## Quantum Field Theory 1 – Problem set 12

Lectures: Jan Pawlowski Tutorials: Felipe Attanasio Institut für Theoretische Physik, Uni Heidelberg

J.Pawlowski@thphys.uni-heidelberg.de F.Attanasio@thphys.uni-heidelberg.de tutorial date: week of 23.01.2023

Suggested reading before solving these problems: Chapter 6.2 in the script and/or Chapter 5.1 of *Peskin & Schroeder*.

## Problem 1: Tree-level cross section for $e^+e^- \rightarrow \mu^+\mu^-$

In the lecture course you have made a lot of formal developments and you are now equipped to perform calculations for real processes in QED. For example, the QED process  $e^+e^- \rightarrow \mu^+\mu^-$  is an important reaction to calibrate  $e^+e^-$  colliders and therefore it constitutes a fundamental building block for the understanding and experimental study of more complicated processes in particle physics. So, ...

... take a deep breath and calculate the tree-level differential cross section<sup>1</sup> for the reaction  $e^+e^- \rightarrow \mu^+\mu^-$  in the highly relativistic limit<sup>2</sup> where  $s = (p_1 + p_2)^2 \gg m_{\mu}^2, m_e^2$ .



<sup>&</sup>lt;sup>1</sup>General strategy: Draw the diagram  $\rightarrow$  use Feynman rules to write down  $\mathcal{M} \rightarrow$  square the amplitude and average or sum over spins  $\rightarrow$  evaluate traces and simplify  $\rightarrow$  choose a particular frame of reference  $\rightarrow$  plug expression for  $|\mathcal{M}|^2$  into cross-section formula and obtain differential cross section. <sup>2</sup>You can follow the notes given on the lecture's website: Cross section for e+e- to mu+mu-).