# SM Exercises 5

To be handed in on 20.05.14

1. (50%) Consider a $U(1)$ model with Lagrangian

$$\mathcal{L} = D^\mu \phi^* D_\mu \phi - \frac{1}{4} F_{\mu\nu} F^{\mu\nu} - \lambda(\phi^* \phi)^2 - \mu^2 \phi^* \phi, \tag{1}$$

and $\lambda > 0, \mu^2 < 0$.

- Find the classical equation of motion of $A^\mu$ and show that it can be written as

$$\Box A^\mu - \partial^\mu (\partial_\nu A^\nu) = j^\mu_{em}. \tag{2}$$

- After spontaneous symmetry breaking $\phi$ takes the form

$$\phi(x) = \frac{1}{\sqrt{2}} \left(v + H(x) + i\pi(x)\right) \tag{3}$$

  where $H, \pi$ are real fields. The t'Hooft gauge condition is given by

$$\partial_\mu A^\mu = (1 - \xi) M_A \pi. \tag{4}$$

  Rewrite the equation of motion taking into account equations (3) and (4). *Hint*: what does the gauge condition above imply?

- From the derived result show that the propagator for the gauge boson in this gauge is

$$\frac{-i}{k^2 - M_A^2} \left( g^{\mu\nu} - \frac{\xi k^\mu k^\nu}{k^2 - (1-\xi) M_A^2} \right) \tag{5}$$

2. (50%) In the lecture, parity violation in weak processes was discussed and shown to be a consequence of the axial-vector current of the interaction. Parity violation requires that the neutrino has a given handedness, either left- or right-handed, and the Wu-experiment could not distinguish between the two possibilities. However, M. Goldhaber came up with a rather ingenious experiment to determine the handedness of the neutrino. In this exercise your task will be to describe this experiment and its ingenuity, preferentially on one page. Please consult your favourite (or any other) textbook or even the internet for making yourself familiar with the idea and with the details of the experiment. Describe the experimental procedure and the results in your own words. You may use simple diagrams.