FRI Astronomy Lab #6

Goal: In this lab you will use the open source stellar evolution code MESA to examine the structure of stars at different stages of their evolution. More information about MESA can be found at `http://mesa.sourceforge.net`.

In addition to running the models and answering the questions, look at the plots that are displayed as MESA runs. Ask us if you have questions about this.

Instructions

1. We've pre-packaged some files for you to make it easier to run MESA. After logging in to one of the Macs, in your home directory do `cp ~mikemon/mesa_work.tar .` to copy the files.

2. Untar this file; it will create a directory called `mesa_work`.

3. To get MESA to run properly, we need to add some lines to the `.bashrc.` file in your home directory. The lines that need to be added are in the file `mesa_work/add_to_bashrc`. Copy these lines and place them at the bottom of your `.bashrc` file. If you don't have a `.bashrc` file then create one and put these lines in it.

4. To get these changes to take effect, either type `. .bashrc`, open a new terminal window, or simply type `bash`. To check that this worked, type `echo $MESA_DIR`. This should print out a long path, ending in `~mikemon/mesa`. If not, you need to get help and/or fix it.

5. Now make sure you are in the `mesa_work/` directory. Type `./clean` followed by `./mk`. This compiles MESA and places a local executable in your directory.

6. Each of you was given two sets of stellar parameters. To use one set of parameters for a MESA run we need to edit the `inlist_project` file (use your favorite editor). The lines to edit look like this in the file:
   ```
   initial_mass = 10d0
   initial_Z = 0.02
   initial_Y = 0.23
   ```
   For instance, the above set of parameters are for a $10 M_\odot$ model with a metallicity (Z) of 0.02 and a helium abundance (Y) of 0.23. Set the values of the above parameters to the first set of parameters you were given.

7. Now run MESA by typing the `./rn` command. You should let it run and watch the output for no more than 30 minutes. As it runs you will record the parameters of the star as it passes certain evolutionary stages. In order to have time to write this down, you will need to pause the calculation by typing `[ctrl]^Z` in the terminal window. After you have finished recording the information, you can continue the calculation by typing `fg`.

The information you need to record at each stage is the model's age, $T_{\rm eff}$, $\log L$, and model number. The stages are:

(a) When it first reaches the main sequence. To define this point use the criterion lg_LH = lg_L (to three significant figures). This information can be found both on the terminal output and on the main plot window. The terminal saves a record of previous models so it may be easiest to read the information from there.

(b) When the central H abundance (H_cntr) goes to zero. This officially signals the end of the main sequence phase.

(c) When He burning becomes more than 1% of the luminosity of the star (i.e., lg_L3a gets within 2.0 of lg_L). For some models this could take longer than 30 minutes; in this case it's okay to stop the run before it reaches this point.

(d) When the central He abundance (He_cntr) goes to zero.

(e) Any other interesting events that occur within a 15 to 20 minute run on your computer.

8. After continuing the run, the the run may be permanently stopped by typing `[ctrl]^C`. Next, `cd` into the `LOGS/` directory. The information on your run is in a file called `history.data`. Change it's name to something more unique, such as `history_1.0Msun_Z=0.02.data`. Now run the script `hrd.py` by typing `./hrd.py history_1.0Msun_Z=0.02.data`. Answer "yes" if it asks if you want to clean the data file. This will create a pdf file called `HRD.pdf` that is a plot of the path of your model in the H-R Diagram. Change the name of this output file to something unique and print it out. Using a pen, label the points (a)–(e) on this plot.

9. Now repeat steps 7 and 8 with the other set of stellar parameters you were given.

10. Just for fun you can plot both sets of evolutionary tracks on the same plot. To do this type `./hrd.py history1.data history2.data`.

11. You should hand in the 2 labeled plots you have made along with a sheet of paper that lists the age, $T_{\rm eff}$, $\log L$, and model number values of (a)–(e) (or as many as you have) for each plot. Also, state the main differences you found between the low and high mass models. Based on your understanding of stellar evolution, give a *brief* explanation for these differences.

12. Finally, `tar` up your 2 history files (give the file a unique name with your name in it) and copy the tar file to `~mikemon/mesa_results/`. Since each one of you did different sets of stellar parameters I will collect the results and show them in class on Friday.

13. Bask in the glory of a job well done...