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Nuclear physics and its relation with lattice QCD

In a first lecture we will consider the complexity of the conventional Nucleon-Nucleon interaction either in the traditional meson exchange or in the EFT framework.
The following lectures aim to be an introductory course to the Lattice techniques used to solve the Quantum Field Theory in a non perturbative regime, with special interest in the Quantum Chromodynamics (QCD).
This activity started 40 years ago when K. Wilson proposed a formulation of QCD in an euclidean discrete space-time lattice as a statistical mechanics problem in a way that exactly preserves the main symmetry property of the theory: its gauge invariance. This branch of theoretical physics, denoted by Lattice QCD (LQCD), constitutes nowadays –even with some limitations –a unique tool to solve ab initio the theory of strong interactions.
We will introduce the theoretical and numerical tools allowing to obtain the solution of a continuous theory formulated in a Minkowski space time on a discret euclidean 4-dimensional lattice. This challenging task has been possible using the Feynman path-integral formulation of the field theories, performing analytically the integral over the fermionic degrees of freedom and using the Monte-Carlo methods to evaluate the functional integral of the remaining bosonic fields in the configuration space.
The lectures will be addressed to PhD students, Postdocs and non specialists in the subject. Their ambition is to provide the audience with a road map of a standard lattice simulations and a key to decrypt the abondant literature in the subject.
The recent progress in Lattice QCD calculations applied to nuclear physics will be
reviewed and we will show how this - a priori unlikely - approach results into a disarming simplicity for the description of light nuclei and even some simple nuclear reactions.

Summary

Primary author: CARBONELL, Jaume (CNRS Institut de Physique Nucléaire Orsay)

Presenter: CARBONELL, Jaume (CNRS Institut de Physique Nucléaire Orsay)

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