DECAYS IN QFT - WS 2012/2013

Sheet 6 **7/12/2012**

Exercise 1: Tree-level decays (15 points = 3 + 3 + 3 + 3 + 3)

Evaluate the decay rate(s) of the unstable state S when the full Lagrangian reads

$$\mathcal{L} = \mathcal{L}_0 + \mathcal{L}_1 \tag{1}$$

whereas $\mathcal{L}_0$ is the free Lagrangian reads

$$\mathcal{L}_0 = \frac{1}{2}\left[(\partial_\mu S)^2 - M_0^2 S^2\right] + \frac{1}{2}\left[(\partial_\mu \varphi_1)^2 - m_1^2\varphi_1^2\right] + \frac{1}{2}\left[(\partial_\mu \varphi_2)^2 - m_2^2\varphi_2^2\right] \tag{2}$$

and the interaction term $\mathcal{L}_1$ takes the following forms:

1.
$$\mathcal{L}_1 = gS\varphi_1\varphi_2 \ . \tag{3}$$

2.
$$\mathcal{L}_1 = g_1 S\varphi_1^2 + g_2 S\varphi_2^2 \ + gS\varphi_1\varphi_2. \tag{4}$$

3.
$$\mathcal{L}_1 = gS(\partial_\mu\varphi_1)(\partial^\mu\varphi_2) \ . \tag{5}$$

4.
$$\mathcal{L}_1 = g(\partial_\mu S)\varphi_1(\partial^\mu\varphi_2) \ . \tag{6}$$

5.
$$\mathcal{L}_1 = gS\varphi_1\varphi_2 + hS(\partial_\mu\varphi_1)(\partial^\mu\varphi_2). \tag{7}$$

Which condition must be met in order that in this case the decay rate $\Gamma_{S\to\varphi_1\varphi_2}$ vanishes?

(Determine in all the previous cases the dimension of the coupling constants g and h).

Exercise 2: Mixing (5 points)

Consider the Lagrangian

$$\mathcal{L}_0 = \frac{1}{2}\left[(\partial_\mu S_1)^2 - M_0^2 S_1^2\right] + \frac{1}{2}\left[(\partial_\mu S_2)^2 - M_0^2 S_2^2\right] + \alpha S_1 S_2 \ . \tag{8}$$

Determine the physical fields $\tilde{S}_1$ and $\tilde{S}_2$. Which is the value of the mixing angle? Then, calculate their decay width when

$$\mathcal{L}_1 = gS_1\varphi^2 \tag{9}$$

whereas the field φ has mass m.