Theoretical Physics 6a (QFT): SS 2022
Exercise sheet 8

13.06.2022

Exercise 1. (100+25 points): Feynman rules

(0)(0 points) How much time did you spend in solving this exercise sheet?

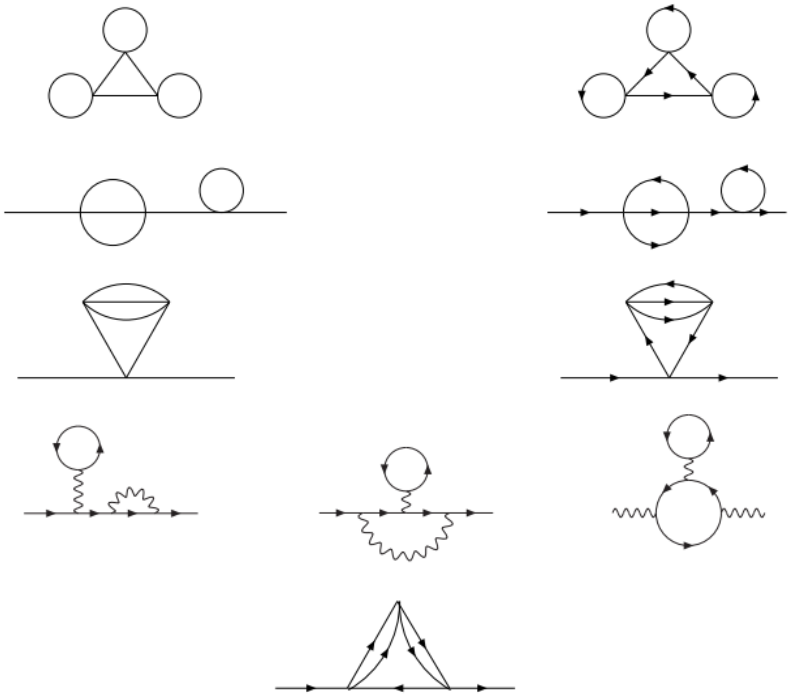
(a)(25 points) In the previous exercise sheet you calculated the cross-section for the Compton scattering in scalar QED, $p + k = p' + k'$.
It appears that this result can be also used to get the cross-section of pair production from two photons, $k + k' = p + p'$. To perform this, start from the matrix element squared, $|M|^2$, and replace $p \to -p$, $k' \to -k'$. Then write the cross-section using the general formula.
Hint: these crossing rules are very useful in QFT - using the symmetry properties of Feynman diagrams you are able to greatly reduce the computation time by expressing the matrix elements of different processes in terms of each other.

(b)(50 points) Calculate the cross-section of electron-electron scattering (Møller process).:

$$p_1 + p_2 = p_1' + p_2'$$

For simplicity, consider the limit of massless particles, $p_i^2 = p_i'^2 = 0$.
Note that two amplitudes have an opposite relative sign because they differ by an odd permutation of two fermions.

(c)(25 points) Calculate the symmetry coefficients for the following diagram and explain your answers. The line without (with) arrows represent neutral (charged) spin-0 field:



(d*)(Advanced level problem for those who are interested - 25 points) Calculate the cross-section of electron-positron scattering (Bhabha process):

$$p_- + p_+ = p'_- + p'_+$$

In the massless limit. You can use either crossing rules or do it by direct calculation. Due to the same reason as before two amplitudes have an oppositve relative sign. *Hint*: one diagram is just scattering, but the second contribution represents annihilation in the first vertex and pair production in the second one.

Literature

1. Quantum Electrodynamics, Berestetskii V.B., Pitaevskii L.P., Lifshitz E.M. - chapters 64-67, 78 and 81.
2. Quantum Electrodynamics, A. I. Akhiezer, V. B. Berestetskii, and G. M. Volkhoff - chapter 36.