Astronomy 2115 Homework #5

Fall 2023 Due Tuesday, Oct 10 in class

For full credit you must write your solutions neatly and include all work. Do not forget the units.

1) (a) Why do neutron stars rotate so much more rapidly than ordinary main sequence stars? (b) Why do they have such strong magnetic fields?

2) The Ring Nebula is a planetary nebula in the constellation Lyra. It has an angular size of 1.4 arcmin x 1.0 arcmin and is expanding at a rate of about 20 km/s. Approximately how long ago did the central star shed its outer layers? Assume a distance to the Ring Nebula of 828 parsecs.

3) (a) Find the average density of a 1 M_sun white dwarf having the same diameter as Earth. (b) What speed is required for gas ejected from the surface to escape? (Note this is also the speed of impact for an object falling in from a great distance).

4) In the classic 1960s science fiction comic book *The Atom*, a physicist discovers a basketball-sized meteorite (about 10 cm in radius) that is actually a fragment of a white dwarf star. With some difficulty, he manages to carry the meteorite back to his laboratory. Estimate the mass of such a fragment. Is the assumption that he could carry it back reasonable?

5) The distance to the Crab Nebula is about 2000 parsecs. In what year did the star actually explode – that is in what year did the light from the explosion begin travelling towards Earth? Explain your answer.

6) The Crab Nebula had an apparent size (diameter) of about 5 arcmin in 1987, and this size is increasing at a rate of 0.411 arcsec/year (Bietenholz et al. 1991). (a) Assuming constant expansion, what year would Earth observers have seen the explosion? (b) Does this agree with the known date of 1054 AD? (c) how can you explain the difference? (d) If the Crab is at 2000 parsecs, calculate the physical size (diameter) in pc today.

7) Emission lines in the spectrum of the Crab Nebula exhibit a Doppler shift, which indicates that the gas in the nebula closest to us is moving towards us at 1450 km/s. (a) Assuming a spherical expansion, calculate the expected motion in the plane of the sky and compare it to the value of 0.411 arcsec/year you used in problem (6).

8) Serena flies past Michael in her spaceship at nearly the speed of light. According to Michael, Serena's clock runs slow. According to Serena, does Michael's clock run slow, fast, or at the normal rate? Explain your answer.

9) If the Sun suddenly became a black hole, how would the Earth's orbit around the sun be affected? Explain your answer.

10) A spaceship flies from Earth to a distant star at a constant speed. Upon arrival, a clock on board the spaceship shows a total elapsed time of 8 years for the trip. An identical clock on Earth shows that the total elapsed time for the trip was 10 years. What was the speed of the spaceship relative to the Earth?

11) How fast should a meter stick be moving in order to appear to be only 60 cm long? What is the orientation of the meter stick?

12) Why are infrared telescopes useful for exploring the structure of the Galaxy? Why is it important to make observations at both near-infrared and far-infrared wavelengths?

13) The galactic halo is dominated by Pop II stars, whereas the galactic disk contains mostly Pop I stars. In which of these parts of the Galaxy has star formation taken place recently? Explain your answer.