Phy 523
PARTICLE PHYSICS
Midsemester -III

Attempt all questions; All questions carry equal marks.

April 9th 2009
Time allowed 90 minutes

1. (a) Assuming ν_μ's are left handed, what will be the helicity of μ^+ emiited in π^+ decay $\pi^+ \rightarrow \mu^+ + \nu_\mu$? Assume π^+ is at rest. (b) Write down the reaction of μ^- decay to electron and neutrinos. Let the μ^- be polarised along the positive z-axis and all the particles be emitted along the z- axis, with the electron moving along the negative z- axis and the neutrinos along the positive axis z- axis. Find the helicity of the electron. for this configuration.

2. Consider the lagrangian density for a complex scalar field $\Phi(x)$ given by

$$L(x) = (D^\mu \Phi)^\dagger(x) D_\mu \Phi(x) - \mu^2 \Phi^\dagger(x)\Phi(x) - \frac{1}{4} F^{\mu\nu} F_{\mu\nu}$$

where $D^\mu \Phi(x) = \partial^\mu + ieA^\mu$ and $F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu$, A^μ being the photon field. Show that the lagrangian density is invaraint under a transformation $\Phi'(x) = e^{i\alpha(x)}\Phi(x)$ provided A_μ is transformed appropriately. Find the transformation for A_μ under the above gauge transformation.

3. Suppose we had a scalar doublet Δ in the standard model

$$\Delta = \begin{pmatrix} \delta^{++} \\ \delta^{+} \end{pmatrix}$$

What is the value of Y for the doublet?

Write down the covariant derivative for this doublet using $W^a_\mu \tau^a = W^a_\mu \sigma^a/2$ and B_μ as gauge fields with coupling g, g' respectively. Introducing the photon field A_μ and the Z-boson field Z_μ, defined by

$$W^3_\mu = \frac{g' A_\mu + g Z_\mu}{(g^2 + g'^2)^{1/2}}, B_\mu = \frac{g A_\mu - g' Z_\mu}{(g^2 + g'^2)^{1/2}}$$

show that the coupling to photon is to the charge of the particle with $e = gg'/(g^2 + g'^2)^{1/2}$.