DIBARYON CONCEPT FOR SHORT-RANGE $2N$ AND $3N$ FORCES: CONSEQUENCES FOR HADRONIC AND NUCLEAR PHYSICS

Vladimir I. Kukulin

Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow 119991, Russia

The present review talk is focused on short-range aspects of $2N$ and $3N$ nuclear interactions in light of numerous novel experimental data collected in JLab, BNL, and Mainz. The point is that many of these new experimental results contradict strongly to the traditional models for short-range (or high-momentum) components of nuclear forces. Thus, they require a novel understanding and new models alternative to the traditional (OBE-like) ones.

The key observation in this area is the fact that at the NN distances $r_{NN} < 1$ fm where the basic heavy-meson exchange (σ, ρ, ω, etc.) is displayed the nucleon quark cores get overlapped with each other and thus the generation of the common six-quark bag is very likely. So, the dibaryon concept considers the generation of the intermediate six-quark bag dressed with meson (predominantly σ) clouds as a driving mechanism for short-range nuclear force [1–3]. It has been demonstrated that the partial phase shifts of NN scattering up to energy 1 GeV and the precise deuteron structure can be described very well within such a model. When applying the new force model to an accurate description of few-nucleon systems, one finds that the role of the novel $3N$ force (of scalar character) turns out to be much higher as compared to the $3N$-force contribution in traditional approaches. This strong σ-exchange $3N$ force provides a much closer overlap of the above dibaryon model with the famous Walecka–Serot approach than the conventional $2N$- and $3N$-force models.

As a good illustration for the general concept we considered a new dibaryon-based mechanism [4] for the old and famous ABC puzzle [5] in the two-pion production in NN and Nd collisions at incident energies ~ 1 GeV. We found that the precise experimental data of the WASA-at-COSY Collaboration [6] can be reproduced accurately if only to assume the partial Chiral Symmetry Restoration (CSR) effect accompanying the process of dibaryon production in pn collision. Another important feature of the above dibaryon model is that the model predicts — in addition to conventional NN Fermi-momentum scale $p \leq 300$ MeV/c — also a high-momentum scale $f(p^2) \sim A\exp(-Bp^2)$, with $B \sim 10$ (GeV/c)$^{-2}$, in all nuclei required by numerous experimental results found at high energies.

Thus, one can state that the strong intermediate-range NN attraction at $r_{NN} \simeq 0.7$ fm (which is ascribed usually to the t-channel σ-exchange) originates in reality from the s-channel dibaryon generation where the (relative) stability of the intermediate σ-dressed dibaryon and high strength of the s-channel mechanism are due to CSR effects. So, the CSR phenomenon becomes to be one of the most fundamental effects for understanding the nuclear structure. Numerous consequences of such general concept in nuclear physics will be considered in the talk.

[1] V.I. Kukulin, I.T. Obukhovsky, V.N. Pomerantsev, and A. Faessler, Phys. At. Nucl. **64**, 1667 (2001); J. Phys. G **27**, 1851 (2001).

[2] V.I. Kukulin, I.T. Obukhovsky, V.N. Pomerantsev, and A. Faessler, Int. J. Mod. Phys. E **11**, 1 (2002).

[3] V.I. Kukulin *et al.*, Ann. Phys. (N.Y.) **325**, 1173 (2010).

[4] M.N. Platonova and V.I. Kukulin, Phys. Rev. C **87**, 025202 (2013).

[5] A. Abashian, N.E. Booth, and K.M. Crowe, Phys. Rev. Lett. **5**, 258 (1960).

[6] P. Adlarson *et al.*, Phys. Rev. Lett. **106**, 242302 (2011).

E-mail: kukulin@nucl-th.sinp.msu.ru