Problem Set 1

ASTR 5420 – Stellar Evolution & Interiors

Due Friday, February 8, 2016

1. [5 points] The Planck radiation spectrum per unit frequency is given by

$$B_\nu(T) = \frac{2h\nu^3}{c^2}\frac{1}{e^{h\nu/kT}-1}\,[\text{erg s}^{-1}\text{cm}^{-2}\text{ster}^{-1}\text{Hz}^{-1}]. \tag{1}$$

   Show by explicit calculation that the equivalent spectrum per unit wavelength is

$$B_\lambda(T) = \frac{2hc^2}{\lambda^5}\frac{1}{e^{hc/\lambda kT}-1}\,[\text{erg s}^{-1}\text{cm}^{-2}\text{ster}^{-1}\text{cm}^{-1}]. \tag{2}$$

2. [5 points] The Wien displacement law states that the peak of the blackbody function occurs at

$$\lambda_{\max}T = 2.898 \text{ mm K}. \tag{3}$$

   (a) Show that this is equivalent to solving the problem $y = 5(1 - e^{-y})$ where $y = hc/(\lambda_{\max}kT)$. Show by inspection that the root of this equation is $y \approx 4.965$, giving the Wien displacement law.

   (b) Show that that Wien law in *frequency* space is

$$\frac{\nu_{\max}}{T} = 5.88 \times 10^{10} \text{ Hz K}^{-1}. \tag{4}$$

3. [10 points] X-ray photons are produced in a cloud of radius R at the uniform rate Γ (photons per unit volume per unit time). The cloud is at a distance d away. Neglect absorption of these photons. A detector at the earth has field of view of $\Delta\theta$ and an aperature of diamter ΔA.

   (a) Assume that the source is completely resolved. What is the observed intensity (in photons per unit time per unit area per steradian) toward the center of the cloud?

   (b) Assume that the source is completely unresolved. What is the observed average intensity when the source is in the beam of the detector?

4. [10 pts] Intro to coding

(a) Download the sample python script at
http://physics.uwyo.edu/∼hannah/teaching/ASTR5420/myfunc.py.
Explain, line-by-line, what this script does.

(b) Write your own code that reads in a number n and outputs the sum of all positive integers up to and including that number. Points will be awarded based on the elegance of your solution. Email your code to hjangcon@uwyo.edu, subject line: "ASTR 5420 PS1 code"

(c) Extra credit if you write your script with good error handling.

5. [extra credit: 3 pts] Typeset your solutions in LaTeX.