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Astronomy 101: The Physics of Stars

Problem Set #5

Due in class Wednesday, November 20, 2002

1. **Mass-Luminosity Relations**

   a) Consider a chemically homogeneous star in which the equation of state is that of an ideal gas and in which heat is transferred only by radiative diffusion. Show that the luminosity L os such a star scales approximately as

   $$L \propto \frac{\mu^4 M^3}{\langle \kappa_R \rangle}$$

   where $\langle \kappa_R \rangle$ is a typical value of the Rosseland mean opacity in the stellar interior.

   b) Determine how L scales as a function of μ, M and R only, for

   (i) a star like the sun (M $\simeq$ 1M$_\odot$)

   (ii) a massive star (M $\simeq$ 30M$_\odot$)

   Hint: What is the dominant opacity source in each of these stars? Your answer for the 30M$_\odot$ star will be inaccurate, since radiation pressure is not negliable within such a star.

2. **Motion of a fluid element**

   Consider a region inside a star which is *stable* against convection. A fluid element in such a region is displaced adiabatically from its equilibrium position by a small distance Δr and remains in pressure equilibrium with its surroundings.

   a) Show that the element oscillates in simple harmonic motion about its equilibrium position.

   b) Find an expression for the frequency ω od oscilllation.

3. **A simple stellar model.** Do problem 2 on page 29 of Hansen and Kawaler.