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The role of Instantons in Yang-Mills Theories

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Content

The Standard Model of Particle Physics (SM), the theory that describes three of the four fundamental interactions of nature, is constructed using Yang-Mills (YM) theories, a kind of generalization of Electromagnetism where the concept of symmetry plays a fundamental role. In particular, the strong interactions between the quarks and gluons that compose the hadrons are described in the SM by Quantum Chromodynamics (QCD). Despite the success of perturbation theory in certain contexts, there are still intriguing phenomena that can't be explained using such an approach. A very important example is the confinement of quarks and gluons in hadrons, one of the greatest challenges of current physics. It is believed that this phenomena is related to the intricate structure of the vacuum in QCD.

The Instantons are classical solutions of the Yang-Mills movement equations with non trivial topology, being a example of a non perturbative effect very relevant to the comprehension of the vacuum of QCD. Indeed, their existence allows a tunneling between different states of minimum energy, modifying the nature of the true vacuum of the theory and maintaining an important relation with the problem of confinement. In this work we will discuss what are Instantons, discuss their main properties, as well as explain their role in the construction of the true vacuum of the Yang-Mills theory.

Primary author(s) : HADDAD, Tárik (CBPF)

Co-author(s) : Prof. DE FABRITIIS, Philipe (Centro Brasileiro de Pesquisas Físicas)

Presenter(s) : HADDAD, Tárik (CBPF)

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