PHY 556/714: Handout 2

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RE: *Topics, Reading & Assignment, lectures 6 thru 9, 09/25/07 thru 10/04/07*

Last week, after completing an empirical discussion of the substructure of matter based on scattering experimental results, we began to address the theoretical basis for our understanding of the spectrum of elementary particles, beginning with a general discussion of symmetries and its relationships to conservation laws. We introduce some important conservation laws and conclude with a discussion of the quark structure of hadrons. Towards the end of lecture 9, we will begin a general discussion of the basic form of a relativistic field theory. This will naturally lead us to the Dirac equation and the formulation of Quantum Electrodynamics in subsequent weeks.

Main Reading:

Griffiths: Section 2.5, Chapter 4, sections 5.8, 5.9 and 7.1.

Supplementary Reading:

Fauenfelder and Henley, Chapter 7, Sections 8.3 thru 8.6 and Chapter 9.

Kane, Sections 2.1 thru 2.6

Homework Assignment 2 *(due 10/15)*

1) Consider a liquid scintillator (mostly water) with a volume of 1000 liters and an electron-antineutrino beam with an intensity of 10^{13}/cm^2/s. How many capture events (via the process $\bar{\nu}_e + p \rightarrow e^+ + n$) are expected in one day, assuming the cross-section is 10^{-43} cm^2?

2) Which of the following 6 reactions can take place? If forbidden, state the reason. If allowed, indicate the dominant responsible interaction.

$$\bar{\nu}_\mu + p \rightarrow e^+ + n$$
$$\nu_e + p \rightarrow e^+ + \Lambda^0 + K^0$$
$$\nu_e + p \rightarrow e^- + \Sigma^+ + K^+$$

$$p + \pi^- \rightarrow p + K^-$$
$$p + \pi^- \rightarrow \Lambda^0 + \bar{\Sigma}^0$$
$$\bar{\nu}_\mu + p \rightarrow \mu^+ + n$$

3) Deduce through which two isospin channels the two reactions below might proceed. Then find the ratio of cross-sections assuming first that one isospin channel dominates and then that the other isospin channel dominates.

$$K^- + p \rightarrow \Sigma^0 + \pi^0$$
$$K^- + p \rightarrow \Sigma^+ + \pi^-$$

4) In the decay $\Delta^{++} \rightarrow p + \pi^+$, what are the possible values of the orbital angular momentum quantum number $\boldsymbol{l}$, in the final state?

5) Suppose you had a system of two particles of spin 2, each in a state with $S_z = 0$. If you measured the $\boldsymbol{J}^2$, where $\boldsymbol{J}$ is the total angular momentum of the system, what values might you get, and what is the probability of each? Check that they add to 1.

6) The neutral Σ^{*0} baryon can decay some of the time to a Σ baryon and a pion. The Σ baryon could be positively charged, negatively charged or neutral and the accopanying pion has the appropriate charge to assure charge conservation. Suppose you observed 100 such decays. On average, predict how many of each of the three pairs of decay particles would be produced. (The isospin assignments for the baryons can be read off the quark model diagrams in lecture 9).

7) Griffiths problem 4.19 (both parts).

8) Griffiths problem 4.20 (parts (a) and (b)).

Following for 714 students only:

9) Griffiths problem 4.23.

10) Griffiths problem 4.37 (part (a)).