Notes

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November 10, 2022

Contents

Abstract

Abstract of this course

1 Symmetries and conservation laws

1.1 Noether's theorem

Noether's theorem: there is a **conserved current** associated with every continuous symmetry of the Lagrangian

1.2 Symmetries and conserved currents

1.3 Global phase symmetry

Consider the Klein-Gordon Lagrangian density for a complex field:

$$L = \partial_\mu \psi^* \partial^\mu \psi - m^2 \psi^* \psi$$

Global phase change of ϵ.
We can then find the conserved Noether current, as well as the conserved charge

1.4 Local phase (gauge) symmetry

We now allow the phase change ϵ to be dependdent on the space-time coordinates x^μ. We realise that electromagnetic fields/ covarinant derivative is an essential requirement for a complex filed to remain invariant under local phase transformation.

1.5 Electromagnetic interaction

Expanding the Klein-Gordon equation:

$$\begin{aligned} L_{KG} &= (D_\mu \psi)^* (D^\mu \psi) - m^2 \psi^* \psi \\ &= \partial_\mu \psi^* \partial^\mu \psi - m^2 \psi^* \psi + ieA_\mu [(\partial_\mu \psi)^* \psi - \psi(\partial^\mu \psi)] + e^2 A_\mu A^\mu \psi^* \psi \end{aligned}$$

We see that the third term being the interaction term eA_muJ^μ, where J^μ is the free-field current. The

1.6 Stress-energy tensor, angular momentum tensor

1.7 Quantum fields