PHYSICS 6433

Problem Set 8 – Due May 05, 2017

Problems (1): Peskin and Schroeder, Problem 4.2

Problems (2): Peskin and Schroeder, Problem 4.3(a,b)

Problems (3): Yukawa Interaction

The interaction between a Dirac field $\psi(x)$ and a charge neutral Klein-Gordon field $\phi(x)$ can be described with the following Lagrangian density $\mathcal{L} = \mathcal{L}_0 + \mathcal{L}_I$

$$\begin{aligned} \mathcal{L} &= \bar{\psi}(i\not{\partial} - m)\psi + \frac{1}{2}\partial_\mu\phi\partial^\mu\phi - \frac{1}{2}M^2\phi^2 - g\bar{\psi}\psi\phi - \frac{\lambda}{4!}\phi^4 \\ \mathcal{L}_I &= -g\bar{\psi}\psi\phi - \frac{\lambda}{4!}\phi^4 \, . \end{aligned}$$

Let us consider p_1 and p_3 to be momenta for fermions, p_2 and p_4 as momenta for anti-fermions, and k as the momentum for a scalar.

(a) Evaluate the matrix element

$$M_1 = \langle p_1, r; p_2, s|T_1|k\rangle$$

with

$$T_1 = -g\int d^4x \, [\bar{\psi}(x)\psi(x)\phi(x)] \, .$$

(b) Evaluate the matrix element

$$M_2 = \langle p_3, s_3; p_4, s_4|T_2|p_1, s_1; p_2, s_2\rangle$$

with

$$T_2 = -\frac{g^2}{2}\int d^4x \int d^4y \, [D_F(x-y)] : \bar{\psi}(x)\psi(x)\bar{\psi}(y)\psi(y) : \ .$$