

PHYS 321: PROBLEM SET 6

Due Mar 28 Thursday @ 2:30 pm

*Solve the problems listed below, and **write up your answers clearly and completely**. Do not turn in rough work – instead, make a clean copy after checking your calculations. Use English sentences and phrases to explain your solution and describe your answers step by step. Even if you did not get the correct answer, you may get partial credits for these steps!*

1. (2 credits) For low- and intermediate-mass stars, during the evolution on the subgiant branch (SGB), the helium core begins to contract rapidly, causing the evolution of the star to proceed on roughly the Kelvin-Helmholtz timescale. Use information given in Fig. 13.1 of the textbook, estimate the Kelvin-Helmholtz timescale for a $5 M_{\odot}$ star on the subgiant branch (you could use the values at the start point of the SGB branch, i.e., point 4 on the diagram). Compare your “back-of-the-envelope” result with the amount of time the star spends between points 4 and 5 as found in Table 13.1 of the textbook.
2. (2 credits) Using the technique of “spectroscopic parallax”, or “main-sequence fitting” described in Chap 13.3 in your textbook, estimate the distance to M3, an old globular cluster. Use Fig. 13.17 of the textbook as the color-apparent-magnitude diagram of M3 and the composite color-absolute-magnitude diagram of Fig. 13.19 as the “template”.
3. (3 credits) Comparing the evolution of low-mass stars and high-mass stars.
 - (a) Using data available in the Tables 12.1 and 13.1 in the textbook, compare the pre-main sequence evolutionary time of a $0.8 M_{\odot}$ star with the lifetime on the main sequence for a $15 M_{\odot}$ star. How does this information help to explain the appearance of a color-magnitude diagram such as Fig. 13.18 in the textbook?
 - (b) Estimate the mass of a star that would have a main-sequence lifetime comparable to the pre-main-sequence evolutionary time of a $0.8 M_{\odot}$ star.
4. (3 credits) The Helix nebula is a planetary nebula with an angular diameter of 16 arcminutes that is located approximately 213 pc from Earth.
 - (a) Calculate the diameter of the nebula in pc.
 - (b) Assuming that the nebula is expanding away from the central star at a constant velocity of 20 km s^{-1} , estimate its age in years.