

Theoretical Physics 6a (QFT): SS 2025

Exercise sheet 11

30.06.2025

(0)(0 points) How much time did it take you to solve this exercise sheet?

Exercise 1. (100 points): Møller process

Consider electron-electron scattering (Møller process) in QED in the center of mass frame:

$$p_1 + p_2 = p_3 + p_4.$$

(a) (50 points) Show that the after averaging over the initial particle spins and summing over the final particle spins, one gets

$$\begin{aligned} \frac{1}{4} \sum_{\text{spins}} |\mathcal{M}|^2 = & e^4 \left\{ \frac{1}{4t^2} \text{Tr} \left[\gamma^\mu (\not{p}_1 + m) \gamma^\nu (\not{p}_3 + m) \right] \text{Tr} \left[\gamma_\mu (\not{p}_2 + m) \gamma_\nu (\not{p}_4 + m) \right] \right. \\ & + \frac{1}{4u^2} \text{Tr} \left[\gamma^\mu (\not{p}_2 + m) \gamma^\nu (\not{p}_3 + m) \right] \text{Tr} \left[\gamma_\mu (\not{p}_1 + m) \gamma_\nu (\not{p}_4 + m) \right] \\ & - \frac{1}{4tu} \text{Tr} \left[(\not{p}_3 + m) \gamma^\mu (\not{p}_1 + m) \gamma_\nu (\not{p}_4 + m) \gamma_\mu (\not{p}_2 + m) \gamma_\nu \right] \\ & \left. - \frac{1}{4tu} \text{Tr} \left[(\not{p}_3 + m) \gamma^\mu (\not{p}_2 + m) \gamma_\nu (\not{p}_4 + m) \gamma_\mu (\not{p}_1 + m) \gamma_\nu \right] \right\}. \end{aligned}$$

(b) (50 points) From here on, consider the particles to be massless and calculate the differential cross section.

Hint: Note that two amplitudes have an opposite relative sign because they differ by an odd permutation of two fermions.