

Particle Physics - Problem Sheet 7

Discussion Questions

D1 What is the definition of weak isospin and weak hypercharge?

Calculate the weak isospin (T, T_3) and weak hypercharge (Y) for each of the first generation fermions.

D2 In the Electroweak model, the fermion current associated with the photon is:

$$(j^\gamma)^\mu = (j^{W3})^\mu \sin \theta_W + (j^Y)^\mu \cos \theta_W$$

What does this equation mean? You may wish to discuss:

- What is a *fermion current*?
- What does the μ stand for?
- What is θ_W ?
- What are $(j^{W3})^\mu$ and $(j^Y)^\mu$?

D3

Standard Questions

S1 In the Electroweak model, the fermion current associated with the photon is:

$$(j^\gamma)^\mu = (j^{W3})^\mu \sin \theta_W + (j^Y)^\mu \cos \theta_W$$

Where:

$$(j^{Wi})^\mu = [g_W T] \bar{\chi}_L \gamma^\mu \tau_i \chi_L$$

and for electrons:

$$j_\mu^Y = \left(\frac{1}{2} g'_W Y_e\right) \bar{e} \gamma^\mu e = \frac{1}{2} g'_W (Y_{eL} \bar{e}_L \gamma^\mu e_L + Y_{eR} \bar{e}_R \gamma^\mu e_R)$$

In these equations e represents the electron spinor and Y_e is the weak hypercharge of the electron.

Substitute in: $\chi_L = \begin{pmatrix} e^- \\ \nu_e \end{pmatrix}$ and $\tau_3 = \begin{pmatrix} 1 & 0 \\ -1 & 0 \end{pmatrix}$ and the appropriate values of weak isospin (T) and weak hypercharge (Y).

Show that if the electron charge, $e = g'_W \cos \theta_W = g_W \sin \theta_W$ then the known behaviour of the photon is reproduced.