

Quantum Field Theory: Example Sheet 4

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1. Calculate the differential scattering cross-section, where the spin is ignored in the final state, for muon-electron scattering.
2. Calculate the scattering cross-section for electron-electron scattering, again where the spin is ignored in the final state.
3. Derive the Klein-Nishina formula for the Compton scattering cross-section.
4. Consider the process, at tree level, for the scattering of an electron and positron into a final state of a muon and an anti-muon. What are the differential scattering cross-sections for all of the possible polarizations of the incoming and outgoing particles. Are your results consistent with crossing symmetry?

Hint: These calculations are quite messy, but can be found in outline in the books of Peskin and Schroeder or Zee.

5. The Lagrangian density for a pseudoscalar Yukawa interaction is given by

$$\mathcal{L} = \frac{1}{2}(\partial\phi)^2 - \frac{1}{2}\mu^2\phi^2 + \bar{\psi}(i\not{\partial} - m)\psi - g\phi\bar{\psi}\gamma^5\psi. \quad (1)$$

Write down the Feynman rules for this theory. Use these to write down the amplitude at order g^2 for $\psi\psi \rightarrow \psi\psi$ scattering and $\psi\bar{\psi} \rightarrow \psi\bar{\psi}$ scattering and then calculate the differential scattering cross-section.