Physics G6050 – Assignment 1

Due: Wednesday September 27, 2006

Problems from Griffiths:

Chpt 1 - 1.8
Chpt 2 - 2.7
Chpt 3 - 3.4, 3.16, 3.18, 3.22
Chpt 4 - 4.11, 4.29 (parts a and b only), 4.37
Chpt 5 - 5.22, 5.25
Chpt 10 - 10.14

Other Problems:

1. Consider decays of the D^0 meson to the following final states: $K^-\pi^+$, $\pi^-\pi^+$, $K^+\pi^-$.

(a) For each final state, draw a lowest-order Feynman diagram.

(b) Estimate quantitatively how large you would expect the branching ratios of the latter two decay modes to be relative to that of $K^-\pi^+$. (Hint: What are the relevant elements of the CKM matrix?)

(c) Compare your expectations from (b) with the measured values, which can be found from the Particle Data Group listings (pdg.lbl.gov).

2. (a) The triplet of Σ states are baryons containing one strange quark and two light quarks.

(a) The lifetime of the Σ^0 is ~ 7.4×10^{-20} s, much shorter than that of the charged states $\Sigma^{\pm}$, which have lifetimes ~ 0.8×10^{-10} s. Explain why this should be expected.

(b) Consider decays of the Σ^+ baryon. What would one expect for the ratio of branching ratios:

$$BR(\Sigma^+ \rightarrow p\pi^0)/BR(\Sigma^+ \rightarrow n\pi^+)$$

assuming the final state is in (i) a pure I=3/2 state or (ii) a pure I=1/2 state?

Measurements show that this ratio is of order unity. What does this say about the isospin of the final state?

(3) (a) Consider a photon beam shot at a stationary proton target. What is the minimum energy of the photons which would be required to allow the process $\gamma + p \rightarrow n + \pi^0$ to occur?

(b) This process is responsible for the expected Greisen-Zatsepin-Kuzmin (GZK) cut-off in the energy spectrum of cosmic rays reaching the Earth, due to the interactions of high energy protons with photons from the cosmic microwave background (CMB) as they travel through space. The CMB temperature is 2.7 K, corresponding to typical photon energies ~ 6×10^{-4} eV. Calculate the proton energy corresponding to the GZK cut-off.

(4) Read the two accompanying papers on the first observations of parity violation. For each of the two experiments, explain **briefly** the following: the technique used, and how the measurement demonstrates the violation of parity conservation.