

Advanced Topics in the Theory of Fundamental Interactions

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1. Determine the correct power counting, in terms of the electric charge e , the electron mass m and the light velocity c of the NRQED operators:

$$\bar{\chi}\vec{\sigma}\cdot\vec{B}\chi \ , \ \bar{\chi}(\vec{D}\cdot\vec{E}-\vec{E}\cdot\vec{D})\chi \ , \ i\bar{\chi}\vec{\sigma}\cdot(\vec{D}\times\vec{E}-\vec{E}\times\vec{D})\chi \ , \ \bar{\chi}(\vec{D}\cdot\vec{D})^2\chi$$

where $\vec{D} \equiv \vec{\partial} + i\frac{e}{c}\vec{A}$ is the spatial covariant derivative and χ is the two-component electron field.

2. Check whether the operators

$$\bar{\chi}D_k\vec{\sigma}\cdot\vec{B}D_k\chi \ , \ i\bar{\chi}\vec{\sigma}\cdot(\vec{B}\times\vec{B}-\vec{E}\times\vec{E})\chi \ ,$$

are invariant under parity and time-reversal and determine their power counting.