PHYS 354 — Problem Set 6 January 20

Due Jan. 21

1. Derive the luminosity/temperature relationship for a radiation pressure dominated star. Apply this result to upper main sequence stars assuming the CNO cycle is the main form of energy production in these stars.

2. Suppose a star of total mass M and radius R has a density profile  = c(1-r/R) where c is the central density. a) Find M(r). b) Express the total mass M in terms of c and R. c) Solve for the pressure profile P(r).

3. To consider the effects of nuclear fusion on the evolution of main sequence stars let’s look at the sun, but not directly at the sun, of course. Assume that the sun’s gravitational pressure remains constant and calculate the core temperature required to support the star when 50%, 75% and 95% of the core hydrogen has become helium. Use the starting point as 25% helium and T = 1.5x107 K and current core size and density. Using your knowledge of how energy production efficiency for the p-p chain depends on T estimate the luminosity of the sun at the start and at each of the later times. Note that the core will need to shrink in order for the temperature to rise (remember the Virial theorem!). Take the sun to be supported entirely by gas pressure but test the quality of that model by calculating the ratio of gas pressure to radiation pressure at the surface of the core currently, discussing the result. Make the simplification that the sun’s surface stays the same size throughout this evolution and graph the position of the sun on an HR diagram at each of the four calculated points. Make the graph both full-scale for a typical HR diagram and blown up to show the evolutionary track in more detail. Discuss what your findings mean for the future of life on earth.

4. Carroll & Ostlie 10.20

5. Carroll & Ostlie 10.21

6. Carroll & Ostlie 10.24