Phy 523
PARTICLE PHYSICS
Final Examination

The paper has two parts. Questions in the part I is for five marks each. Questions of part II is of ten marks each. Attempt six questions from part I and three from part II.

April 21st 2009
Time allowed 3 Hours

PART I

1. Describe (BE BRIEF) an experiment which shows that the law of parity conservation is not valid in weak interactions.

2.A particle of mass $1000 MeV/c^2$ decays to two pions with a decay rate of $\Gamma \approx 100 MeV$. Is this decay due to weak, electromagnetic or strong interaction? Justify your answer.

3. Consider the reaction

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

. Find the minimum energy in the laboratory frame (proton at rest) for the above reaction to occur. The rest masses of the particles are m_π, m_p, m_Λ and m_K. Note $m_\Lambda + m_K > m_p + m_\pi$.

4. Consider a massive spin one particle moving along the 3-axis with momentum P. If it is polarised with spin component 0 along the 3rd axis, write down all the four components of the polarisation vector.(Mass=M) (Use $(S^i)_{jk} = -i\epsilon_{ijk}$ for the ith component of spin S^i.)

5. Show that the concept of helicity is not a Lorentz invariant for massive particles.

6.Suppose a Langrangian is invariant under $SU(3)$ and it undergoes spontaneous breaking to $SU(2)$.
(a) How many generators do $SU(3)$ and$SU(2)$ have?
(b) How many Goldstone bosons appear in the theory ?

7.How does the ratio $R = \sigma(e^+e^- \rightarrow hadrons)/\sigma(e^+e^- \rightarrow \mu^+\mu^-)$ vary as the centre of mass energy of e^+e^- varies from 1Gev to 20GeV.

8.Using genralised statisitics (interchange in space,spin and isospin space) find the allowed combinations of I, S and L for a bound state of a neutron and a proton.

PART II

9. Consider the reaction $\pi^+(p_1) + \pi^+(p_2) \rightarrow \pi^+(q_1) + \pi^+(q_2)$ whose matrix element is given by (momenta indicated in brackets)

$$M = N\lambda(2\pi)^4\delta^4(p_1 + p_2 - q_1 - q_2)$$

where N is the normalisation constant and λ is the coupling constant. Calculate the total cross section in the centre of mass frame. If the total centre of mass energy $E = 1GeV$ calculate the cross section in cm^2 (in terms of λ. (mass of pion $= 140MeV/c^2$.)

10. Write the matrix element for the μ decay $\mu^- \rightarrow e^- + \nu_\mu + \bar{\nu}_e$ in the standard model. Show that in the limit $m_W >> m_\mu$, it goes over to the "current current" matrix element $\frac{G_F}{\sqrt{2}}\bar{U}_{\nu_\mu}\gamma_\mu(1-\gamma_5)U_\mu\bar{U}_e\gamma^\mu(1-\gamma_5)V_{\nu_e}$. Write down the relation between G_F and the $SU(2)_L$ coupling g.

11. (a) Consider the reaction $A + B \rightarrow C + D$ in the centre of mass frame with the total initial energy $2(M_C + M_D)$. Find the energy of the outgoing particles C and D. (Masses of the particles A, B, C and D are M_A, M_B, M_C, M_D respectively.

(b) If a particle is unstable with a decay rate Γ this can be phenomenologically represented by adding an imaginary part to the mass term. Justify the above statement and write down the appropriate expression for the mass term including the complex part.

12. (a) Derive the relation

$$\Sigma_{r=1,2}u(p,r)\bar{u}(p,r) = (\not{p} + m)$$

where $u(p,r), r = 1, 2$ represents positive energy wavefunctions of the free Dirac equation and m is the mass of the particle.

(b) Consider a spin zero particle which is an eigenstate of the charge conjgation operator C. Asuume it to be made of quark-antiquark pair. Show that the C-parity must be positive.