ASTR 220 Spring 2007 Professor Hamilton

Final, Part I: (10 Points)

Take home, Open book, Work together, Due May 3 in class.

1. The flux of light F from a star of Luminosity L at distance d is given by

$$F = \frac{L}{4\pi d^2} \qquad \text{where} \qquad L = (4\pi R^2)(\sigma T^4),$$

R is the star's radius, T is its temperature, and $\sigma = 5.67 * 10^{-8}$ Watts/(m^{2}K^4) is Stefan-Boltzman's constant. From the Earth you see two red stars orbiting in a close (tightly-bound) binary system, and one appears to be 10^4 times brighter than the other (its flux is 10^4 times higher), how are the luminosities of the two stars related? How do the temperatures of the two stars compare? How do the sizes compare? Which star is more massive? Which star is older? What types of stars are these likely to be? Explain your answers.

2. In class, I said that if a binary system loses 1/2 of its mass, the binary becomes unbound. There is a clarification and an exception to this rule. The clarification is that for the rule to apply, the mass loss must occur quickly as in a supernova. If it occurs slowly, as with stellar winds, then systems will stay bound for arbitrary amounts of mass loss. The exception to the "1/2 rule" occurs if the supernova produces an asymmetric explosion - if the stars are sent off in the same direction by the explosion, then they may remain bound even if more than 1/2 of the system mass is lost in the explosion. Describe a plausible sequence of events that would lead to 2 Neutron Stars orbiting each other using this information and the methods from class. Start from when the stars were first formed.

3. A 10-Solar-Mass red giant transfers mass to a 1-Solar-Mass white dwarf. Describe three possible future histories of the system, noting possible novae, supernovae, and whether the final system is bound or not. Draw pictures as we did in class.

4. a) Compare the gravity at the surface of the following 2 Solar Mass stars: A main sequence star ($R_{MS} = 800,000$ km), a white dwarf ($R_{WD} = 8,000$ km), a red giant ($R_{RG} = 80,000,000$ km) and a neutron star($R_{NS} = 8$ km). Use the following equation for gravity g:

$$g = \frac{GM}{R^2},$$

where R is the star's radius, M is its mass, and G is the gravitational constant. Use the fact that the main sequence star has gravity 33 times stronger than Earth's, and give your answers in units of Earth's gravity.

b) Can you use this information to explain why nova explosions eject material from white dwarfs into space but the equivalent process on neutron stars ejects no material?

c) Stellar winds occur when the hottest gas molecules move quickly enough to overcome a star's gravity and escape into space. Which of the four stars of this problem should have the strongest stellar winds?