ASTR 300 — Stars and Stellar Systems — Fall 2009

Homework Set No. 2 — Due Sep 24, 2009

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, 6th 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. Why must telescopes observing in the far-infrared be cooled to low temperatures? (Chapt. 6, Review Question 13)

3. An astronomer wants to put a telescope in space that will have a resolving power of 0.01 seconds of arc at visible wavelengths. What must the diameter of the mirror be to achieve this resolution?

4. Infrared observations of a star show that it is most intense at a wavelength of 2000 nm. What is the temperature of the star's surface? (Chapt. 7, Problem 3)

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

$$E \;=\; \sigma T^4 \quad \text{Joule/s/m}^2, \quad \text{where} \quad \sigma = 5.67\times10^{-8} \quad \text{Joule/s/m}^2\text{/degree}^4$$

   Suppose a space station has a panel one square meter in area exposed to space. The panel is at a temperature of 22 C (71.6 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?

6. Near the end of their lives, stars like the sun become very luminous but have low surface temperatures. Consider such a star with a luminosity of $L = 10^4\ L_\odot$ and a surface temperature of $T = 3000$ K.

   (a) Calculate the radius of this star. Give your answer in solar units (units of $R\odot$).

   (b) Convert your radius into AU. Where would the surface of this star be located if you superimposed it on our solar system?

7. We saw that the energy of the nth level of the hydrogen atom is

$$E_n = \frac{E_1}{n^2} \quad \text{where} \quad E_1 = -2.178 \times 10^{-18} \text{ Joule}$$

is the energy of the ground state (it is negative since the the energy is taken as zero if the electron is completely removed – we have to add energy to free a bound electron).

(a) What is the energy of the $n = 109$ state of the H atom? What is the energy of the $n = 110$ state? If an atom is in the $n = 110$ level and jumps to the $n = 109$ level, what is the energy of the photon emitted? What other levels might the electron jump to from the $n = 110$ level?

(b) Recall that the photon energy is related to the frequency f by $E = hf$ where $h = 6.626 \times 10^{-34}$. What is the frequency of the photon emitted by the $n = 110$ to $n = 109$ transition? How is the frequency related to the wavelength, and what is the wavelength of this photon?

(c) Astronomers actually observe this radiation. What part of the electromagnetic spectrum is it in? (See Fig. 6-3) What type of telescope would the astronomer use?