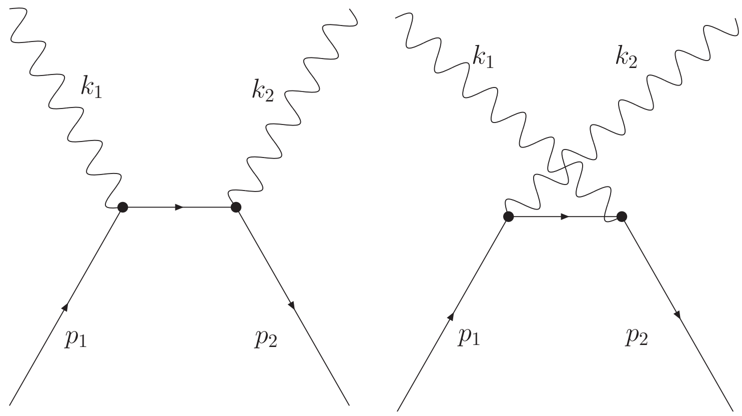
# Particle Physics Phenomenology I

HS 10, Series 7

Due date: 12.11.2010, 1 pm

**Exercise 1**

The aim of this exercise is to evaluate the unpolarized differential cross section $\frac{d\sigma}{dt}$ for Compton scattering. The following two graphs contribute to order $e^2$:




The amplitude $\mathcal{M}$ consists of two terms, the second graph can be seen as the $u$-channel of the first graph. Use the crossing relations to get $|\mathcal{M}_{\text{u-channel}}|^2$ from $|\mathcal{M}_{\text{s-channel}}|^2$ and use $|\mathcal{M}_{\text{s-channel}} + \mathcal{M}_{\text{u-channel}}|^2 = |\mathcal{M}_{\text{s-channel}}|^2 + |\mathcal{M}_{\text{u-channel}}|^2 + 2\Re(\mathcal{M}_{\text{s-channel}}\mathcal{M}^*_{\text{u-channel}})$ to reduce the explicit calculation to two traces.
Average over spins/polarizations of incoming particles and sum over spins/polarizations of outgoing particles and use the completeness relations. We recall a few identities:

- $\text{Tr}\left(\gamma^\alpha\gamma^\beta\right) = 4g^{\alpha\beta}$
- $\text{Tr}\,(\text{odd number of } \gamma \text{ matrices}) = 0$
- $\text{Tr}\left(\gamma^\rho\gamma^\sigma\gamma^\zeta\gamma^\xi\right) = 4\left(g^{\rho\sigma}g^{\zeta\xi} + g^{\rho\xi}g^{\sigma\zeta} - g^{\rho\zeta}g^{\sigma\xi}\right)$
- $\gamma^\mu\gamma_\mu = 4$
- $\gamma^\mu\gamma^\rho\gamma_\mu = -2\gamma^\rho$
- $\gamma^\mu\gamma^\rho\gamma^\sigma\gamma_\mu = 4g^{\rho\sigma}$

- $\gamma^\mu \gamma^\rho \gamma^\sigma \gamma^\delta \gamma_\mu = -2\gamma^\delta \gamma^\sigma \gamma^\rho$
- $\sum_\lambda \epsilon_\mu^{*\lambda}(p) \epsilon_\nu^\lambda(p) = -g_{\mu\nu}$ (for external photons)
- $\sum_s u^s(p) \overline{u}^s(p) = \not{p} + m$
- $\frac{\mathrm{d}\sigma}{\mathrm{d}t} = \frac{|\mathcal{M}|^2}{16\pi(s-m^2)}$