ASTR 337: Homework 1

Due Date/Time: Beginning of class (7 pm), Wednesday, September 11th 2019

Problems

1. From Chromey: Chapter 1, Exercise 2
    a. What wavelength photon would you need to ionize a hydrogen atom (ionization energy = 13.6 eV)?
    b. Compute the temperature of the blackbody whose spectrum peaks at the wavelength you found in (a).
2. From Chromey: Chapter 1, Exercise 5a ("Consider an eclipsing binary star…")
3. Investigate the relationship between the Stefan-Boltzmann equation and the Planck function by completing the following steps:
    a. Integrate $L_\lambda d\lambda = 4\pi^2 R^2 B_\lambda d\lambda$ over all wavelengths to obtain an expression for the total luminosity of a blackbody-emitting star.

    Hint: Use the expression for B_λ *and* $\int_0^\infty u^3 du/(e^u - 1) = \pi^4/15$
    b. Compare your result with the Stefan-Boltzmann equation, and show that the Stefan-Boltzmann constant σ is given by: $\sigma = 2\pi^5 k^4/(15c^2h^3)$
    c. Calculate the value of σ from this expression, and compare it with the accepted value (which you can find online or in a textbook)

4. The most massive stars that can form are those where the radiation pressure and the kinetic pressure are approximately equal. Estimate the mass of the most massive stars, by following the steps below.
    a. Assume that the gravitational binding energy of a star of mass M and radius R is $\left|E_{gr}\right| \sim GM^2/R$. Use the Virial Theorem $\overline{P} = -E_{gr}/(3V)$, where V is the volume of the star to show that $P \sim \left(4\pi/3^4\right)^{1/3} GM^{2/3}\rho^{4/3}$ where ρ is the density.
    b. Using the relation $P_{total} = P_g + P_{rad} = \rho kT/\overline{m} + aT^4/3$, where k is Boltzmann's constant and a is the radiation constant ($a = 4\sigma/c$), show that if the radiation pressure P_{rad} equals the kinetic pressure P_g , then the total pressure is $P = 2(3/a)^{1/3}(k\rho/\overline{m})^{4/3}$
    c. Equate the expressions for the pressure in (a) and (b) to obtain an expression for the maximal mass of a star. Find its value in solar masses for a fully ionized hydrogen composition (in which case $\overline{m} = 0.5m_H$)

Pre-Lab Reading and Questions for Week 2

Reading

Please read the following sections in Chromey:

- All of Chapter 1, with special emphasis on Section 1.5 (magnitudes)
- Sections 3.1.1 through 3.1.6 in Chapter 3

Reading Questions

1. How are flux, luminosity, and the magnitude system related?
2. What is the difference between an absolute magnitude and an apparent magnitude?
3. Define three important/main points from Chapter 1 in your own words.
4. Choose **two** of the following concepts and explain them as you would to a peer:
    a. Bolometric flux
    b. Standard star
    c. The relationship between an object's spectrum and its photometry
5. How do the altitude-azimuth and equatorial systems differ?
6. How is the "observer's meridian" defined?
7. Define three important/main points from Chapter 3 in your own words.
8. What were the two least-clear concepts from Chapter 3?