

## Homework # 10; due Wednesday, November 24

Reading: Chapter 9 of Griffiths; you might need to browse through Ch. 8 (that we skipped) as well

34. Starting from the formula for the lifetime of the muon [Eq. (9.35) in Griffiths] and the value of the muon lifetime ( $\approx 2.2 \mu\text{s}$ ), estimate the lifetime of the tau lepton. How does one need to modify Eq. (9.35) so it is appropriate for the tau lepton? The masses of the leptons are  $m_\mu \approx 106 \text{ MeV}/c^2$ ;  $m_\tau \approx 1777 \text{ MeV}/c^2$ . Compare the result of the estimate with the experimental value of the tau-lepton lifetime of  $\approx 291 \text{ fs}$ . Hint: no explicit calculations (beyond elementary) are needed here, but one has to consider what is different in the case of tau in addition to just the heavier mass.

35.

- Draw the Feynman diagram for the processes  $e^+e^- \rightarrow \mu^+\mu^-$ . Assuming we are in the center-of-mass frame, how does the corresponding cross-section scale with energy? (Assume that the energy is in the  $1 \text{ GeV} \ll E \ll 50 \text{ GeV}$  range.)
- Estimate the order-of magnitude of the cross-section for this process for the electron (positron) energy of  $E=10 \text{ GeV}$ . (Once again, this is an “island physics” problem that does not assume complex calculations.)
- Is it possible to draw a similar (general) diagram for  $e^+e^- \rightarrow q\bar{q}$ , where  $q$  is a light quark? What happens to the quarks after they are produced?
- What is the ratio of the two cross-sections  $\sigma(e^+e^- \rightarrow \text{hadrons})/\sigma(e^+e^- \rightarrow \mu^+\mu^-)$  assuming that we are far away from any resonances?

Note: the study of this cross-section ratio provides direct measurement of the number of quark colors.

36. Your friend working at LBNL tells you at lunch that there is an exciting proposal in the works for a new collider for particle physics. Naturally, you want to ask her about some of the details. Think of a list of, say, 5-7 parameters of the proposed machine you would want to ask her about. After you make the list, look up these parameters for LHC, RHIC, Tevatron, LEP, and SLC.