Cornell University

Department of Physics

Phys 651 November 15, 2006

Relativistic Quantum Field Theory, Fall 2006

Homework Assignment # 11

(Due Wednesday, November 22, after the lecture.)

Lectures and Reading Assignments:

Readings are from *"An Introduction to QFT"* by Peskin and Schroeder.

- Lec 21, 11/15 (Wed): The electron vertex function **Sec. 6.3**
- Lec 22, 11/20 (Mon): Anomalous Magnetic Moment. Regularization. Electron Self-Energy. **Sec. 6.2, 6.3, 7.1**
- Lec 23, 11/22 (Wed): Renormalization **Sec. 7.1**

Problems:

Numbered problems are from Peskin and Schroeder, Ch. 6.

1. **Scattering of Polarized Beams**

   Consider Yukawa theory with electrons and muons:

   $$\mathcal{H}_{\rm int} = \int d^3x \, (\lambda_e \phi \bar{e} e + \lambda_\mu \phi \bar{\mu} \mu) \,, \tag{1}$$

   where ϕ is a real Klein-Gordon field, e and μ are the electron and muon fields (Dirac fermions), and λ_e, λ_μ are dimensionless coupling constants. We will assume $m_e = 0$, and consider the reaction $e^+e^- \to \mu^+\mu^-$ with polarized initial and final states. We will restrict our analysis to the leading order in perturbation theory (tree level).

   (a) Show that all scattering matrix elements with the $e_L^- e_R^+$ and $e_R^- e_L^+$ initial states vanish.

   (b) Using projectors and trace technology, compute $|\mathcal{M}|^2$ for the following four reactions:

   $$e_L^- e_L^+ \to \mu_L^- \mu_R^+, \quad \mu_R^- \mu_L^+, \quad \mu_L^- \mu_L^+, \quad \mu_R^- \mu_R^+. \tag{2}$$

   (Note that these give the full set necessary to evaluate any process: the matrix elements with the $e_R^- e_R^+$ initial state can be obtained by parity.)

2. Prove the Feynman parameter formula, Eq. (6.41) of P& S.
3. Problem 6.3, (a) and (b).