Physics 310/610 – Cosmology

Homework Set B

1. The sun is d = 1.000 AU from the Earth.
   (a) Find a formula for the brightness of the Sun F at Earth in terms of $L_\odot$ and d.
   (b) The Earth intercepts the light coming from the Sun if it intersects its cross-section, a circle of radius R. What is the total power falling on the Earth?
   (c) Assume the Earth is a perfect blackbody, so that all the light you found in part (a) is absorbed. Assume that all of this power is then reradiated at a constant temperature T (but this time from the entire surface of the Earth). Find the equilibrium temperature T in terms of $L_\odot$ and d. Notice that R, the area of the Earth, cancels out.
   (d) Calculate T in K for d = 1.000 AU. The number should come out about right.

2. Which is hotter, heaven or hell? Use the following data to find out:
   (a) Isaiah 30:26 says, "Moreover the light of the moon shall be as the light of the sun, and the light of the sun shall be sevenfold, as the light of seven days." So Moon plus Sun is 1 + 7×7 times the regular luminosity. Based on this, redo problem (1) to find the temperature of heaven.
   (b) Revelation 21:8 says, "But the cowardly, the unbelieving … will be consigned to the fiery lake of burning sulfur." Look up the melting and boiling point of sulfur, and deduce upper and lower bounds on the temperature of hell. Which is hotter?

Graduate Problems – Only do these problems if you are in PHY 610

3. The total energy density can be found by doing the following integral over the wave number **k:**

   $$u = 2\int \frac{d^3\mathbf{k}}{(2\pi)^3} \frac{E}{e^{E/k_BT} - 1}$$

   Show that this can be written in terms of an integral over the wavelength or frequency, so $u = \int_0^\infty u_\nu(\nu)\,d\nu = \int_0^\infty u_\lambda(\lambda)\,d\lambda$, and find the form of $u_\nu(\nu)$ and $u_\lambda(\lambda)$. Also, perform the integral (feel free to use software to assist you if necessary).

4. To find the total amount of flux crossing the $z = 0$ plane, an additional factor of v_z must be incorporated into the previous integral, where v_z is the velocity in the z-direction, and the integral must be restricted to just $v_z > 0$. Perform the relevant integral, and derive the Stefan-Boltzmann law.