Section Exercises: Week of 05/13

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Exercise 1. Show that the "decay" $e^- \to e^- \gamma$ is forbidden by conservation of 4-momentum. Argue that the "crossed diagrams," $\gamma \to e^- e^+$ and $e^- e^+ \to \gamma$ are similarly forbidden. What particle(s) could you add to the initial or final state to allow for energy and momentum conservation?

Exercise 2. Consider the weak decays $B^+ \to \tau^+ \nu_{\tau}$ and $B^+ \to \overline{D}{}^0 \pi^+$. For each decay, calculate the invariant mass of the propagator, the virtual W-boson. You may approximate that all of the 4-momentum of the B-meson is contained in the b-quark and that all of the 4-momentum of the D-meson is contained in the c-quark.

Exercise 3. Consider the weak decays $D^+ \to \bar{K}^0 e^+ \bar{\nu}_e$ and $D^0 \to K^- e^+ \nu_e$. Estimate the ratio of the partial widths for each decay,

$$\frac{\Gamma(D^+ \to \bar{K}^0 e^+ \bar{\nu}_e)}{\Gamma(D^0 \to K^- e^+ \nu_e)} \tag{1}$$

According to the PDG, the corresponding branching fractions are

$$B(D^+ \to \bar{K}^0 e^+ \bar{\nu}_e) = 8.6\%$$
 (2)

$$B(D^0 \to K^- e^+ \nu_e) = 3.6\%$$
 (3)

Using this additional information, estimate the ratio of the lifetimes,

$$\frac{\tau_D^+}{\tau_D^0} \tag{4}$$

Exercise 4. Draw all lowest-order diagrams for the allowed weak decays of the τ^- lepton (m = 1.777 GeV). Don't worry about strong interactions and hadronization effects. Estimate the branching fraction of the τ^- lepton to a purely leptonic final state.