WD SURF AT TAU 1M4

The purpose of this test is to extend the `MESA` model to include more of the atmosphere to enable astroseismology calculations. Therefore, this test does not need to run long and cuts off when effective temperature drops below 10^5 K.

This test case starts with a 1.025 $M_\odot$ carbon-oxygen white dwarf that cools for approximately 143,000 years. To extend the mesa model to include more of the atmosphere, we set the inlist variables `set_tau_factor = .true.` and `set_to_this_tau_factor = 0.00015`. The `tau_factor` sets the optical depth of the outer edge of the outer cell of the model. A smaller `tau_factor` means the more of the star's atmosphere will be included in the model.

Below is an abundance profile (figure 1), which plots the log of the mass fraction against logxq where logxq = log(1-q) and q is the fraction of star mass interior to outer boundary of each zone, moving outward from the core. (Note: The Ne20 shown here actually represents Ne22, this is because `MESA` is using a simplified nuclear reaction network.)

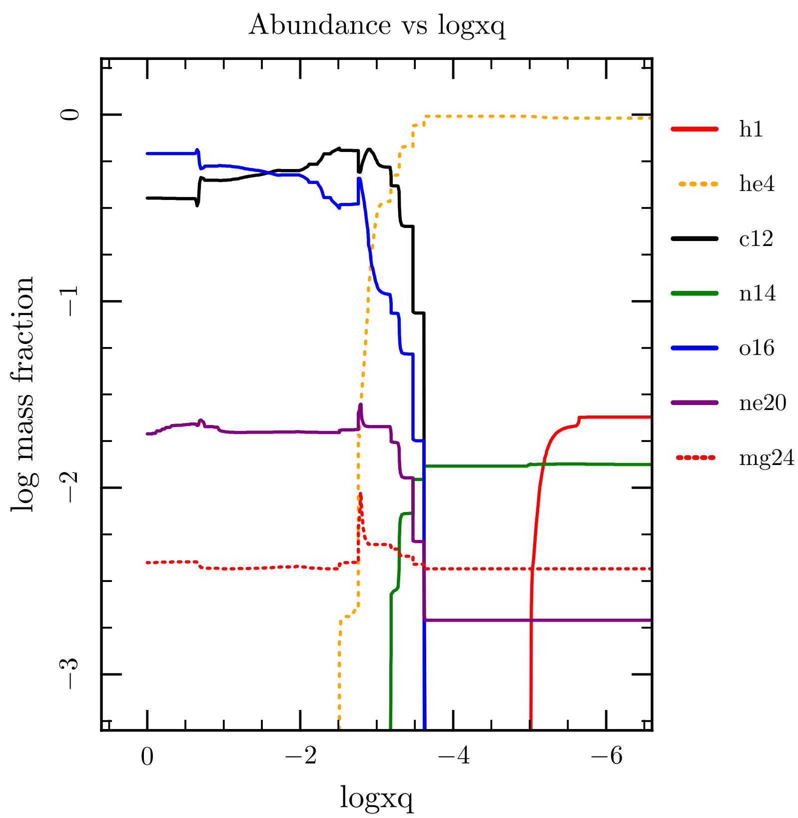

Figure 1: Abundance profile

Besides the astroseismology calculations, there is not much going on in this white dwarf. It loads the same saved model as the test case `wd_cool`, but doesn't let it run as long. The H.R. Diagram to the left (figure 2) shows that the star is steadily cooling. The real purpose of this model is revealed in the profile to the right (figure 3). If we had not set the `tau_factor` to 1.5×10^{-4}, and instead left it at its default value of 2/3, we would not see high brunt frequencies in the outer atmosphere.

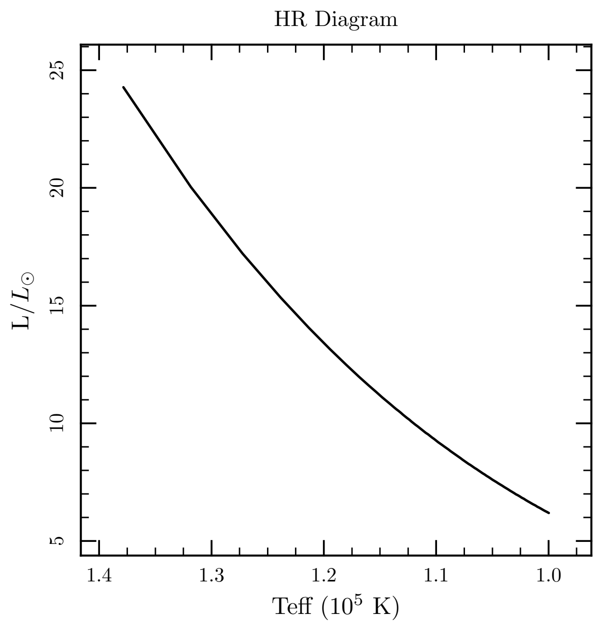

Figure 2: H.R. Diagram shows that the white dwarf is steadily cooling

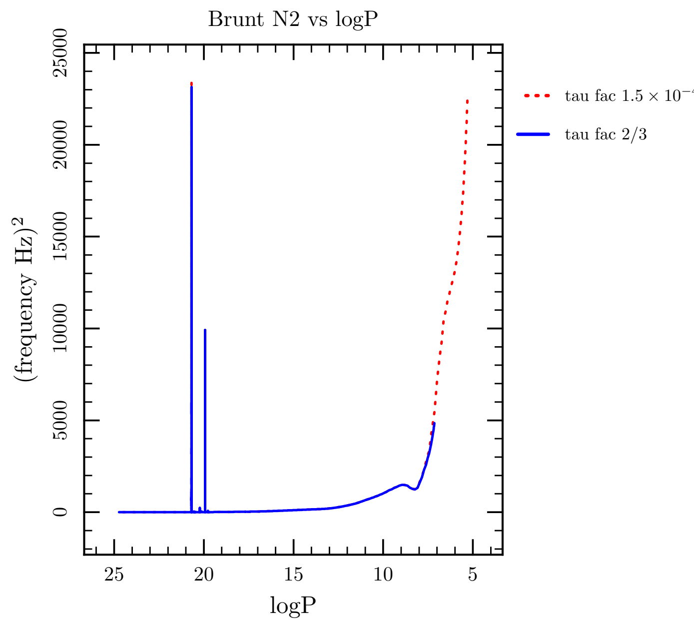

Figure 3: Lowering the "tau factor" allows for more astroseismology calculations in outer atmosphere

You may notice that, in addition to the increase in brunt frequencies in the atmosphere, there are two large spikes in brunt frequency deeper in the interior. If we zoom up on them a little more and compare them to the compostion of the star (figure 4), we see that the spikes in brunt frequency correspond with sharp changes in composition.

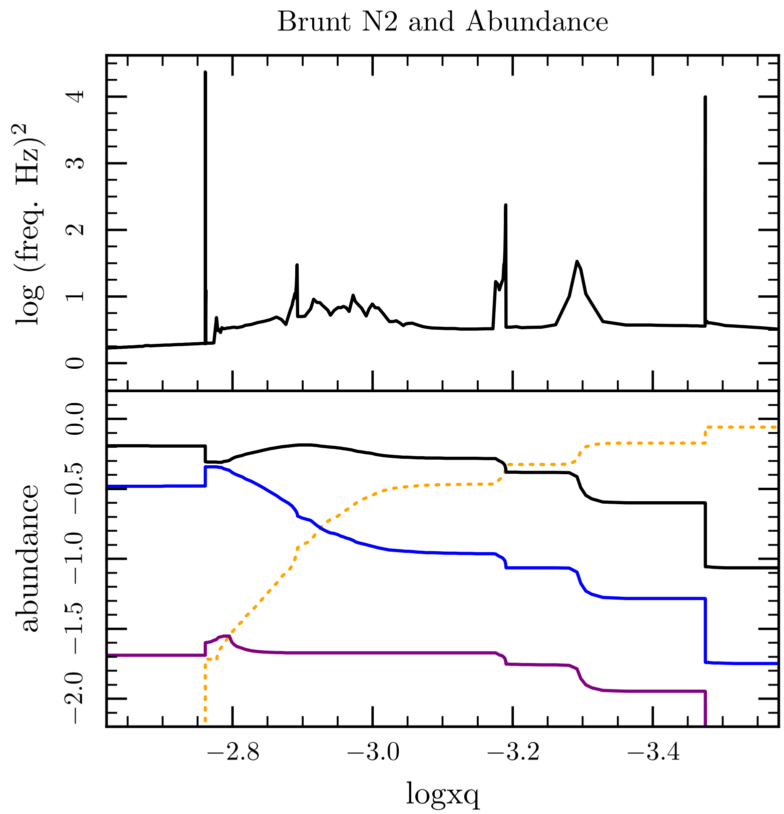

Figure 4: Close-up of two spikes in brunt frequency line up with composition boundaries

This final plot (figure 5) 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.

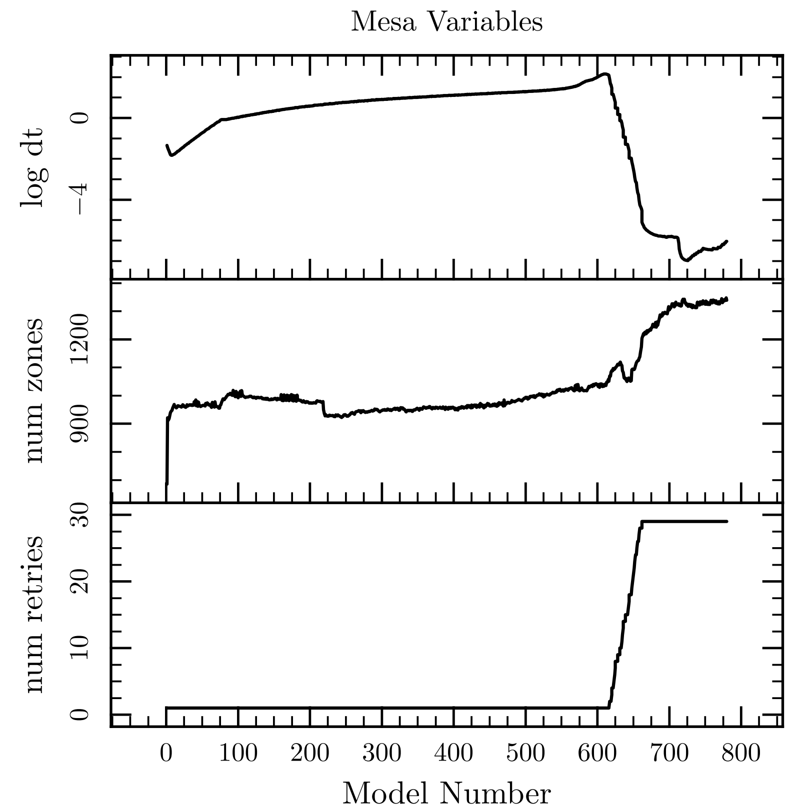

Figure 5: `MESA` variables plotted against model number show how hard `MESA` is working