Phy 523
PARTICLE PHYSICS
Midsemester -II

Attempt all questions; All questions carry equal marks.

March 28th 2009
Time allowed 90 minutes

1. Consider the decay of $\Lambda^0(P_\Lambda) \rightarrow p(P_p) + \pi^-(P_\pi)$ whose matrix element is given by

$$< pP_p; \pi P_\pi|M|\Lambda^0 P_\Lambda >= N\bar{u}(P_p)(A + B\gamma_5)u(P_\Lambda)(2\pi)^4\delta^4(P_\Lambda - P_p - P_\pi)$$

where N is the normalisation constant.

Show that the terms $\bar{u}(P_p)\sigma_{\alpha\beta}P_p^\alpha P_\pi^\beta u(P_\Lambda)$ and $\bar{u}(P_p)\sigma_{\alpha\beta}P_\pi^\alpha P_\Lambda^\beta u(P_\Lambda)$ can be converted to the terms of the form A and B. ($\sigma_{\alpha\beta} = i(\gamma_\alpha\gamma_\beta - \gamma_\beta\gamma_\alpha)/2$).

2. Consider the interaction of a Dirac particle $\Psi(x)$ with a scalar field $\phi(x)$ obeying the equation

$$(i \not{\partial} - m)\Psi(x) = -g\phi(x)\gamma_5\Psi(x)$$

. Show that

$$\Psi_i(x) = \psi_i(x) - g\int d^4y S_F(x-y)\phi(y)\gamma 5\Psi_i(y)$$

where $S_F(x-y)$ is the free particle Feynman propagator.Ψ

Show that S-matrix element is given by

$$S_{fi} = (2\pi)^3\delta_{if} + ig\epsilon\int d^4y\bar{\psi}_f(y)\phi(y)\gamma_5\Psi_i(y)$$

where $\psi_i(x), \psi_f(x)$ are the free particle initial and final wave functions.$\epsilon = (-1)^n$ where n is the number of antiparticle at time $-\infty$.

(You can use the expression for the Feynman propagator

$$S_F(x-y) = -i\theta(x^0-y^0)\int \frac{d^3p}{(2\pi)^3}\sum_{r=1,2}\psi_p^r(x)\bar{\psi}_p^r(y) + i\theta(y^0-x^0)\int \frac{d^3p}{(2\pi)^3}\sum_{r=3,4}\psi_p^r(x)\bar{\psi}_p^r(y)$$

derived in the class. $\psi_p^r(x)$ are the plane wave solutions.)

3. Draw the Feynman diagram for the process $e^- + \mu^- \rightarrow e^- + \mu^-$, assuming only electromagnetic ineraction is present. Write down the matrix element including the normalisation and the phase.