Physics 492 Homework X, due Fri Apr 9

Reading: Chapters 9, 10.1-7 and 13.1

Problems:

1. A typical strange particle production reaction is

$$\pi^- + p \to K^0 + \Lambda \,.$$

(a) Determine the Q value. (Particle masses: Williams, Tables 10.3, 10.4, and 10.5)

(b) Determine the π^- threshold energy in the p rest frame.

(c) Draw a Feynman diagram with quarks and gluons for this reaction. What is the basic quark process?

2. At the LEP collider at CERN, head-on electron-positron collisions take place, with E_e = electron energy = positron energy.

(a) Determine E_e for the production of a Z^0 boson in the reaction

$$e^+ + e^- \to Z^0 \,.$$

The Z^0 mass is 92 GeV/c^2, and the total momentum is 0.

(b) Suppose that instead a fixed target experiment is carried out, with the electron at rest and the positron energy E'_e. Determine E'_e for the production of a Z^0.

(c) Explain in words why colliding beams can produce higher mass particles, than a single beam hitting a fixed target.

3. Look up the masses of the spin-$\frac{3}{2}$ baryons of the baryon decuplet (Williams, Table 10.5).

(a) Plot the masses vs strangeness.

(b) Estimate the mass of the strange quark from the baryon masses.

4. One of the strange particles observed in early bubble chamber experiments was Ξ^-, called the "cascade" particle. It was produced in the reaction

$$K^- + p \to K^+ + \Xi^- \,,$$

and it decayed through the cascade

$$\Xi^- \to \Lambda^0 + \pi^- \quad \text{followed by} \quad \Lambda^0 \to p + \pi^- \,.$$

Draw Feynman diagrams with quarks and gluons for the production and decay processes.

5. Williams, Problem 10.7. Charge symmetry and charge independence are discussed in Sec. 9.7. The charge symmetry is based on the symmetry of strong interactions under the exchange of u and d quarks. The charge independence is based on the symmetry of strong interactions under the rotations of basis in the u-d flavor space, similar to rotations in the two-dimensional spin-up and spin-down space (hence the names for quarks). Those rotations give rise, in particular, to rotations in the proton-neutron space

Reminder: The first draft of your term paper is due on Wednesday, April 7.