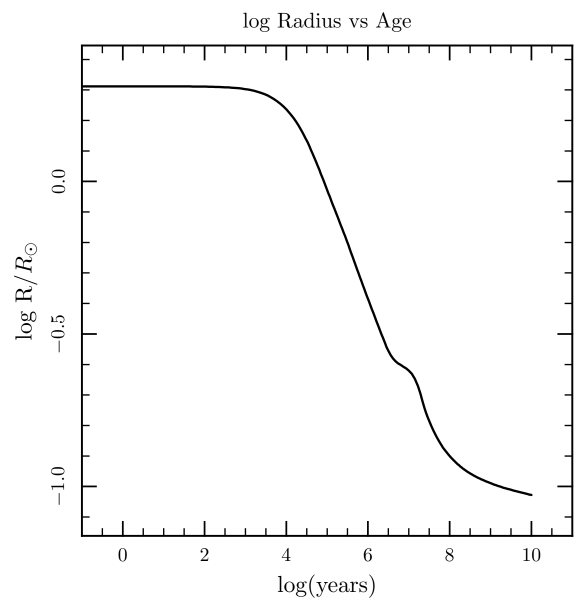

Figure 3: Gravitational potential energy is released as the star contracts, leading to slight rise in effective temperature

This next plot to the left (figure 4) similarly shows effective temperature behavior, but against log[g], and a profile of temperature vs. density at several different ages (figure 5).

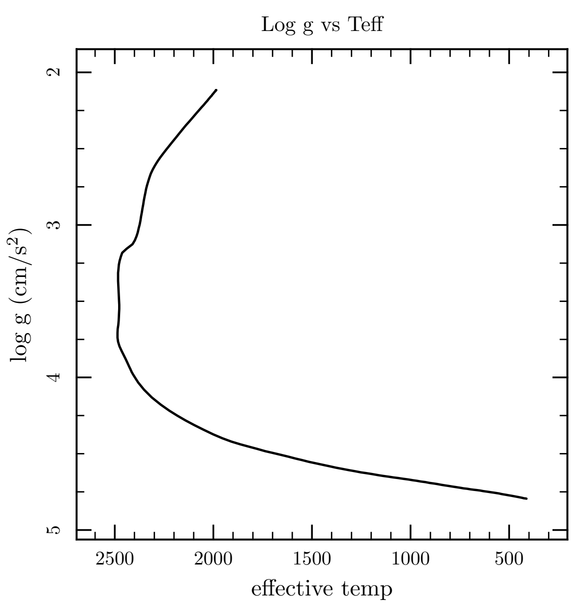

Figure 4: Log g vs. effective T where the evolution track goes from top to bottom

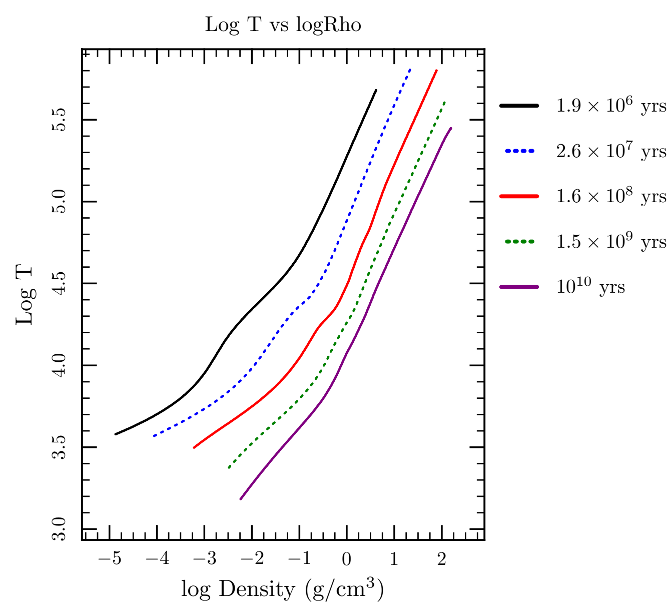

Figure 5: Temperature vs. density profile at several ages show increase in density and temporary bump in temperature

This next plot (figure 6) was taken from a convergence study. The C value is proportional to the spatial and temporal resolution controls, where higher C values correspond to lower resolution, and vice versa. The error is RMS error taken at 5 ages (1 Myr, 10 Myr, 100Myr, 1 Gyr, 10 Gyr) relative to the lowest C value used, which is C=0.1.

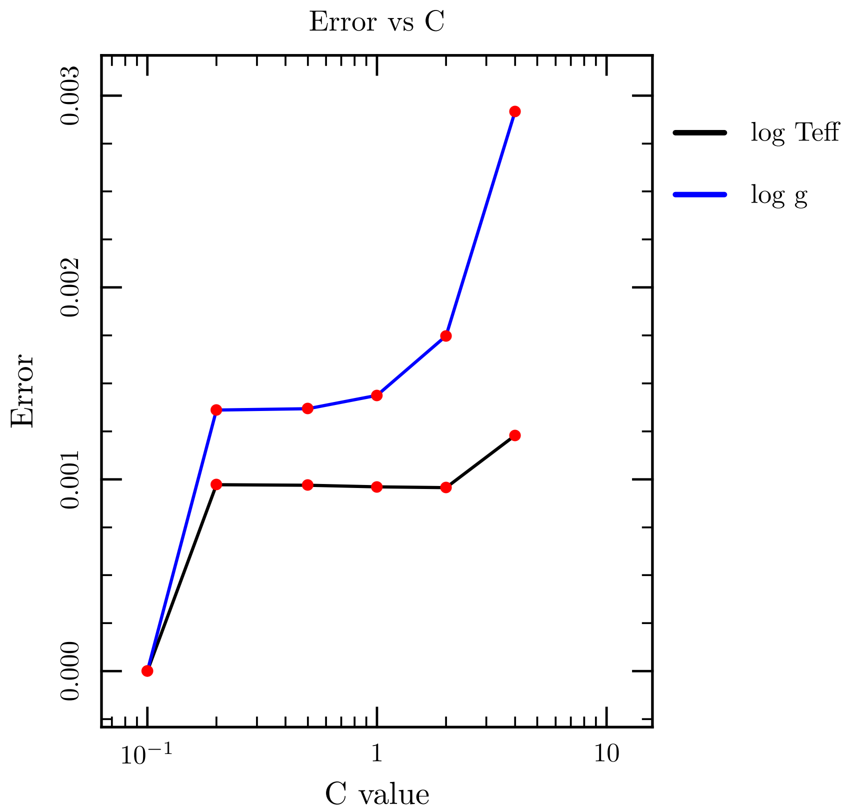

Figure 6: RMS error vs C, where C is inverse of resolution

This final plot (figure 7) shows 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.

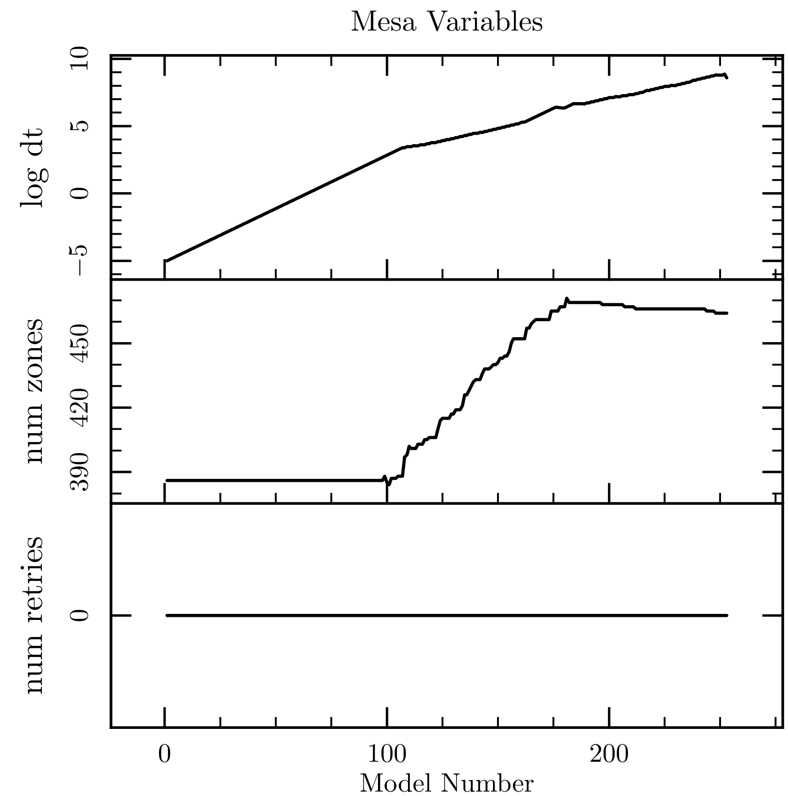

Figure 7: `MESA` variables plotted against model number show how hard `MESA` is working