AA 201 : Introduction to Astronomy – Tutorial

August 6, 2019

To be submitted on 15.08.2019

1. The luminosity of the Sun is 4 x 10^{33} erg/s, and its radius is 7 x 10^{10} cm. a) What is the Sun's effective temperature? b) What is the flux of sunlight on the Earth? c) You are tasked with building a solar power plant in a desert, using solar panels with 10% efficiency. How large an area must your solar panels cover to match the power output of a large nuclear power plant(about a GigaWatt)?

2. Assuming surface temperature of a star emits radiation like a black body, which law will you use to determine the surface temperature of the star? Using the same find the surface temperature of : a) a blue star with peak wavelength 3000 A° b) a yellow star with peak wavelength 6000 A°.

3. A star such as our Sun will eventually evolves into a "red giant" star and then to a "white dwarf" star. A typical white dwarf is approximately the size of Earth, and its surface temperature is about 2.5×10^{4}K. A typical red giant has a surface temperature of 3.0×10^{3}K and a radius ~100,000 times larger than that of a white dwarf. What is the average radiated power per unit area and the total power radiated by each of these types of stars? How do they compare?

6. Satellite A is 7 times farther from a planet than satellite B. If it takes satellite B 4 weeks to complete a full orbit around the planet, how long will it take satellite A to travel around the planet once?

5. In this problem assume that the moon is only under the influence of the earth's gravitational force given by a magnitude $\mathbf{F_{e,m}} = -(G\, m_e m_m / r^2_{e,m})\, \mathbf{r_{e,m}}$. Also assume that the moon is moving in a circular orbit around the earth and that the moon travels with a constant speed in that orbit. Let $G=6.67\times10^{-11}$ Nm^2/kg^2. The mass of the earth is $m_e = 5.98\times10^{24}$ kg . The mass of the moon is $m_m = 7.36\times10^{22}$ kg . The radius of the orbit is $r_{e,m} = 3.8\times10^{8}$ m). Calculate the period of the moon's orbit around the earth. Is this the same period as the time between full moons as seen from the earth? Can you give possible reasons?

6. (a) Based on Kepler's laws and information on the orbital characteristics of the Moon, calculate the orbital radius for an Earth satellite having a orbital period of 1.0 h. (b) What is unreasonable about this result?

7. From Planck function, the amount of radiated energy per unit time having wavelengths between λ and λ+d λ emitted per unit area perpendicular to direction of travel per unit solid angle is given as

$$B_\lambda (T) = 2hc^2 / \{ \lambda^5 (e^{hc/\lambda kT} - 1) \}$$

a) Show that the monochromatic luminosity (energy radiated per unit time between λ and λ+d λ) can be given as

$$L_\lambda d\lambda = 8 \Pi^2 R^2 h c^2 / \{ \lambda^5 (e^{hc/\lambda kT} - 1) \} . d\lambda$$

b) Integrate the above equation over all wavelengths to obtain an expression for the total luminosity of a blackbody star. Hint:

$$\int_0^\infty u^3 du / (e^u - 1) = \Pi^4 /15$$

c) Compare with Stefan Boltzmann equation to find the expression of σ.

8. The individual apparent magnitudes of two binary stars are +2 and +4. What is the combined apparent magnitude of the binary system?

9. At opposition, Mars apparent magnitude m_1 was -1.6 and solar distance r_1 was 1.55 AU. At opposition seven years later, r_2 was 1.64 AU. Find Mars apparent magnitude, m_2.
* Oppostion is when Mars is on opposite side of Sun as observed from the earth*

10. The two stars have identical diameters. One has a temperature of 5800 K; the other has a temperature of 2900 K. What are the colors of these stars? Which had the larger luminosity? How much more luminous is it? What would be their apparent magnitudes if both of them were at a distance of 10 pc? What would be their apparent magnitudes if one if the hotter one is at twice the distance?