Ay 145 — Problem Set 2

Due Wednesday, February 23th, 2005

Problem 1. Blackbodies, the Sun & the Earth

Starting with the Planck blackbody distribution, show that the flux of radiation emitted by a surface at temperature T is given by

$$F = \sigma T^4 \tag{1}$$

where $\sigma = 5.67 \text{ x } 10^{-5}$ erg cm^{-2}s^{-1} K^{-4}.

Using information about blackbody radiation you can compute what the Earth's temperature should be. In this problem, assume that the Earth and Sun are perfect blackbodies.

- From the Stefan-Boltzmann law that you derived in Problem , determine the total flux at the surface of the Sun.
- Assuming knowledge of the solar radius, compute the total luminosity of the Sun.
- Compute the solar constant, which is the solar flux at the location of the Earth.
- Write an expression for the amount of energy per second that the Sun deposits on the Earth. Include a diagram of the Earth-Sun system and label all relevant geometric quantities.
- Compute the expected temperature of the Earth. Express your answer in Kelvin, Celsius and Fahrenheit.
- Does your value of the expected temperature of the Earth agree with your daily experience? What sould you include in this calculation to give a more accurate result? Using your more accurate calculation, what is your best estimate of the Earth's expected temperature?

Problem 2. Hydrogenic Atom Energy Levels

Uranium-238 has 92 electrons. Imagine that 91 of the electrons have been stripped away (making it UXCII!). Using the simple Bohr model

- Compute the energy of the three lowest energy states of UXCII.
- Compute the UXCII analog of Lyman-α in HI (transition from $n = 2$ to $n = 1$.
- Is the Earth's atmosphere transparent at this wavelength?

Problem 3. Isotopes of Hydrogen

Deuterium, often labeled D (and sometimes called heavy hydrogen) is an isotope of hydrogen in which the nucleus contains a neutron in addition to a proton. Again, using the Bohr model

- Compute the energies and wavelengths of the Balmer-α and Balmer-β emission lines in Deuterium and compare them to those of Hydrogen.