PHYC 523: QAuantum Field Theory I

Fall 2016

Homework Assignment #3

(Due November 18, 2016)

1- Problem **(4.1)** from Peskin and Schroeder.

2- Problem **(4.2)** from Peskin and Schroeder.

3- Problem **(4.4)** from Peskin and Sschroeder.

4- This problem studies scattering of fermions ψ via the exhange of a real scalar field ϕ with mass m_ϕ, due to the interaction term $\mathcal{L} \supset -g\bar{\psi}\psi\phi$ in the nonrelativistic limit. By comparing the amplitude for this process to the Born approximation formula from nonrelativistic quantum mechanics, derive the Yukawa potential $V(r)$ created by the scalar exchange:

$$V(r) = -\frac{g^2}{4\pi}\frac{1}{r}e^{-m_\phi r}.$$

Show that the Yukawa potential is universally attractive, whether it is between a pair of fermions, a pair of antifermions, or one of each.

5- Repeat problem 4 for scattering of fermions via photon exchange in the nonrelativistic limit and derive the Coulomb potential. Show that the Coulomb potential is attractive for fermion-antifermion scattering, while it is repulsive for fermion-fermion or antifermion-antifermion scattering.