ASTR 300 Stars and Stellar Systems Fall 2009

Homework Set No. 2 Due Feb 17, 2011

Please type up or print out your homework and staple the pages together. Leave a blank space to write in mathematical equations or diagrams. Make sure you **show your work** for any calculations – "magical" answers will receive no credit. Problems are **due at the beginning of the lecture**.

Review questions, Problems, etc. which have a chapter and number noted are from your text *Stars and Galaxies, 7th edition*.

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1. Why do optical astronomers often put their telescopes at the tops of mountains, while radio astronomers sometimes put their telescopes in deep valleys? (Chapt. 6, Review Question 4)

2. Optical and radio astronomers both try to build large telescopes but for different reasons. How do these goals differ? (Chapt. 6, Review Question 5)

3. An astronomer wants to put a telescope in space that will have a resolving power of 0.02 seconds of arc at visible wavelengths. What must the diameter of the mirror be to achieve this resolution?

4. We discussed the Stefan-Boltzmann law which gives the energy, E, radiated by a surface at temperature T:

$$E = \sigma T^4 \text{ Joule/s/m}^2, \text{ where } \sigma = 5.67 \times 10^{-8} \text{ Joule/s/m}^2\text{/degree}^4$$

   Suppose a space station has an exterior panel one square meter in area exposed to space. The panel is at a temperature of -20 C (-4 F).

   (a) What temperature units must be used in the Stefan-Boltzmann equation and what is the temperature of the panel in these units?

   (b) How much energy/s is radiated into space by the panel (in Joule/s)? (One Joule/s is a power of one Watt).

   (c) At what wavelength does the radiation from the panel peak?

5. Suppose you are on Mercury, 0.39 AU from the Sun. How bright would the Sun appear compared to its brightness as seen from the Earth?

6. In class we derived a formula for the radius of a star, given its effective temperature and luminosity (Slide 17 of "Slides from Lecture 4". It is a bit more accurate to use 5777 K instead of 5800 K for the sun's effective temperature in that equation).

   In the appendix of your text, you will find a table, Table A-7, which lists the properties of main sequence stars, including their effective temperature and their luminosity, mass and radius in solar units. I want you to check the self-consistency of this table: In particular, use the luminosity and effective temperature given in the table to **compute** the radius of the M5 star. Then compare your result with the tabulated value.

7. Table A-7 also lists the *average density* of these stars. Now the average density ρ is related to the mass and radius by the equation

$$\rho = \frac{Mass}{Volume} = \frac{M}{\frac{4}{3}\pi\, R^3}$$

From this equation we find that the average density of the sun is $\rho_\odot = 1.41$ gm/cm^3 , in agreement with the table for a G0 star. If we divide the above equation by the same equation evaluated for the sun, we obtain

$$\frac{\rho}{\rho_\odot} = \frac{M/M_\odot}{(R/R_\odot)^3} \quad \text{and solving for the radius:} \quad \left(\frac{R}{R_\odot}\right) = \left[\frac{1.41}{\rho}\frac{M}{M_\odot}\right]^{1/3}$$

Use this last equation along with the mass and density listed in A-7 to calculate the radius of the M5 star in this table. Compare your result with the radius listed in A-7.

Is this calculated value of the radius in better or worse agreement with the tabulated value than the one you calculated in problem 6 above?

8. The highest-velocity stars an astronomer might observe have velocities of about 400 km/s. What change in wavelength would this produce in the Balmer gamma line? (Hint: Wavelengths are given on page 133.) (Chapter 7, Problem 10)