QFT Exam

7 Januari 2019

1 Question 1 : Classical Fields

Given a Dirac spinor field ψ and two real boson fields ϕ_1 and ϕ_2, we have a Lagrangian density

$$\mathcal{L} = \frac{1}{2}\partial_\mu\phi_1\partial^\mu\phi_1 + \frac{1}{2}\partial_\mu\phi_2\partial^\mu\phi_2 - \frac{m^2}{2}\phi_1 - \frac{m^2}{2}\phi^2 - \tilde{m}^2\phi_1\phi_2 + i\bar{\psi}\partial\!\!\!/\psi - M\bar{\psi}\psi + i\lambda\phi_1\bar{\psi}\gamma_5\psi$$

with $\lambda, M, m, \tilde{m} \in \mathbb{R}$ different from zero and $m^2 > \tilde{m}^2$.

1. What is the dimension of λ? Why is there a factor i in the last interaction term?
2. How should ϕ_1 and ϕ_2 transform under Lorentz transformations so that $\mathcal{L}$ is invariant under the full Lorentz group.
3. What are the asymptotic states of this theory?

2 Question 2 : Gauge Invariance of Feynman amplitudes

1. Why is $e^+e^- \to \gamma$ not a physical process?
2. Look at the physical proces $e^+e^- \to \gamma\gamma$. The positron has momentum and helicity (p_1, r_1) and the electorn has (p_2, r_2). The photons have (k_1, s_1) and (k_2, s_2). Give the two Feynman diagrams that desribe this process in leading order. Write down the Feynman amplitudes explicitly.
3. Replace in the preceding expressions $\epsilon_{s_1}(k_1)$ with k_1 and show that the two terms cancel each other.
4. Explain why this happens.