M4111
Assignment 1

Construct a standard solar model using the evolution code you have been running.

To do this we wish to determine the parameters which a star of 1 solar mass would need to have had to reach its current luminosity and radius at its current age (assuming that mass loss has been negligible throughout its entire lifetime!). Observationally we determine the metal composition of the Sun to be $Z = 0.02$, but we cannot determine X or Y. The other free parameter which we must vary is the ratio $\alpha = \ell_{mix}/H_P$ in the mixing-length theory of convection. Thus we have two parameters to vary, and two constraints to fit.

We will assume that the solar age is 4.6×10^9 years. This is a parameter in the input file `inm1.dat`. Be sure to run with `ITIME=2`. The code will then produce a model at the specified time and write it to the `bobfile` and the `seqfile`.

When you run the code you will find that you do not obtain the correct luminosity and radius at the current age. You must therefore change the helium abundance Y and the mixing-length parameter α and re-run the code. We treat the code as a non-linear equation (which it is!) which generates the luminosity L and radius R at the present time. As these depend on the initial Y and α we essentially have two non-linear equations in two unknowns, which we solve with the Generalised Newton's method. The linear approximation requires estimates of the partial derivatives $\left(\frac{\partial L}{\partial Y}\right)_\alpha$, $\left(\frac{\partial L}{\partial \alpha}\right)_Y$,$\left(\frac{\partial R}{\partial Y}\right)_\alpha$ and $\left(\frac{\partial R}{\partial \alpha}\right)_Y$. These are found by running the code for different cases. A few iterations is usually sufficient (which may mean running the code a dozen or more times!) to obtain Y and α. Try to get the luminosity and radius to within 1% of the correct values.

I have set up a pair of initial models for each of you. These have slightly different properties so you will all have to do your own convergence to find a standard solar model.

Carlos: use the files ending in A.dat
Tom: use the files ending in B.dat
Jake: use the files ending in C.dat
Lawrie: use the files ending in D.dat

Once you have made a standard solar model, investigate its later evolution. Marks will be awarded for a complete description of the evolution up to the core flash. If you want to go through the core flash, let me know and I will help.

Hand your work to me by 5pm on 3 June.

JCL: 20-May-2011