Kern- und Teilchenphysik II
Spring Term 2016

Exercise Sheet 5

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1. Tau decay

Consider the decay $\tau^- \to \pi^- \nu_\tau$.

a) Draw the Feynman diagram and show that the corresponding matrix element is

$$\mathcal{M} \approx \sqrt{2} G_F f_\pi \bar{u}(p_\nu) \gamma^\mu \frac{1}{2}(1-\gamma^5) u(p_\tau) g_{\mu\nu} p_\pi^\nu$$

2 pt

b) Taking the τ^- spin to be in the z-direction and the four-momentum of the neutrino to be

$$p_\nu = p * (1, sin\theta, 0 cos\theta)$$

show that the leptonic current is

$$j^\mu = \sqrt{2 m_\tau p^*}(-s, -c, -ic, s),$$

where $s = sin(\frac{\theta}{2})$ and $c = cos(\frac{\theta}{2})$. Note that, for this configuration, the spinor for the τ^- can be taken to be u_1 for a particle at rest.

2 pt

c) Write down the four-momentum of the π^- and show that

$$|\mathcal{M}|^2 = 4 G_F^2 f_\pi^2 m_\tau^3 p^* sin^2(\frac{\theta}{2})$$

1 pt

d) Hence show that

$$\Gamma(\tau^- \to \pi^- \nu_\tau) = \frac{G_F^2 f_\pi^2}{16\pi} m_\tau^3 (\frac{m_\tau^2 - m_\pi^2}{m_\tau^2})^2$$

1 pt

2. Kaon decay

Consider the kaon (K^-) decay into leptons in its rest frame.

a) Determine its decay rate and the ratio

$$\frac{\Gamma(K^- \to e^- \bar{\nu}_e)}{\Gamma(K^- \to \mu^- \bar{\nu}_\mu)}$$

3 pt

3. Weak Interactions

Draw the Feynman diagrams of the following processes and write the related matrix element (ignore spectator quarks in matrix element computation).

a) $\pi^- \to \pi^0 e^- \bar{\nu}_e$

b) $K^+ \to \mu^+ \nu_\mu$

c) $\tau^- \to e^- \bar{\nu}_e \nu_\tau$

2 pt