AST 301
Homework #4
Due Friday, Oct. 3

1. The Sun has a surface temperature of about 6000 K. The light it emits is brightest at a wavelength of about 0.5 μm (that is 0.5 x 10^{-6} m), and it emits a total power of 3.9 x 10^{26} Watts. The Earth has a surface temperature of about 300 K, and its diameter is about .01 times the diameter of the Sun. Both the Sun and the Earth emit radiation according to the blackbody rules.

a) At about what wavelength is the light emitted by the Earth brightest? (This is the light the Earth emits because it is warm, not the sunlight it reflects.) In what part of the spectrum is this?

$\lambda \alpha 1/T$, so $\lambda_{Earth} / \lambda_{Sun} = T_{Sun} / T_{Earth} = 20$, so $\lambda_{Earth} = 20 \times 0.5$ μm = 10 μm in the infrared.

b) How many times more or less light power does each square meter of the Earth emit than what each square meter of the Sun emits?

$P \alpha T^4$, so $P_{Earth} / P_{Sun} = (T_{Earth} / T_{Sun})^4 = (1/20)^4 = 1/160{,}000$

c) How many times more square meters are there on the surface of the Sun than on the surface of the Earth? $A \alpha D^2$, so $A_{Sun} / A_{Earth} = (D_{Sun} / D_{Earth})^2 = 100^2 = 10{,}000$

d) Combine your answers to parts b and c to calculate how many times more light power is emitted by the Sun than by the Earth. $160{,}000 \times 10{,}000 = 1.6 \times 10^9$

Hint: Do these questions using proportional methods. It is much easier than using the formulas involving numbers like π and σ. For example, you can figure out how many times shorter or longer the wavelength of light emitted by the Sun is than that emitted by the Earth by figuring out how many times hotter or cooler the Sun is and using the proportionality: $\lambda \alpha 1/T$. Then if you know that the light emitted by the Earth is at x times longer wavelength than that emitted by the Sun, you multiply the wavelength of the Sun's light by x to get the wavelength of the Earth's light.

2. I measured the wavelength of the red line of hydrogen gas in my lab to be 656 nm. Because of the Doppler shift, the wavelength of this line from a distant galaxy is 722 nm. What does this tell me about the galaxy? Be quantitative. Give a number in your answer.

The observed wavelength is longer than the emitted wavelength. The galaxy must be moving away from us. Its speed is given by $v / c = (\lambda_{observed} - \lambda_{emitted}) / \lambda_{emitted} = 66 / 656 = 0.1$, so v = 30,000 km/s.