

Introduction to Supersymmetry

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Abstract

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1 Symmetries

Let us consider the Lagrangian for a complex scalar field

$$\mathcal{L}(\phi) = \frac{1}{2}(\partial_\mu \phi)(\partial^\mu \bar{\phi}) - V(\phi \bar{\phi}). \quad (1)$$

It is invariant under $U(1)$ transformations,

$$\phi \rightarrow \phi' = e^{i\alpha} \phi. \quad (2)$$

Indeed,

$$\mathcal{L}(\phi') = \frac{1}{2}(\partial_\mu \phi')(\partial^\mu \bar{\phi}') - V(\phi' \bar{\phi}') \quad (3)$$

$$= \frac{1}{2}e^{i\alpha}(\partial_\mu \phi)e^{-i\alpha}(\partial^\mu \bar{\phi}) - V(\phi \bar{\phi}) \quad (4)$$

$$= \frac{1}{2}(\partial_\mu \phi)(\partial^\mu \bar{\phi}) - V(\phi \bar{\phi}) \quad (5)$$

$$= \mathcal{L}(\phi). \quad (6)$$

Then, we say that the Lagrangian possess a continuous symmetry which gives rise conserved current, that is, $\partial_\mu j^\mu = 0$ which in turn gives rise to a conserved charge defines in the usual way

$$Q := \int j^0 d^3x. \quad (7)$$

In general, all continuous transformation which leaves the Lagrangian invariant, defines a symmetry from which we can find a conserved charge.

References