Standard Model/Quantun Field Theory III

Problem Set 4

Due: Wednesday, 11 March 2020

Suggested reading: QFT Notes, Ch 28; Sr, Secs 88-90; P, Ch 21; Sc, Ch 31. Here Sr=Srednicki, P=Peskin&Schroeder, and Sc=Schwartz.

10. τ **decay**. Since the τ lepton is so massive, it can decay into many more final states than the μ could. But the options for decay into leptons is, at lowest order, limited to the two processes $\tau \to \mu + \nu_\tau + \bar{\nu}_\mu$ and $\tau \to e + \nu_\tau + \bar{\nu}_e$. Adapt our result for the decay rate of the μ to obtain the decay rates for these two processes. Look up the lifetime and branching fractions for τ decay and compare your lowest order results to the data. How good is the approximation of setting $m_\mu = m_e = 0$?

11. **Photon Z-Boson Interference**

a) Calculate the differential cross section for the reaction

$$e^+ + e^- \to \mu^+ + \mu^-$$

in the center of mass frame and for energies small compared to M_Z but large compared to m_μ. Include contributions from both the photon and the Z boson. In this kinematic region the Z boson term is small compared to the photon term, so in the squared amplitude you may drop the square of the Z term. For simplicity, assume unpolarized e's and unobserved spin of the μ's

b) Integrate over angles to find the total cross section σ and also find the front back asymmetry defined as

$$A_{FB} = \frac{1}{\sigma}\left[\int_{\theta<\pi/2} d\Omega - \int_{\theta>\pi/2} d\Omega\right]\frac{d\sigma}{d\Omega}.$$

12. Calculate the differential and total cross sections, with unpolarized electrons and muon spin unobserved, for the "flavor changing" neutrino scattering processes

a) $\nu_\mu + e^- \to \nu_e + \mu^-$

b) $\bar{\nu}_e + e^- \to \bar{\nu}_\mu + \mu^-$

In each case confirm the applicable one of Eqs(28.60) through (28.63) in the lecture notes.