Physics 131: Survey of the Universe
Spring 2004
Prof. Michael S. Vogeley
Homework assignment 6

Due at the beginning of class, 12:30 p.m. Thursday, May 20. Please write your work and answers on a separate sheet of paper, with your name at the top and all pages stapled together.

1. Age of Supernova Remnant

(a) You observe a supernova remnant that has an angular radius of 1 arcmin in a star cluster that is 1 kpc away. What is the physical radius (in km) of the supernova remnant?

(b) You obtain a spectroscopic observation of the gas in the supernova remnant and determine that the near side of the gas bubble is blueshifted by $\lambda_{obs}/\lambda_{emit} = 0.99$. What is the velocity of this gas, in km/s? Is this gas moving toward you or away from you?

(c) Using the physical size of the supernova remnant and the outflow velocity of the gas, estimate the age (in years) of this remnant. In other words, how many years ago would the supernova have been observed to explode?

2. Life Cycle of Stars

The following questions regard the "circle of life" for star birth, stellar evolution, stellar death, and star formation.

(a) What are the two most abundant elements in the universe?

(b) What is the name of the physical process that produces most of the elements heavier than those in part (a)?

(c) Our solar system is filled with carbon, oxygen, silicon, and other heavy elements. How did most of these heavy elements get into the solar system?

(d) What is the end state of a star like the Sun? In other words, what is left at the end of the Sun's life?

(e) What is the end state of a twenty solar mass star?

(f) What is the heaviest element made in the core of stars?

(g) How is uranium made?

3. White Dwarfs and Neutron Stars

(a) What is the average density in kg/m^3 of a $1M_{\text{sol}}$ white dwarf that has a radius of 6000km? (Reminder: Density is mass/volume. What is the volume of a sphere of radius r?)

(b) What is the ratio of the gravitational force felt on the surface of the white dwarf in part (a) to the force at the surface of the Earth?

4. Death of a Massive Star

Place the following events in the lifetime of a massive star in correct chronological order.

(A) Silicon core burning

(B) Helium core burning

(C) Photodisintegration

(D) Carbon core burning

(E) Supernova explosion

(F) Formation of a supernova remnant

(G) Hydrogen shell burning

(H) Formation of a neutron star

(I) Hydrogen core burning

(J) Iron catastrophe

5. Flying a Spaceship Near a Black Hole

(a) Suppose we place our space ship in a circular orbit around an unseen object (black hole?) of mass $5 \times 10^6 M_{\text{sol}}$. If the radius of our orbit is $r = 10^{13}$km, what is the velocity of our spaceship? Is that velocity larger or smaller than the speed of light?

(b) Suppose that the radius of the unseen object is $R = 1.5 \times 10^7$km. Is that object a black hole? Why or why not?

(c) Light is emitted at wavelength of $\lambda_{emit} = 500$nm from a point that lies $r = 6 \times 10^7$km from the center of the unseen object. At what wavelength would we observe that light?