PHYS 182 Fall 2019 Prof. R. Brandenberger

Readings and Homework for Weeks of Oct. 21 & 28, 2019

Readings

Textbook, Chapters 15 - 18.

Problems & Exam Preparation (due Nov. 4 in class)

1. What energy do photons comng to us from outer space have to have before they can produce electrons when they enter the atmosphere?

2. The LHC (Large Hadron Collider) is a machine which accelerates protons and smashes them together. To what velocity do you have to accelerate the protons if you are to have enough energy to produce a Higgs particle? I want you to assume that all you need to produce the Higgs particle is enough energy. You can assume that the Higgs particle has a mass which is 100 times the mass of the proton.

3. According to the Big Bang model of cosmology, the universe has been expanding since some initial time (call it $t = 0$) when the temperature was infinite. At early times, the temperature T scales as $t^{1/2}$. The current temperature is about $3^o K$. Consider the part of space which corresponds to the currently visible universe. It is about 10^{10}Mpc. Consider a proton confined to this part of space. Assuming that the proton is an elementary particle, then at what temperature does the momentum uncertainty become so large that we cannot tell if there is one proton in the volume or more than one?

4. Taking into account of what you know about elementary particles, then what will happen to the proton when you go back in time? At what approximate temperature will this abrupt event to the proton happen? I am expecting a qualitative and not a quantitative answer.

5. Consider the gravitational attractive force and the electromagnetic repulsive force between two electrons. How many times smaller is the gravitational force? Does the answer to the last question depend on the distance between the electrons? You can use the following numbers: the mass of the electron is 9.1×10^{-31}kg, the charge of the electron is -1.6×10^{-19}Coul, and the electromagnetic force between two charges of magnitude q_1 and q_2 separated by a distance d is

$$F_{EM} = k(q_1 q_2)/d^2 \,,$$

where $k = 9 \times 10^9 (N \times m^2)/(\text{Coul})^2$.

6. Suppose that the Earth and the Sun each had an excess charge equivalent to the charge of an electron. Using the data from the previous problem, compare the gravitational and electromagnetic forces between the Earth and the Sun.. What does the answer tell you about why gravity dominates on large scales?

7. The sun's average temperature is about 5800K. Using Wien's displacement law, find the wavelength of the peak emission. What color does this correspond to? The temperature of a sunspot is about 4000K. What color does this correspond to?

8. The power needed to operate your body is about 100 Watts. Suppose your body could run on fusion power and could convert 0.7% of its mass into energy. For how long could your body then run on fusion power?

9. Describe (in half a page or less) how scientists determine what the interior of the sun is like.

10. How different would the interior temperature of the sun be if the strong nuclear force were ten times as strong as it is, but the weak force the same as it is?