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NUCLEAR FORCE FROM QCD POINT OF VIEW

In the talk, it is surveyed the path how to construct the nuclear force theory starting from Quantum Chromodynamics (QCD) which is considered now as a basic theory of strong interactions in physics. Historically, since the pioneer Yukawa's work by 1935 the nuclear interactions were considered as those originated from meson exchange between nucleons (or, more generally, between baryons). But until the end of 90ies, there was no consistent meson-nucleon theory that could derive the nuclear force from a unified meson-nucleon Hamiltonian. Instead, there were many phenomenological models for NN interactions with parameters values fitted to empirical NN phase shifts. In 80ies, however, Weinberg suggested some new way in this area to treat consistently strong NN-interaction in terms of the Chiral Perturbation Theory (ChPT) or Effective Field Theory (EFT). In this approach, one calculates the successive terms of the perturbative expansion, order by order, and remained unknown short-range terms are found from the fit to the NN empirical phase shifts. So, from the general physical point of view, the EFT is also not a complete theory in a proper sense.
The consistent theory of nuclear force must be based on QCD which is the theory of strong interactions. But QCD is operating with quark, gluon and string degrees of freedom (d.o.f.) while the EFT and similar meson-exchange approaches operate with mesons and nucleons. And first of all, one has to build a bridge between nuclear physics d.o.f. and QCD d.o.f. and then to formulate the nuclear force using some hybrid model which is based just on the quarks and gluons.
In the present review, we will survey our recent work devoted to the new way how to build the above bridge connecting QCD and nuclear physics. This path is based on dibaryon (six-quark) resonances dressed with meson fields. In this picture, these resonances transmit the strong interaction between nucleons in free space and in nuclei. In principle, the dibaryon resonances can be calculated purely theoretically using well known QCD-lattice calculations in different NN-partial waves. In our recent works [1,2], we demonstrated how to realize the second crucial step in this way: i.e. how to construct in a quantitative manner, starting with experimentally found dibaryon resonances, both elastic and inelastic NN phase shifts in a very broad energy range from zero energy till 1 GeV. We will review also the various implications for nuclear physics of this new paradigm for nuclear force.

[1] V.I. Kukulin et al., Phys. Lett. B **801**, 135146 (2020).
[2] V.I. Kukulin et al., Phys. At. Nucl. **82**, 934 (2019).

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