PH3520 (Particle Physics)
Problem sheet 4
To be turned in by 10:00 a.m., Thursday 27 October, 2011

1: The decay rate of the ρ^0 meson is $\Gamma = 150$ MeV. (a) What is its mean lifetime τ in MeV^{-1} (i.e., in 'particle physics' units)?

(b) What is τ in seconds (i.e., in normal units)?

(c) If a ρ meson had an energy of 1 GeV, how far would it travel (in metres) in one mean lifetime. Include the effects of relativistic time dilation, and use the mass of the ρ meson $m_\rho = 0.770$ GeV.

(d) The ρ^0 meson decays with almost 100% branching ratio to $\pi^+\pi^-$. Explain qualitatively how one can use the invariant mass of $\pi^+\pi^-$ pairs in a particle reaction (e.g., $e^+e^- \to$ hadrons) to determine the mass and mean lifetime of the ρ^0 and also the mean number of ρ^0 mesons produced in the reaction. Include a sketch of the relevant invariant mass distribution and explain the relevant features.

2: Draw possible Feynman diagrams for the following decays or scattering reactions. Remember to build the diagrams using only the vertices we saw in the lectures. Label all particles and state what coupling (e, g or g_s) is associated with each vertex. You do not need to give the Ze couplings for (c); it is enough to know that these are a specific function of e and g.

(a) $\tau^- \to \nu_\tau \bar{c} s$

(b) $\gamma\gamma \to \mathrm{e^+e^-}$

(c) $\mathrm{e^+e^-} \to \mathrm{ZZ}$

(d) $\mathrm{e^+e^-} \to q\bar{q}g$ (where q stands for any flavour of quark, g is a gluon).

(e) $\mathrm{n}\nu_\mathrm{e} \to \mathrm{pe^-}$ (draw the n and p as the appropriate combination of quarks)

(f) $\mathrm{e^+e^-} \to \mu^+\mu^-\gamma$

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