Homework Set No. 2, Physics 8808.02

Deadline – Thursday, February 7, 2013

1. Construct the momentum-space Feynman rules for the following theories (draw all the propagators and vertices, and find their contributions to the diagrams):

a. (10 pts) Scalar electrodynamics, with the Lagrangian density

$$\mathcal{L} \,=\, (D_\mu \,\varphi)^* \, D^\mu \,\varphi \,-\, m^2 \,\varphi^* \varphi - \frac{1}{4} \,F_{\mu\nu} \,F^{\mu\nu},$$

where $D_\mu = \partial_\mu + i\,e\,A_\mu$. Here φ is a complex scalar field, A_μ is a real gauge field, $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$.

b. (5 pts) Complex scalar theory, with the Lagrangian density

$$\mathcal{L} \,=\, (\partial_\mu \,\varphi)^* \, \partial^\mu \,\varphi \,-\, \lambda^2 \,\varphi^* \varphi \,(\varphi^* \varphi - v^2)^2,$$

where λ and v are real positive constants and φ is a complex scalar field.

Note that while for the photon propagator you can simply use the expression given in class, I would like you to derive the propagator for the complex scalar field in part **a**.

2. (15 pts) In class when calculating the cross section for Compton scattering we encountered the following Dirac trace

$$\text{Tr}\left[(\not{p}' + m)\,\gamma^\nu\,(\not{p} + \not{k} + m)\,\gamma^\mu\,(\not{p} + m)\,\gamma_\nu\,(\not{p} - \not{k}' + m)\,\gamma_\mu\right].$$

Show that this trace is equal to

$$8\,\left[4\,m^4 + m^2\,(s - m^2) + m^2\,(u - m^2)\right]$$

as we used in class. Here $s = (p+k)^2 = (p'+k')^2$ and $u = (p-k')^2 = (p'-k)^2$, with p, p' the 4-momenta of the electron and k, k' the 4-momenta of the photon.