Introduction to Astronomy

HW080602

due in one week

1. A neutron has a mass of ~1.7 x 10^{-27} kg, and a radius of about 10^{-15} m. (a) Calculate the density of matter in a neutron with the average density of a neutron star. (b) If the neutron star's density is more than that of a neutron, the neutrons within the star are overlapping; if it is less, the neutrons are not overlapping. Which of these seems to be the case for average neutrons inside the star? Which do you think is the case at the center of a neutron star, for which densities are higher than average?

2. (a) Prove that the density of matter needed to produce a black hole is inversely proportional to the square of the mass of the black hole. (b) If you wanted to make a black hole from matter compressed to the density of water, how much mass would you need? (c) Find the Schwarzschild radius for an object having a mass equal to that of the planet Saturn. (d) What is the Schwarzschild radius of a supermassive black hole of mass 3.7 x 10^6 $M_\odot$? What is the angular diameter of such a black hole as seen at a distance of 8 kpc, the distance from the Earth to the Galactic center? Give your answer in arcseconds.

3. It is estimated that the Coma cluster contains some 10^{13} $M_\odot$ of intracluster gas. (a) Assuming that this gas is made of hydrogen atoms, what is the total number of intracluster gas atoms in the Coma cluster? (b) The Coma cluster appears roughly spherical in shape, with a radius of 3 Mpc. Assuming the gas is uniformly distributed, calculate the gas density (i.e., number of hydrogen atoms per cubic centimeter) inside the cluster space. (c) Compare this density with the gas in Earth's atmosphere (3 x 10^{19} molecules per cubic centimeter, temperature 300 K); a typical gas cloud in the Milky Way (a few hundred molecules per cubic centimeter, temperature less than 50 K); and the corona of the Sun (10^5 ions per cubic centimeter, temperature 10^6 K).

4. The Milky Way Galaxy is in the processing of absorbing the satellite galaxy called the Canis Major Dwarf. Discuss whether this process could someday cause the Milky Way to become an active galaxy.

5. If a photon from the cosmic microwave background (CMB) had wavelength λ_0 when it was emitted at redshift z, its wavelength today is $\lambda = \lambda_0 / (1 + z)$. (a) Let T be the temperature of the CMB today. Show that the radiation temperature was $T_0 = T (1+z)$ at redshift z. (b) What was the radiation temperature at z=1?

6. Describe one of the latest discovery or breakthrough news in astronomical research. State the content and significance of the event. Remember to give the references of your work.