Ay 145 — Problem Set 2
Due Wednesday, February 23rd, 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 $\sigma = 5.67 \times 10^{-5}$ erg $\text{cm}^{-2}$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 could 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 UXClII!). Using the simple Bohr model

• Compute the energy of the three lowest energy states of UXClII.

• Compute the UXClII 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 Deu-
  terium and compare them to those of Hydrogen.