Homework Set No. 3, Physics 880.08

Deadline – Monday, February 22, 2010

1. (You may want to read Section 4.7 in Peskin and Schroeder before/while doing this problem.) Consider a theory of a real scalar field coupled to a Dirac field (Yukawa theory) with the Lagrangian

$$\mathcal{L} = \bar{\psi}\,(i\gamma^\mu\partial_\mu - M)\,\psi + \frac{1}{2}\,\partial_\mu\varphi\,\partial^\mu\varphi - \frac{m^2}{2}\,\varphi^2 - g\,\varphi\,\bar{\psi}\,\psi.$$

a. (5 pts) Construct and list Feynman rules for the theory.

b. (10 pts) Draw Feynman diagrams and write down the scattering amplitude for the process

$$\text{fermion}\,(k_1, r_1) + \text{fermion}\,(k_2, r_2) \;\to\; \text{fermion}\,(p_1, \sigma_1) + \text{fermion}\,(p_2, \sigma_2) \tag{1}$$

at the order g^2.

c. (10 pts) Using the result of part **(b)** find the differential scattering cross section $d\sigma/dt$ for the process in Eq. (1). Express your result in terms of Mandelstam variables s, t and u. Note that to obtain the cross section one has to sum over fermion polarizations in the final state and average over fermion polarizations in the initial state after squaring the scattering amplitude. What happens to the cross section when $s \gg t$?

2. (25 pts) Problem 5.2 in Peskin. Clarification to his problem formulation: you are asked to find the differential cross section in the center-of-mass frame. Also write an expression for $d\sigma/dt$.