Physics 171.313 Introduction to Stellar Physics Fall 2008

Problem Set 2
(due October 7)

1. The gravitational binding energy of the Sun is of the order of

$$\Omega \approx -\frac{GM^2}{R} = -4 \times 10^{41}\ \mathrm{J}$$

By the virial theorem, the thermal kinetic energy is $U = 2 \times 10^{41}$ J. Assume that the temperature T, as a function of r, can be represented by

$$T = T_c(1 - r/R)^2$$

where $T_c = 10^7$ K. What is the total trapped energy in the radiation field? Apparently most of the radiant energy escaped during the contraction.

2. Show that the weighting factor dB_ν/dT in the Rosseland mean absorption coefficient is such as to place the greatest weight on the value of κ_ν near $\nu = 4kT/h$.

3. For a nearly isotropic radiation field we can represent I by

$$I = I_0 + I_1 \cos\theta.$$

For a certain star the luminosity (say $L_\odot$) originates in a region inside $r = 3 \times 10^8$ m, at which point the temperature is 3×10^6 K. Show that the ratio I_1/I_0 is very much smaller than unity.

4. Suppose the radiation field has the form

$$I(\theta) = I_0 \exp(a \cos\theta).$$

[note that for small a we get the same relation as in problem 3 with $a = I_1/I_0$.]

What is the relationship between energy density, flux, and radiation pressure for this field?