Bildsten Minilab: Mass Loss/Gain on the Main Sequence

Friday, August 15, 2014

Setup

In this short exercise, you'll investigate how a 5 $\mathcal{M}_\odot$ star responds to mass loss or gain while on the main sequence. Such mass change is likely in binary systems, but more importantly, we can gain some good intuition for how mass change affects the structure of star depending on how quickly or slowly the mass is removed or added.

If you haven't done so already, download the zipped work directory for the minilab from the MESA Summer School 2014 repository. The file should be called `bildsten_minilab.tar.gz` or something like that. This will be your work directory, so move it wherever you like and unzip it.

Before we set up our inlist, pick a mass change rate between 10^{-3} $\mathcal{M}_\odot\,\mathrm{yr}^{-1}$ and 10^{-7} $\mathcal{M}_\odot\,\mathrm{yr}^{-1}$, sampled evenly in log space. That is, pick a random float between -7.0 and -3.0, and then exponentiate that number by 10. For the indecisive, go here to get such a number.

Overview/The Quick Version

Do two runs evolving the provided `5M_MS.mod` star. The first run should involve *losing* mass at the rate you just determined, and the second should *gain* mass at that rate. Stop each run when the mass has changed by one percent. At the end of each run qualitiatvely compare the resulting entropy profile with that of the original model. Then answer the question in the **Question** section.

For a more guided approach read on (*recommended*).

Setting up the Inlist

Now that you have a mass change rate, we'll do two runs using `inlist_bildsten_minilab`. The master `inlist` should already point to this and a pre-made `pgstar` inlist (don't edit the `pgstar` inlist or the even more magical `my_pgstar` inlist). Open up `inlist_bildsten_minilab` and follow along with the comments to fill it out. You need to fill in the following:

- Mass change rate
- Stopping condition(s)
- Starting timestep size
- Maximum timestep
- Log directory name

Mass Change Rate For the first run, use the negative of your randomly chosen mass loss rate. For instance, if your mass loss rate was 10^{-3} $\mathcal{M}_\odot\,\mathrm{yr}^{-1}$, you'll need to set this to

```
mass_change = -1.00d-3
```

For the second run, you'll need to make this positive instead.

Stopping Condition The stopping condition is that the run should end after the mass has changed by one percent. How might you enforce this? Note that different conditions may be necessary for mass gain vs. mass loss.

Time Steps Additionally, you are gently encouraged to limit the timesteps in such a way that this condition is met after at least 100 timesteps (E.g. you have a mass loss rate of $10^{-3}\ \mathcal{M}_\odot\,\mathrm{yr}$, so a change in mass of $0.05\ \mathcal{M}_\odot$ will only take 50 years. So, you should limit the timestep to 0.5 years). If you don't this, your simulation may end after only one timestep!

Log Directory Name While you can certainly can just use the default value of `LOGS` and rename it after each run, a good practice is to use the `log_directory` option in your `controls` namelist. This way, if you want to reuse inlists, you won't worry about them overwriting your other data.

Executing the Runs

After setting up your inlist and making the appropriate log directory (if you chose to use a custom one), run `./clean; ./mk`, and finally `./rn`. Three pgstar windows should appear. The front-most window will show you the your current model's entropy profile as well as the base (no mass loss/gain) entropy profile so you can see how the structure of the star changes with respect to its original. A second window sill show a history of the star in the $\log \mathcal{R}/\mathcal{R}_\odot - \log \mathcal{M}/\mathcal{M}_\odot$ plane. The third is just the standard `Grid1`, showing your the $T-\rho$ profile, HR diagram, $T_c - \rho_c$ history, and basic text information.

Before dismissing the run at the end due to the pause command, examine the resulting entropy profile. Note if the ending entropy profile qualitatively matches the original entropy profile, which should be plotted in orange.

Question

What is the radius-mass relation for both models? To quantify this, find a best-fit linear solution (ζ, b) for $\log \mathcal{R} = \zeta \log \mathcal{M} + b$. Your history files should have columns for both $\log \mathcal{R}$ and $\log \mathcal{M}$, so use whatever regression tool you prefer to do this. Then record your mass loss rate, ζ_{loss}, and ζ_{gain} in the crowdsourcing Google spreadsheet here. Don't worry if your relations aren't perfect power laws...others' might have been!