PHY983 - Nuclear Astrophysics - Spring 2007
Homework Set 5
Due: March 2, 2006, 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]:

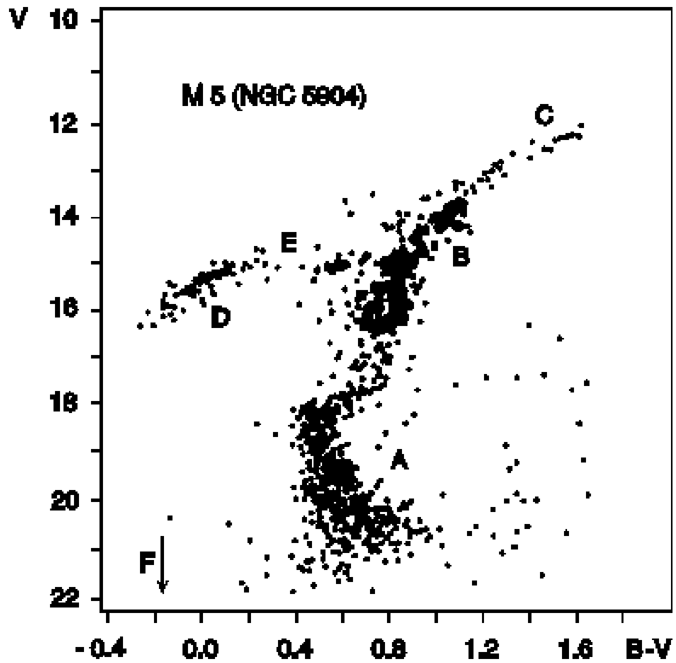
Compare your result of central pressure and temperature with the standard solar model of John Bahcall. Go to his homepage http://www.sns.ias.edu/~jnb/ and click through Solar Neutrinos - Solar models - this url - BS05. Also check the assumptions made above on enclosed mass and pressure at a mid radius point.

Problem 2 [5pts]:

Show that the absolute magnitude of the sun is +4.85 given that the observed magnitude is -26.73.

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 magnitude in visual wavelengths (MV) (a measure for the Luminosity) versus the magnitude difference between blue and visual wavelengths (MB-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 M5 with A denoting the main sequence. As you can see, many of the stars have moved already off the main sequence. Determine the age of M5 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 Mass - Luminosity and Luminosity - Main Sequence Age relations from class to determine the age of these stars. Note that the observed visual magnitude has to be converted into an absolute magnitude. You can use the tables below to determine the bolometric correction, if you think it is necessary (correction to obtain the total observed magnitude from the observed magnitude in the V spectral band). As a "distance modulus" M - m use -14.55.

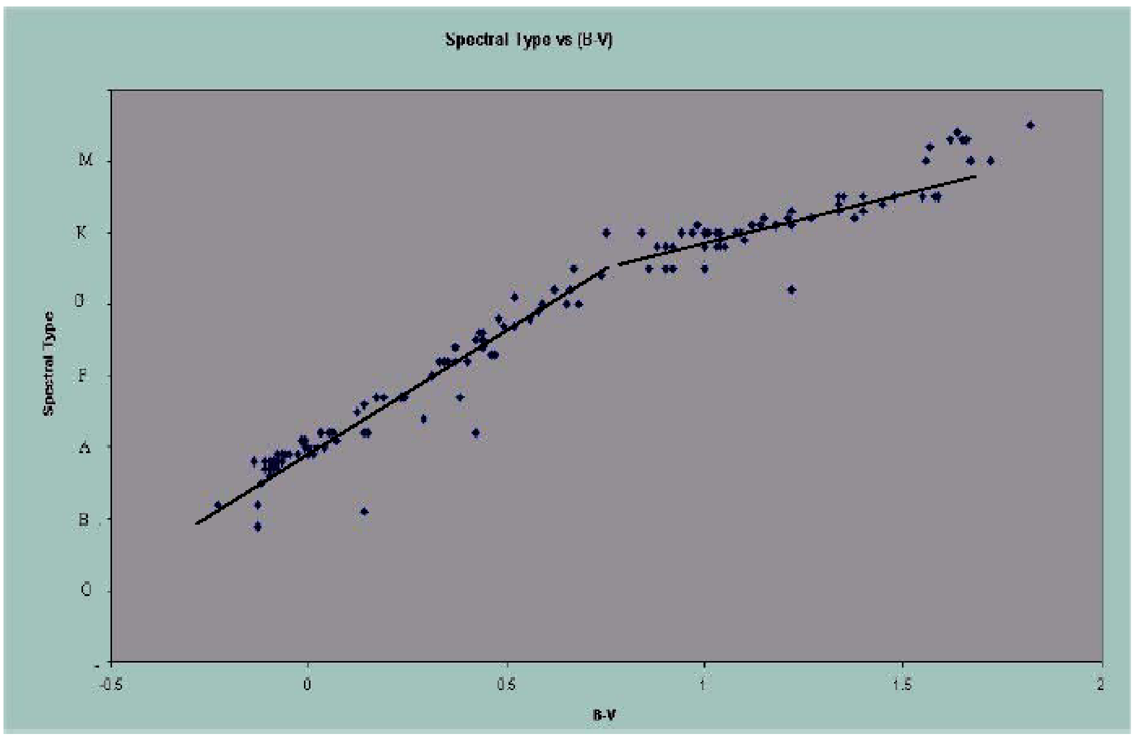
Class	Main Sequence	Giants	Supergiants
O3	-4.3	-4.2	-4.0
B0	-3.00	-2.9	-2.7
A0	-0.15	-0.24	-0.3
F0	-0.01	0.01	0.14
G0	-0.10	-0.13	-0.1
K0	-0.24	-0.42	-0.38
M0	-1.21	-1.28	-1.3

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:

Spectral Type versus B-V for 150 stars from the Bright Star Catalog



Problem 3b [5pts]:

Using the distance modulus given in Problem 3, what is the distance to M5 in parsecs and in light years ?

Problem 3c [2pts]:

Compare your age of M5 with the professional analysis - for example in Raul & Paolo Ap. J. 498 (1998) 704. Also, compare your age (and theirs) with the age of the universe.