ASTR 498N Stellar Evolution Spring 2014

Computer Exercise Due Feb 13, 2014

For this exercise you are to use the FORTRAN program **zam.f** to make a *zero age main sequence* solar model. Such models are characterized by having a uniform chemical composition throughout. (So the program cannot be used to construct models of evolved stars, where nucleosynthesis has altered the composition of the core.)

If your computer has a FORTRAN compiler (it may be called **g77** or **f77** – later versions like **gfortran** or **f95** will also work) you can *compile* zam.f by typing "g77 zam.f". This should result in an executable program called, by default, "a.out", which you can rename "zam.exe". This web site has three precompiled binaries, zam_linux.exe, zam_Mac.exe and zam_PC.exe. Try the one which matches your computer. Or you could install a compiler on your computer – try googling "free fortran compilers" – the first link is to the GNU compilers: "http://gcc.gnu.org/wiki/GFortran". The second link I see there is "http://www.cse.yorku.ca/ roumani/fortran/ftn.htm" which is quite old, but still has some useful information. I've posted the file Fort99.zip mentioned there.

Start by making a one solar mass model. Just execute **zam.exe** by typing its name.
The program will ask for the star's mass. Input mass M of 1 and hit return.
For the composition you can enter as "0.7 0.28".
(That is X=0.70,Y=0.28, which implies a "metal" (heavy element) content Z=0.02, since X+Y+Z=1.)
For the central pressure P_c guess 2E17.
For central temperature T_c use 1.5E7, for radius R enter 7E10, and for luminosity L enter 1.0.
The program then asks for a name that it will give to the file containing your output.
For example, you can type "sun.dat".
To the question "DO YOU WANT PULSATION OUTPUT? (Y/N)", answer "n".

The program will then run, printing out the mismatches at the fitting point and the corrections to the guessed initial inputs. When it has converged, it will stop. Now use your editor to look at the contents of the file "sun.dat". You will find the values of Pc,Tc,R, and L for the final converged model, and tables of the important variables for 200 zones in that converged model. *Write down the values of M, X, Y, Pc, Tc, R, and L.* These values can be used as a first guess to construct another model, provided the initial M, X and Y are not too far from this one. Also, write down the value of ρ_c.

Look at the first table. At what fractional radius, r/R, does the luminosity L reach half its final value? At what r/R does L equal 99% of the final L? What is the mass fraction m/M at these two points?

Look at the second table, and note that the column Lc/Ltot is the fraction of the flux carried by convection. If it's not zero, you're in a convective region. Where does convection in this model begin and end in terms of radius r/R? In what zone does the mean opacity have its maximum? What is the temperature in this zone? What is the density? Note the values of LOG(T) and LOG(RHO) for this zone. High opacity makes it difficult for energy to flow by radiation, and thus convection is likely to set in.