Astronomy 45 study problems

(March 11, 1999)

1- The sun has a radius of 7×10^{10} cm, a luminosity of 4×10^{33} erg/sec, and an effective temperature of of 5770 $^\circ K$. Calculate how many watts are emitted from one cm^2 of solar surface,

- start with the luminosity and don't use the temperature,
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2-Assume that the solar interior is all at a temperature of $T = 10^{7\circ}K$, and that a typical photon has energy kT. Are there more photons, or more particles, in the sun? Take the solar particle density to be 1.4 grams/cm^3 and assume that the particles have masses equal to the proton mass.

3- The sun's apparent magnitude, as seen from the Earth, is -27. What's the sun's apparent magnitude as seen from Saturn. The distance from Saturn to sun is about 10 AU. Ans: -32.

4-What would be the distance from the sun in AU of an inferior planet that has the greatest elongation of 30°? Assume circular orbits.

5-A Jupiter satellite has a period of 5.196 times longer than that of another Jupiter satellite. By what factor is the orbit of the first satellite more elongated than the orbit of the second satellite?

6-If you eyes are capable of seeing a star than delivers 10^3 photons in the V-band ($\lambda = 550$nm) per second to your pupils (8 mm diameter), what is the faintest visual magnitude m_V?

7-Consider a giant star with a radius of 1AU and a temperature of 3000 $^\circ K$. How much more energy does this star emit than an ordinary star with the same temperature but with a radius of 150,000 km?

8-A satellite can be placed in orbit around the Earth such that it will have a period equal to that of the Earth's rotation about its axis. Calculate the size of the orbit (the semi-major axis) for this stationary geosynchronous satellite.

Solutions:

1-This problem is straightforward and is useful for the assumption of solar blackbody radiation.

2-Start with the energy density of photons in the interior of the sun and calculate the total energy within the solar volume. You can then get the number of photons, knowing the average energy in each photon.

3-

$$m^E - M = 5log\frac{10}{d_E} \tag{1}$$

$$m^S - M = 5log\frac{10}{d_S} \tag{2}$$

$$m^E - m^S = 5log\frac{d_S}{d_E} = 5 \tag{3}$$

$m^S = -32.$

4-Recognizing that at the greatest elongation, the Earth, the planet and the sun sit on the corners of a right triangle and the angle beween the distances to the planet and the sun from Earth is 30°, then

$$SP = ES \sin 30 \tag{4}$$

5-Use Kepler's law third law to obtain the ratio of the semimajor axes.

6-The amount of energy per unit area per second at the surface of the eye is $F = \frac{nh\nu}{\pi d^2}$, where $\nu = \frac{c}{\lambda}$, n is the number of photons, and d is the diameter of the pupil. From Tables in your notes (Chapter 2), the flux in the visual band for a $m = 0$ star is given as $F_v = 3.4{\times}10^{-6} ergcm^{-2}s^{-1}$. Then, the visual magnitude can be obtained from $\frac{F}{F_v} = 10^{-0.4m_v}$.

7-Since the two stars are the same temperature, their emergent flux at the surface will be the same. We're assuming blackbody radiation, i. e. $F = \sigma T^4$, which then gives us $\frac{L_1}{L_2} = (\frac{R_1}{R_2})^2 = 10^6$.

8-Again, we can use Kepler's third law here. The period is one Earth day (24 hours).