

FY3403 Particle physics
Problemset 7 fall 2024

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NTNU



Institutt for
fysikk

Background material: mainly Griffiths chapter 7.

Problem 1. Averaged scattering amplitude and cross section

Consider the spin-averaged amplitude for electron-muon scattering:

$$\langle |\mathcal{M}|^2 \rangle = \frac{g_e^4}{4(p_1 - p_3)^4} \text{Tr}\{\gamma^\mu(\not{p}_1 + mc)\gamma^\nu(\not{p}_3 + mc)\} \times \text{Tr}\{\gamma_\mu(\not{p}_2 + Mc)\gamma_\nu(\not{p}_4 + Mc)\} \quad (1)$$

where m is the electron mass, M is the muon mass, p_1 corresponds to the incoming electron, p_2 is the incoming muon, p_3 is the outgoing electron, and p_4 is the outgoing muon. Compute the traces in this expression and then assume high-energy scattering ($m, M \rightarrow 0$) to evaluate the resulting expression in the CM-frame. Finally, obtain the CM differential cross section expressed with (among other things) the electron energy E and the scattering angle θ .

Problem 2. Loop diagram

Consider the vacuum polarization diagram (see *e.g.* Griffiths book chapter 7) where a virtual photon momentarily splits into an electron-positron pair. This is a fourth-order correction to lepton-lepton' scattering (*e.g.* electron-muon scattering). Derive in detail the scattering amplitude $\mathcal{M}$ for this process (it is sufficient to write down the amplitude in integral form: you do not have to evaluate the traces and perform the integration).