DECAYS IN QFT - WS 2012/2013

Sheet 7 **14/12/2012**

Exercise 1: A new type of mixing (8 points)

Consider the Lagrangian

$$\mathcal{L}_0 = \frac{1}{2}\left(\partial_\mu S_1\right)^2 + \frac{1}{2}\left(\partial_\mu S_2\right)^2 + \alpha\left(\partial_\mu S_1\right)\left(\partial^\mu S_2\right) + \frac{1}{2}\left[\left(\partial_\mu \varphi\right)^2 - m^2\varphi^2\right] + g\varphi S_1^2 \ . \tag{1}$$

Which range is allowed for the parameter α?
Determine the decay rates of the field φ.
Hint: one has to make an appropriate transformation in order to 'eliminate' the mixing term $\alpha\left(\partial_\mu S_1\right)\left(\partial^\mu S_2\right)$.

Exercise 2: Decays of a scalar particle in vector particles (7 = 3 + 4 points)

Consider the free Lagrangian

$$\mathcal{L}_0 = \frac{-1}{4}\rho_{\mu\nu}^2 + \frac{m_\rho^2}{2}\rho_\mu^2 + \frac{1}{2}\left[\left(\partial_\mu \varphi\right)^2 - m^2\varphi^2\right] \tag{2}$$

where $\rho_{\mu\nu} = \partial_\mu\rho_\nu - \partial_\nu\rho_\mu$; ρ_μ describes a vector field, while φ describes a scalar field.
Determine the decay width $\varphi \to \rho\rho$ generated by the following interaction Lagrangians:

1. $$\mathcal{L}_1 = g\varphi\rho_\mu\rho^\mu \ . \tag{3}$$

2. $$\mathcal{L}_1 = g\varphi\left(\partial_\mu\rho_\nu\right)\left(\partial^\mu\rho^\nu\right) \ . \tag{4}$$

Exercise 3: Decay of the Higgs particles into two photons (5 points)

Consider the Lagrangian

$$\mathcal{L} = \frac{-1}{4}F_{\mu\nu}^2 + \frac{1}{2}\left[\left(\partial_\mu H\right)^2 - m_H^2 H^2\right] + gHF_{\mu\nu}F^{\mu\nu} \tag{5}$$

where H represents the Higgs field; $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$ and A_μ is the photon field.
Evaluate $\Gamma_{H\to\gamma\gamma}$.
Hint: use the following polarization sum for the photon:

$$\sum_{a=1,2}\varepsilon_\mu^a\varepsilon_\nu^a = -g_{\mu\nu} \ . \tag{6}$$