

Homework set 4

Problem 1: Scattering

Compute the differential cross section $d\sigma/d\Omega$ of the following process:

$$\nu_\mu + e^- \rightarrow \nu_e + \mu^- \quad (1)$$

as a function of the center-of-mass energy, in the center-of-mass frame. Assume that the initial electron is unpolarized. Sum over all polarization of the final state particles. Assume the center-of-mass energy is much larger than m_μ , but much smaller than m_W .

(the steps are: (i) draw Feynman diagram(s), (ii) find the matrix element, (iii) find the cross section)

Integrate the differential cross section to obtain the total cross section.

Problem 2: B and D mesons

(i) B mesons are the lightest bound states of a b quark and a light (u or d) quark and D mesons are the lightest bound states of a c quark and a light quark. The masses of B and D mesons are: $m_B \approx 5.28$ GeV, $m_D \approx 1.87$ GeV. The lifetime of B mesons are around 1.5×10^{-12} sec, and of D mesons range from 0.4×10^{-12} sec for D^0 and 1.0×10^{-12} sec for D^\pm mesons.

(i) Are the decay of these mesons strong, weak, or electromagnetic?

(ii) Why do B mesons live longer than D mesons, despite the fact that B mesons are heavier than D mesons?

(iii) Make a rough estimate of the ratio of the life times of B and D mesons, τ_B/τ_D . Express your answer in terms of the fundamental parameters of the Standard Models.

Problem 3: Production of B mesons

B factories are e^+e^- machines with the center of mass energy exactly at the center of the $\Upsilon(4S)$ resonance. The $\Upsilon(4S)$ decays predominantly to $B\bar{B}$ pairs. How many $B\bar{B}$ pairs are produced in a second at luminosity $10^{34}\text{cm}^{-2}\text{sec}^{-1}$? Find the information about the $\Upsilon(4S)$ at <http://pdg.lbl.gov/2007/listings/mxxxcomb.html#mesonsbbbbarres>.