Theoretische Teilchenphysik II

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Exercise Sheet 14

Due 8.2.2016

Problem 1 - QCD β-function

Calculate the one-loop β-function in QCD by considering the counter-terms for ghost-gluon vertex and the ghost self-energy. Assume that the counter-term for gluon self-energy is known (computed in class). Renormalize all relevant Green's functions in the $\overline{\text{MS}}$-scheme. Make use of the fact that in this calculation you only need divergent contributions to Green's functions.

Problem 2 - The contribution of scalar particles to the β-function

Consider an SU(3) gauge theory with two types of matter fields – Dirac fermions and complex scalars – that transform in the fundamental representation of $SU(3)$. Take fermions and scalars to be massless.

1. Write down the Lagrangian and derive Feynman rules for the couplings of gluons to scalars.

2. Find the contribution of these scalars to the β-function. You are allowed to use any results that we derived in class or in the exercise class. Set up the calculation of the β-function in a way that minimizes the number of Feynman diagrams that need to be computed.