PHYS545-PARTICLE PHYSICS II
4^{th} Homework

1. In the definition of the cross-section, we have used $\sqrt{(p_a \cdot p_b)^2 - p_a^2 p_b^2}$ to represent the relative velocity of the initial state particles. Suppose, you are in the center of mass frame. Show that this factor is indeed proportional to the relative velocities. What does the expression reduce to (in terms of velocities) in an arbitrary reference frame? (*Hint:* Use the relativistic velocity expression defined as $\vec{v} = \vec{p}/E$ to eliminate all the three momenta.)

2. Complete the simplification of the differential cross-section in the class. Note that unless some of the particles have spin that is measured, nothing can depend on the angle ϕ. Thus, you can integrate over ϕ. Express your final result in terms of the Mandelstam variables s, t and u only (you should also express the angles in terms of these parameters).

3. The scattering amplitude for the unpolarized $e^-\mu^- \to e^-\mu^-$ scattering can be written as

$$|\mathcal{M}|^2 = \frac{8e^4}{q^4}\left[(p_1 p_2)(k_1 k_2) + (p_1 k_2)(k_1 p_2)\right] \tag{1}$$

   where $p_{1(2)}$ and $k_{1(2)}$ is the initial(final) four momentum of the electron and muon respectively, and $q = p_2 - p_1$ is the momentum transfered. where $p_{1(2)}$ and $k_{1(2)}$ is the initial(final) four momentum of the electron and muon respectively, and $q = p_2 - p_1$ is the momentum transfered. Express this amplitude in terms of the Mandelstam variables. What is the differential crossection?

Questions From the Book

4. The cross-section for the reaction $\pi^- + p \to \Lambda + K^0$ at 1 GeV incident momentum is about 1 mb (10^{-27} cm^2). Both the Λ and K^0 particles decay with a mean lifetime of order 10^{-10} s. From this information, extimate the relative magnitude of the couplings responsible for the production and decay, respectively, of these strange particles.