EASTERN UNIVERSITY, SRI LANKA

SPECIAL DEGREE EXAMINATION IN SCIENCE – 2009/10

FIRST SEMESTER

(May 2010)

PH 415 Particle Physics

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30 DEC 2011
Eastern University, Sri Lanka.

Time: 02 Hours.

Answer ALL Questions

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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) $\pi^- + p \rightarrow K^o + \Sigma^o$

(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, $\dfrac{\sigma(\Delta^+ \rightarrow n\pi^+)}{\sigma(\Delta^+ \rightarrow p\pi^0)}$

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.

$$M(baryons) = m_1 + m_2 + m_3 + A\left\{\frac{\underline{S}1 \cdot \underline{S}2}{m_1 m_2} + \frac{\underline{S}2 \cdot \underline{S}3}{m_2 m_3} + \frac{\underline{S}3 \cdot \underline{S}1}{m_3 m_1}\right\}$$

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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 ½ and even parity in terms of ħ.

(c) Estimate the mass of the Σ^0 and Λ^0 particles.

You may find the following information useful:

(i) Constituent quark masses are $m_u = m_d = 310$ MeV/c^2 and $m_s = 483$ MeV/c^2.

(ii) Proton mass = 940 MeV/c^2.