Exercises for "Phenomenology of Particle Physics I"

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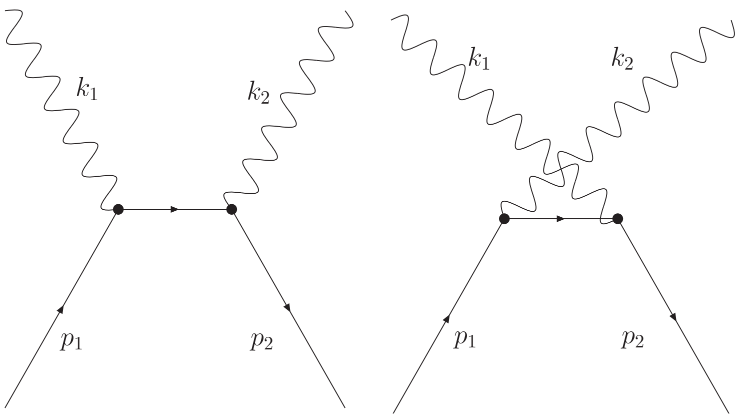
Exercise 25

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:

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

- $\gamma^\mu \gamma_\mu = 4$
- $\gamma^\mu \gamma^\rho \gamma_\mu = -2\gamma^\rho$
- $\gamma^\mu \gamma^\rho \gamma^\sigma \gamma_\mu = 4g^{\rho\sigma}$
- $\gamma^\mu \gamma^\rho \gamma^\sigma \gamma^\delta \gamma_\mu = -2\gamma^\delta \gamma^\sigma \gamma^\rho$
- $\sum_\lambda \epsilon_\mu^{*\lambda}(p)\epsilon_\nu^\lambda(p) = -g_{\mu\nu}$ (for external photons)
- $\sum_s u^s(p)\overline{u}^s(p) = \not{p} + m$
- $\frac{\mathrm{d}\sigma}{\mathrm{d}t} = \frac{|\mathcal{M}|^2}{16\pi(s-m^2)}$