

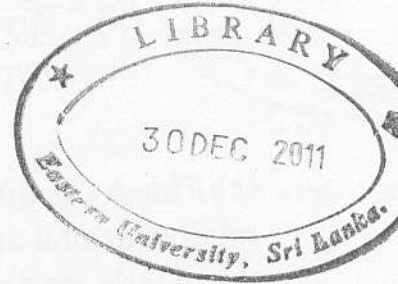
EASTERN UNIVERSITY, SRI LANKA

SPECIAL DEGREE EXAMINATION IN SCIENCE - 2009/10

FIRST SEMESTER

(May 2010)

PH 415 Particle Physics



Time: 02 Hours.

Answer ALL Questions

1. Describe briefly the function of a linear accelerator and give a brief account of the mechanisms of radial focussing and phase focussing in linear accelerators.

An experimentalist conducts an experiment to create π^+ mesons by striking a target of stationary protons by a beam of protons emerging from a linear accelerator. What is the minimum kinetic energy needed for the proton beam emerging from the linear accelerator to produce π^+ mesons?

You may find the following information with usual notation useful:

(i) $p+p \rightarrow d+\pi^+$

(ii) $M_p = 938.8 \text{ MeV}/c^2$, $M_d = 1876.0 \text{ MeV}/c^2$ and $M_{\pi^+} = 140 \text{ MeV}/c^2$

2. (a) Give the charge Q , baryon number B , isospin I , third component of the isospin I_3 and strangeness S of u , d and s quarks. Explain why each of the following particles cannot exist according to the quark model:

(i) A meson of spin $1/2$.

(ii) A baryon of electric charge -2 .

(iii) A baryon with charge $+1$ and strangeness -2

(iv) A meson with charge $+1$ and strangeness -1

(b) What are the quark contents of particles p , n , Σ^+ , Σ^0 , Σ^- , Λ^0 , Ξ^0 and Ξ^- ?

- (i) Give the isospin, third component of the isospin, strangeness and hyper charge of the above particles.
- (ii) Arrange these particles in a diagram according to their hypercharge and third component of isospin.

(c) The Δ^- is a spin $3/2$ baryon consisting of 3 d-quarks with no relative orbital angular momentum. Explain why the application of the quark model to baryons requires the introduction of a new quantum number, called colour quantum number.

3. (a) Indicate, giving reasons, whether the following interactions proceed through strong, electromagnetic or weak interactions or forbidden.

- (i) $\Lambda^0 \rightarrow p + \pi^-$
- (ii) $\pi^- + \Sigma^+ \rightarrow \Omega^- + K^+$
- (iii) $\pi^- + p \rightarrow K^+ + \Sigma^-$
- (iv) $\gamma + p \rightarrow n + \pi^+$

(b) Draw the Feynman diagrams for the following processes:

- (i) $\Delta^{++} \rightarrow p + \pi^+$
- (ii) $\pi^- + p \rightarrow K^0 + \Sigma^0$
- (iii) $\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$

(c) The Δ^+ particles decay through the following strong interaction decay modes:

- (i) $\Delta^+ \rightarrow p + \pi^0$
- (ii) $\Delta^+ \rightarrow n + \pi^+$

Identify the branching ratio, $\frac{\sigma(\Delta^+ \rightarrow n\pi^+)}{\sigma(\Delta^+ \rightarrow p\pi^0)}$

You may find the following information useful:

$$|I, I_3\rangle = \left| \frac{3}{2}, \frac{1}{2} \right\rangle = \frac{1}{\sqrt{3}} |1, 1\rangle \left| \frac{1}{2}, -\frac{1}{2} \right\rangle + \sqrt{\frac{2}{3}} |1, 0\rangle \left| \frac{1}{2}, \frac{1}{2} \right\rangle$$

4. The formula given below can be used to estimate the mass of the members of baryon multiplets.

$$M(\text{baryons}) = m_1 + m_2 + m_3 + A \left\{ \frac{S_1 \cdot S_2}{m_1 m_2} + \frac{S_2 \cdot S_3}{m_2 m_3} + \frac{S_3 \cdot S_1}{m_3 m_1} \right\}$$

where A is the same for all baryons in the same quantum state and the other symbols have their usual meaning.

- (a) Obtain an expression for the mass of a proton. You may assume the masses of u and d quarks are equal to m_u .
- (b) Obtain an expression for A for a baryon octet with spin $\frac{1}{2}$ and even parity in terms of \hbar .
- (c) Estimate the mass of the Σ^0 and Λ^0 particles.

You may find the following information useful:

- (i) Constituent quark masses are $m_u = m_d = 310 \text{ MeV}/c^2$ and $m_s = 483 \text{ MeV}/c^2$.
- (ii) Proton mass = $940 \text{ MeV}/c^2$.