

Homework 3: Due Tuesday September 28

READING 1: <http://particleadventure.org/particleadventure/index.html> Read first three sections: what is fundamental?, what is the world made of?, and what holds it together?

READING 2: <http://abyss.uoregon.edu/~js/cosmo/lectures/lec20.html>

READING 3: <http://abyss.uoregon.edu/~js/cosmo/lectures/lec21.html>

1. (5 points) Quarks

a) The positively charged sigma particle Σ^+ has charge $Q = +1$, strangeness $S = -1$, and spin $J = 1/2$. Its baryon number is $B = 1$. How many quarks does it contain, and which flavors must they be?

b) The K- meson has charge $Q = -1$, strangeness $S = -1$, and spin $J = 0$. Its baryon number is $B = 0$. How many quarks does it contain, and which flavors must they be?

2. (5 points) The Particle Adventure: Short answer questions based upon Reading 1

a) What are electrons made of?

b) Which of the following are made of quarks: baryons, leptons, mesons, muons, photons, gluons?

c) Which fundamental interaction is responsible for: 1) planetary orbits?; 2) nuclear bonding?; 3) friction?

d) Which interaction has heavy carriers and why does that matter?

e) What happens when a matter particle and an antiparticle meet?

3. (5 points) Early Universe: Questions based upon Reading 2

a) What is the meaning of the term “Planck length”? What is the numerical value of the Planck length in cm, i.e. calculate it using the Planck time and the speed of light?

b) How is it that the weak and electromagnetic forces are unified in the early universe, when the mass of the W and Z particles are clear much larger than the rest mass of a photon?

c) Why can't we ever observe or measure a singularity? How does this relate to the early universe?

d) What is the spacetime foam and how does it create particles?

e) What is the difference between a GUT (Grand Unified Theory) and supergravity?

4. (5 points) Calculations in a flat universe with $\Omega_{matter} = 1$

Imagine a flat universe with $d_{crit} = 1 \times 10^{-29} \text{g/cm}^3$. Assume that this universe is 14 billion years old.

a) When the universe was 100 million years old, what was its density?

b) What was the redshift at that time (100 million years after the Big Bang)?

c) By how much has the universe expanded since then (since 100 million years after the Big Bang)?

5. (6 points) Essay question. We have discussed the Planck time, 10^{-43}s into the history of our universe. Do you believe that science will ever be able to identify what happened before that time? Will we be able to devise a scientific theory about how the universe was created?

6. (4 points) Question to the professor. Write a question about something that you are still wondering about. I will answer your question on your graded homework.