PHY 5667 : Quantum Field Theory A, Fall 2017

October $19^{th}$, 2017

Assignment # 4

(due Thursday November $2^{nd}$, 2017)

**1.** Consider an interacting scalar field theory with $H_{\rm int} = \frac{\lambda}{4!}\phi^4$. Sketch the diagrams contributing to the invariant scattering matrix element $\mathcal{M}(p_1, p_2 \to p_3 p_4)$ at $O(\lambda^2)$ and write the corresponding explicit expression in momentum space.

**2.** Consider a theory of three scalar fields ($A$, $B$, and $C$) with interaction $\mathcal{L}_{\rm int} = gABC$. Write down the tree-level scattering amplitude (given by the sum of the contributing tree-level diagrams) for each of the following processes:

$$AA \to AA \ , \ AA \to AB \ , \ AA \to BB \ , \ AA \to BC \ , \ AB \to AB \ , \ AB \to AC \, .$$

Express your answer in terms of Mandelstam variables $s$, $t$, and $u$.

**3. 3.a)** Consider a theory with two real scalar fields $A$ and $B$ with an interaction $\mathcal{L}_{\rm int} = gAB^2$. Assuming that $m_A > 2m_B$, compute the total decay rate of the $A$ particle at tree level.

**3.b)** Consider a theory of a real scalar field $\varphi$ and a complex scalar field $\chi$ with $\mathcal{L}_{\rm int} = g\varphi\chi^\dagger\chi$. Assuming $m_\varphi > 2m_\chi$, compute the total decay rate of the $\varphi$ particle at tree level.

**4.** Problem 4.3 of Peskin and Schroeder's book.