PHY983 - Nuclear Astrophysics - Spring 2009
Homework Set 5
Due: Feb 20, 2009 beginning of lecture
Key words: hydrostatic equilibrium, main sequence, absolute and apparent magnitudes, globular cluster ages

Problem 1a [6 pts]:

Give a ROUGH order of magnitude estimate of central pressure and temperature in the sun just from its observed radius and mass. To do this look at a point midway (in terms of radius) between the center and the surface and assume that the density at this point corresponds to the average density of the sun, and that the enclosed mass at this radius is about half the solar mass. Use hydrostatic balance at this point, and assume further that the pressure gradient is linear from the center to zero at the surface. Give the resulting central pressure in CGS units (dynes/cm2) and atmospheres. Using the average density of the sun and the assumption of an ideal gas with solar hydrogen and helium composition, estimate the temperature.

The purpose of this is to show that just the assumption of hydrostatic balance maintained by a hot gas sets the scale for the enormous pressures and temperatures in the sun.

Problem 1b [2pts]:

Compare your result of central pressure and temperature with the standard solar model of John Bahcall BS2005-AGS,OP. Go to his homepage http://www.sns.ias.edu/~jnb/ and click through Solar Neutrinos - Solar models. Also check the assumptions made above on enclosed mass and pressure at a mid radius point.

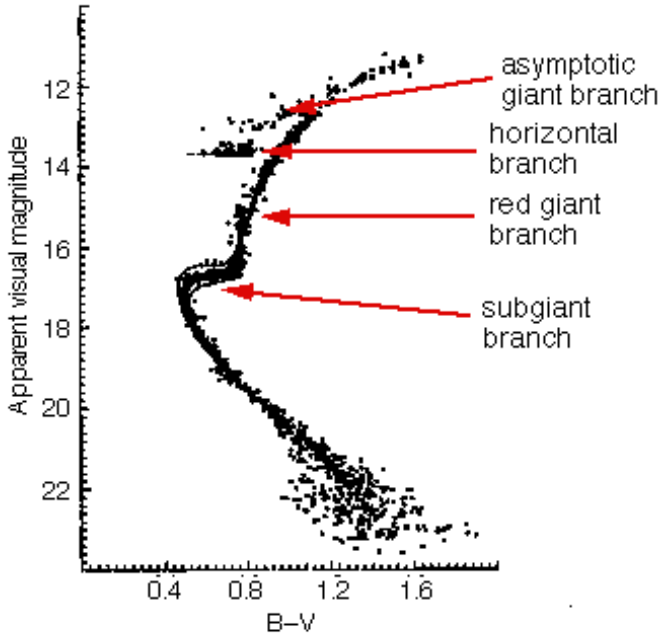
Problem 2 [5pts]:

Derive the absolute visual magnitude of the sun given that the observed visual magnitude is -26.73. Also compare the absolute visual magnitude to the absolute bolometric magnitude of the sun (see lecture notes) and explain the difference qualitatively.

Problem 3a [10 pts]:

Globular clusters are great laboratories for stellar evolution as they are a group of stars that was born at the same time and that are all at about the same distance from earth. In addition, distances to globular clusters can be determined relatively accurate (as many stars can be used to obtain many measurements). Plotting the observed visual magnitude versus the magnitude difference between blue and visual wavelengths (B-V)(A measure for the color or effective temperature) directly maps out a Hertzsprung-Russell (HR) diagram because all stars are at the same distance to the earth and therefore the observed magnitudes do not need to be corrected for distance variations. The picture below shows the HR diagram of the globular cluster 47 Tucanae. As you can see, many of the stars

have moved already off the main sequence. Determine the age of 47 Tuc from the observed main sequence turnoff point using the following method:



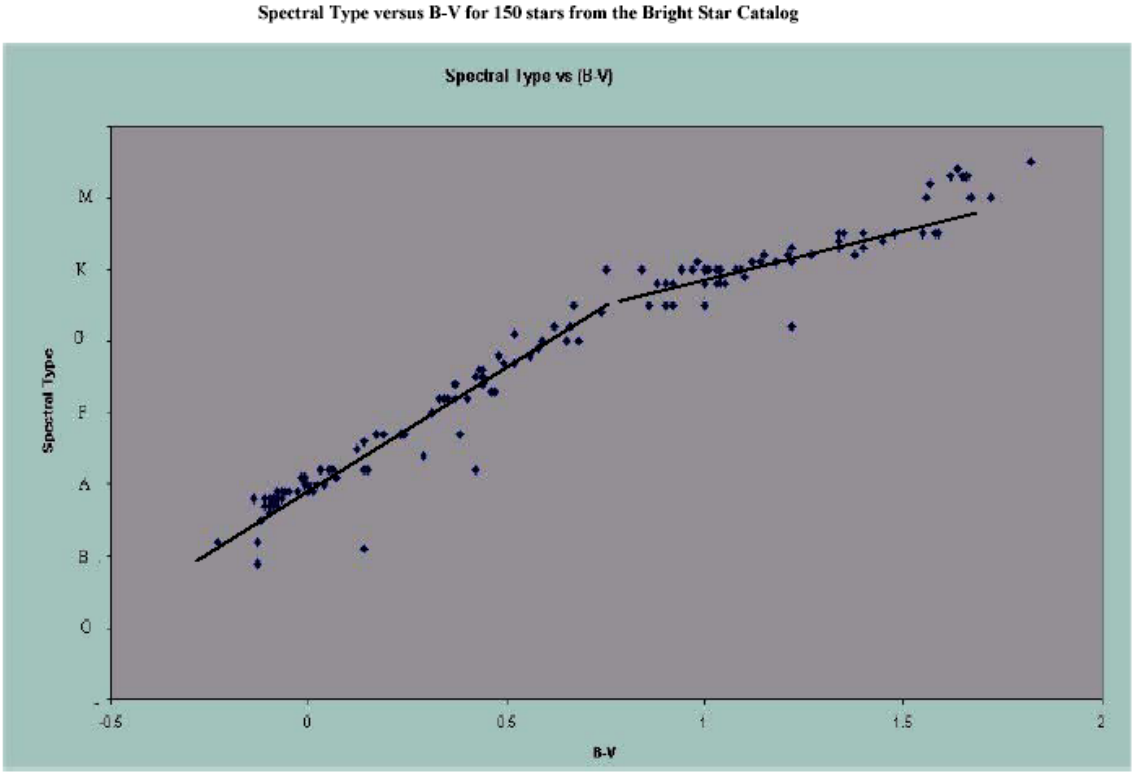
Determine the luminosity of the stars at the main sequence turnoff relative to the sun. These stars must be just at the end of their main sequence lifetime. You can then use the Luminosity-Mass and Mass-Main Sequence Lifetime relations from class to determine the age of these stars. Note that the observed visual magnitude has to be converted into an absolute bolometric magnitude. You can use the tables below to determine the bolometric correction (correction to obtain the total observed magnitude from the observed magnitude in the V spectral band). The distance to 47 Tuc is often given in form of a "distance modulus" M - m =-13.27.

Class	Main Sequence	Giants	Supergiants
O3	-4.3	-4.2	-4.0
B0	-3.00	-2.9	-2.7
A0	-0.15	-0.24	-0.3
F0	-0.01	0.01	0.14
G0	-0.10	-0.13	-0.1
K0	-0.24	-0.42	-0.38
M0	-1.21	-1.28	-1.3
M8	-4.0		

Table 1: Table of bolometric corrections for some stars. After Kaler 1997, p. 263.

Bolometric correction: $M=M_{bol} = M_v$ + correction in table

To get the spectral type from the B-V measurement you can use this figure:



Problem 3b [5pts]:

Using the distance modulus given in Problem 3, what is the distance to 47 Tuc in parsecs and in light years ?

Problem 3c [2pts]:

Compare your age of 47 Tuc with the professional analysis in the literature. Give the reference of the paper(s) you are using. Also, compare the age with the age of the universe.