ASTR 300 Stars and Stellar Systems Spring 2011

Homework Set No. 6 Due April 26, 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*.

---

1. Astronomers believe that a 13 $M_\odot$ star will end as a neutron star. What is the maximum mass of a neutron star? What happens to the rest of the mass of the original star?

2. According to the modern model of a pulsar, if a neutron star formed with no magnetic field at all, could it be a pulsar? Why or why not?

3. Why would astronomers naturally assume that the first discovered millisecond pulsar was relatively young? (Chapter 14, Review Question 10)

4. What is "The Black Widow" pulsar and what puzzling objects does it help explain?

5. Suppose that a neutron star has a radius of 10 km and a temperature of 1,000,000 K. How luminous is it? Give your answer in solar luminosities. At what wavelength would the radiation peak? (Use Wien's law.)

6. Your text gives the formula for the Schwarzschild radius of a black hole (p 292). Earlier in this course, you encountered the formula for the velocity of a body in a circular orbit of radius r about a body of mass M (p 82).
   Now, the last stable circular orbit about a black hole has a radius equal to 3 times the Schwarzschild radius. Combine these two expressions to find the velocity of a body in this last circular orbit. Express your result as a fraction of the speed of light. (This result isn't quite right since you are using Newton's gravity for V_c rather than Einstein's theory, but it's pretty close.)

7. There is a black hole with a mass of $4 \times 10^6\ M_\odot$ at the center of our Galaxy.
   (a) What is the Schwarzschild radius of this black hole?
   (b) What is the circumference of the last stable circular orbit about this black hole? (See the preceding problem.)
   (c) Using the velocity you obtained above, find the period of a body that is in the last stable orbit about this black hole. Express your result in minutes.

8. A neutron star and a white dwarf have been found orbiting each other with a period of 11 minutes. If their masses are typical, what is their average separation? Compare their separation with the radius of the sun, 7×10^5 km. (Hint: See Chapter 9)
   (Chapter 14, Problem 3)

continued overleaf ...

9. The speed of Saturn in it's orbit is 9.64 km/sec. Suppose a very distant observer saw the Sun's light decrease as Saturn passed across the Sun's disk.

   (a) How long would the decrease in light last?

   (b) By what fraction would the Sun's light decrease?

   (c) How long would the observer have to wait to see the next eclipse?

   (d) How close to the plane of Saturn's orbit would the observer need to be in order to see this eclipse? (I.e., how many degrees above or below Saturn's orbital plane?)

   (See Table A-10, p 424, for properties of planets.)

10. Suppose a star of spectral type F3 has been found by the Kepler satellite to have a planetary companion which passes in front of the star every 12.3 days. From this star's spectral type, we know that its radius is 1.3 $R_\odot$. During the planet's transit, the star's light is seen to decrease by 0.31%. What is the radius of the planet it terms of the star's radius? What is its radius in units of Jupiter radii?