ASTRONOMY 1102 – 1

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Answers to HW4, Fall 1999

1) **Problem 8** *The Color of the Sun*
Applying Wien's law (see Ch. 7), one gets $\lambda_{\max} = 500$ nm for a blackbody or perfect emitter with surface temperature $T = 5800$ K. That corresponds to green in the color spectrum. The sun nevertheless appears yellow because the eye perceives the combined effect of all wavelengths between 400 nm and 700 nm. Furthermore the response of the eye peaks at a wavelength of 560nm (greenish yellow).

Problem 5 *The Lifetime of the Sun*
a. Total mass of hydrogen available for fusion in the sun is $0.75 \times 0.13 \times M_\odot = 1.95 \times 10^{29}$ kg.

b. The burning time in seconds is $1.95 \times 10^{29}\text{kg}/6 \times 10^{11}\text{kg/s} = 3.25 \times 10^{17}$ seconds. In years this time is $3.25 \times 10^{17}/3.15 \times 10^{7} = 1.05 \times 10^{10}$ yr.

c. In about 5.9 billion years.

2) Since $T_{\text{spot}} = 4500$ K and $T_{\text{eff}} = 5800$ K, the ratio of these temperatures is $T_{\text{spot}}/T_{\text{eff}} = 0.776$. Therefore according to the Stefan-Boltzmann law, the ratio of fluxes from every square inch is the above ratio raised to the 4th power, or 0.362. So the spots are only 36% as bright as the surrounding solar surface.

3) The efficiency is the ratio of luminous energy divided by the total mass-energy consumed or 4 billion kg divided by 600 billion kg.
Efficiency $= 4/600 = (2/3) \times 10^{-2} \approx 0.7$ %

4) Suppose the central temperature were to rise slightly, the rate of H fusing to He would increase much more, and the luminosity generated would exceed what the sun normally radiates from its surface. So the pressure would build to increase the size of the sun (pressure wins temporarily), the sun expands, and as a result of expansion the core would cool down again. So there is only one optimal temperature at which the luminosity generated exacly equals what is being radiated from the surface and the sun is stable to small deviations from this equilibrium (thermostat).