ASTRONOMY 300B

Homework No. 4
Prof. Jill Bechtold

Due: in class, Wednesday, Feb. 11, 2009

1. Blackbody radiation.

a. A 100-W tuncsten filament lamp operates at 1800 K. Assuming the filament emits like a blackbody, what is the total power emitted between 6000 $\mathring{A}$ and 6001 Å? How many photons per second are emitted in this wavelength interval? Clearly state any approximations or assumptions you make. (5 points)

b. Assuming the light bulb in part (a) emits light isotropically, how many photons per second enter one eye of an observer looking at the bulb from a distance of 10 meters? Take the diameter of the observer's pupil to be 4mm. (5 points)

2. Estimate Planet Temperatures.

The temperature of planets in the solar system can be estimated by assuming that they absorb radiation from the Sun, and then radiate like blackbodies, at temperatures which turn out to be such that the peak of the black body typically is in the infrared.

Assume that planets reflect a fraction of the incident solar radiation, A, called the albedo, and absorb the rest, and that they are rotating rapidly enough that the temperature is the same over the entire surface.

a. Derive an expression for the equilibrium temperature achieved, as a function of distance from the Sun. (10 points)

b. Calculate the equilibrium temperature of Mercury and Saturn, under these assumptions, assuming A=0.1. (Neglect Saturn's rings.) (10 points)

c. Few substances can be heated to hotter than 2000 degrees without melting. How close could a spaceship (assume it absorbs and emits like a perfect black body) get to the Sun without melting? (10 points)

3. Cosmic Microwave Background. The cosmic microwave background (CMB) radiation has a temperature of approximately 2.73 K. In this problem, neglect any attenuation of the CMB by the Earth's atmosphere.

a. What is the wavelength (in mm), λ_{max}, of the maximum of the specific intensity, B_λ, of the cosmic microwave background? What is the frequency of the maximum of B_ν, in Hz? What wavelength, in mm, does this frequency correspond to? (2 points)

b. What is the energy, in eV, of a photon with wavelength λ_{max}? (2 points)

c. What is the intensity, in ergs/cm^2 of the CMB striking the Earth? (3 points)

d. What is the number of CMB photons with wavelength λ_{max} hitting the Earth per second, per square meter? (3 points)