What’s next?

Hungarian Teacher Programme

19 August 2022
\[ L = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + i e A \gamma^\mu \psi \frac{\partial A}{\partial x^\mu} \]
\[ + \bar{\psi} Q \gamma_5 \Psi + \bar{\psi} \gamma^\alpha \sigma^\alpha_{\mu \nu} F_{\mu\nu} \]
\[ + D_\mu \phi^2 - V(\phi) \]
Let’s have a coffee with the Standard Model of particle physics!

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Abstract

The Standard Model of particle physics is one of the most successful theories in physics and describes the fundamental interactions between elementary particles. It is encoded in a compact description, the so-called ‘Lagrangian’, which even fits on t-shirts and coffee mugs. However, it is complex and only rarely makes it into the physics classroom. Therefore, to support high school teachers in their challenging endeavour of introducing particle physics in the classroom, we provide a qualitative explanation of the terms of the Lagrangian and discuss their interpretation based on associated Feynman diagrams.

1. Introduction

The Standard Model of particle physics is one of the most important achievements of high energy physics to date. This tightly drawn theory sorts elementary particles according to their respective charges and describes how they interact through fundamental interactions. In its context, a charge is a property of an elementary particle that defines the fundamental interaction by which it is influenced. We then say that the corresponding interaction particles couple to a certain charge. For example, gluons, the interaction particles of the strong interaction, couple to colour-charged particles. Of the four fundamental interactions in nature, all except gravity are described by the Standard Model of particle physics: particles with an electric charge are influenced by the electromagnetic interaction (quantum electrodynamics, or QED for short), particles with a weak charge are influenced by the weak interaction (quantum flavour dynamics or QFD), and those with a colour charge are influenced by the strong interaction (quantum chromodynamics or QCD). Contrary to the fundamental interactions, the Brout–Englert–Higgs (BEH) field acts in a special way. Because it is a scalar field, it induces spontaneous symmetry-breaking, which in turn gives mass to all particles with which it interacts (this is commonly called the Higgs mechanism). In addition, the Higgs particle (H) couples to any other particle which has mass (including itself). Interactions are mediated by their respective interaction particles: photons (γ) for the
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Abstract

The Standard Model of particle physics is one of the most successful theories in physics and describes the fundamental interactions between elementary particles. It is encoded in a compact description, the so-called ‘Lagrangian’, which is presented in this article. The Lagrangian is complex and only rarely makes it into the physics classroom. Therefore, in support of high school teachers in their challenging task of introducing particle physics in the classroom, we provide a qualitative explanation of the terms of the Lagrangian and discuss their interpretation based on associated Feynman diagrams.

1. Introduction

The Standard Model of particle physics is the most important achievement of high-energy physics to date. This tightly diagram-free story of elementary particles according to their respective charges and describes how they interact through fundamental interactions. In the context of a charge is a property of an elementary particle that defines the fundamental interaction by which it is influenced. Thus not that the corresponding interaction particle ‘couples’ to a certain charge. For example, gluons, the interaction particles of the strong interaction, couple to colour-charged particles. Of the four fundamental interactions in nature, all except gravity are described by the Standard Model of particle physics: particles with an electric charge are influenced by the electromagnetic interaction (quantum electrodynamics, or QED for short); particles with a weak charge are influenced by the weak interaction (quantum flavour dynamics or QFD), and those with a colour charge are influenced by the strong interaction (quantum chromodynamics or QCD). Contrary to the fundamental interactions, the Brout–Englert–Higgs (BEH) field acts in a special way. Because it is a scalar field, it induces spontaneous symmetry-breaking, which in turn gives mass to all particles with which it interacts (this is commonly called the Higgs mechanism). In addition, the Higgs particle (H) couples to any other particle which has mass (including itself). Interactions are mediated by their respective interaction particles: photons ($\gamma$) for the electromagnetic interaction, the W and Z bosons for the weak interaction, and the gluons for the strong interaction.

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“There is nothing more enriching and gratifying than learning.”

[teacher image and text]

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