PHY305A
Exercise Set 3

1. The luminosity of the Sun is 3.826×10^{33} erg s^{-1}. Find the flux density at a distance of 1 AU $= 1.496 \times 10^{13}$ cm. This value of the solar flux is known as the solar constant. Also find the absolute magnitude of the Sun given that the apparent magnitude $m_{\mathrm{Sun}} = -26.81$.

2. Consider a binary star such that the two components have magnitudes 1 and 2 respectively. Find the total magnitude of the binary system.

3. The absolute magnitude of a star is $M = -2$ and the apparent magnitude $m = 8$. Ignoring interstellar and atmospheric extinction find the distance of the star?

4. Obtain an expression for the mean temperature of earth in terms of the temperature of sun T_S, the earth sun distance r, the radius of the earth R_E and the radius of the sun R_S. You may assume that the earth and sun are perfect black bodies. Numerically estimate the mean temperature.

5. In this problem use the magnitude system in which all apparent magnitudes of a reference star are set equal to 0. Let the color index for a particular star be $B - V = 1$. Mathematically express the ratio of the flux density of B filter to the V filter (F_B/F_V) in terms of the corresponding ratio of the reference star.

5. Consider the diffuse radiation from the sky. Assume that it is uniform over the entire sky. Mathematically express the intensity received at earth. What is the typical power that we receive from the sky on a sunny day? Make a rough estimate.

6. Integrate the formula for blackbody specific intensity in order to obtain an expression for the Stefan-Boltzmann constant. You may use the integral

$$\int_0^\infty dx \frac{x^3}{e^x - 1} = \frac{\pi^4}{15} \tag{1}$$

7. Define the specific intensity B_λ such that

$$\int_0^\infty d\lambda B_\lambda = \int_0^\infty d\nu B_\nu = B \tag{2}$$

where λ is the wavelength of the electromagnetic wave. Show that

$$B_\lambda = \frac{2hc^2}{\lambda^5} \frac{1}{e^{hc/kT\lambda} - 1} \tag{3}$$

8. Find the peak position of wavelength and the corresponding frequency for the CMBR.

9. Consider a model of a star consisting of a spherical blackbody with a surface temperature of 28,000 K and a radius of 5.16×10^{11} cm. Let this model star be located at a distance of 180 pc from Earth. This is a model of the star Dschubba, the center star in the head of the constellation Scorpius. Determine the following for the star:

   a. Luminosity
   b. Absolute bolometric magnitude
   c. Apparent bolometric magnitude
   d. Distance modulus
   e. Radiant flux density at the star's surface
   f. Radiant flux density at the Earth's surface
   g. Peak wavelength

10. (a) Make a Taylor expansion of the Blackbody intensity formula in the low frequency limit keeping only the leading order term. In this limit the intensity is proportional to temperature. (b) Assume that we are making observations in a narrow frequency band in which this approximation is valid. Obtain a formula for the flux density for a radiation field whose blackbody temperature has a $\cos\theta$ (dipole) dependence where θ is the polar angle in a chosen coordinate system. (c) What would be the angular dependence of this temperature field in a different (rotated) coordinate system?