Introduction to Supersymmetry

Borja Diez

Instituto de Ciencias Exactas y Naturales, Universidad Arturo Prat,
Avenida Playa Brava 3256, 1111346, Iquique, Chile.
Facultad de Ciencias, Universidad Arturo Prat,
Avenida Arturo Prat Chacón 2120, 1110939, Iquique, Chile.

Abstract

Please write to borjadiez1014@gmail.com *for corrections, typos, and literature suggestions.*

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1 Symmetries

Let us consider the Lagrangian for a complex scalar field

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

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

$$\phi \to \phi' = e^{i\alpha}\phi. \tag{2}$$

Indeed,

$$\begin{align}
\mathscr{L}(\phi') &= \frac{1}{2}(\partial_\mu \phi')(\partial^\mu \bar{\phi}') - V(\phi'\bar{\phi}') \tag{3}\\
&= \frac{1}{2}e^{i\alpha}(\partial_\mu \phi)e^{-i\alpha}(\partial^\mu \bar{\phi}) - V(\phi\bar{\phi}) \tag{4}\\
&= \frac{1}{2}(\partial_\mu \phi)(\partial^\mu \bar{\phi}) - V(\phi\bar{\phi}) \tag{5}\\
&= \mathscr{L}(\phi). \tag{6}
\end{align}$$

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

$$Q := \int j^0 \mathrm{d}^3 x. \tag{7}$$

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

References