Quantum Field Theory 2 – Problem set 10

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Suggested reading before solving these problems: Chapter 14.1-14.2 in the script and/or chapter 16.5 in *Peskin & Schroeder*.

Problem 1: Gauge boson self-energy 2

In the exercise sheet 9, you computed the one-loop correction to the gauge boson self-energy in pure Yang-Mills theory (without fundamental fermions). For theories such as QCD, there is an additional contribution coming from quarks (or other fundamental fermions). Compute this contribution using dimensional regularization, for Feynman gauge ($\xi = 1$) and for n_f fermion species, all in the same representation.

Note: A similar calculation has been performed in QED in chapter 7.3 of the script.

Problem 2: Fermion self-energy

Consider now the one-loop correction to the fermion self-energy in the massless case. Show that the corresponding expression for an arbitrary gauge parameter ξ reads

$$g^2 \int \frac{d^4 l}{(2\pi)^4} \gamma^\mu t^a \frac{i(l+k)_\sigma \gamma^\sigma}{(l+k)^2} \gamma^\nu t^a \frac{\delta^{\mu\nu} - (1-\xi) l^\mu l^\nu / l^2}{l^2}. \tag{1}$$

Evaluate this expression further using dimensional regularization and show that the result is regular for $d \to 4$ in the Landau gauge $\xi = 0$.