NEW INTERPRETATION OF THE ABC EFFECT IN TWO-PION PRODUCTION IN NN COLLISIONS

Maria N. Platonova, Vladimir I. Kukulin

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

The ABC effect first observed by Abashian, Booth and Crowe [1] more than 50 years ago stands for a pronounced near-threshold enhancement in the $\pi\pi$ invariant mass spectrum of the double-pionic fusion reactions, such as $pn \to d + \pi\pi$, $pd \to {}^3\mathrm{He} + \pi\pi$, etc. Numerous theoretical and experimental studies undertaken since the discovery of the ABC effect shed light on its basic features, such as its scalar-isoscalar nature. However the effect has not received a reliable and commonly accepted theoretical explanation up to now.

The interest in the ABC effect has increased again quite recently, after publication of the results of the first exclusive and kinematically complete experiments for the basic 2π-fusion reaction $pn \to d + \pi^0\pi^0$ in the ABC region (T_p = 1.0–1.4 GeV) done by the WASA-at-COSY Collaboration [2]. The comparison of the new experimental data with theoretical predictions has demonstrated clearly that the conventional model for this reaction which included the $\Delta\Delta$ and the Roper resonance excitations via t-channel meson exchange cannot reproduce the observed energy and angular distributions. At the same time, the new exclusive measurements revealed a generation of the dibaryon resonance D_{03} in the pn collision, with quantum numbers $I(J^P) = 0(3^+)$, the mass $m_{D_{03}} \simeq 2.37$ GeV and the narrow width $\Gamma_{D_{03}} \simeq 70$ MeV. Such a resonance state has been predicted already in 1964 by Dyson and Xuong [3] and since then studied in numerous works, both theoretical and experimental, but never reached such a level of evidence before. Furthermore, from the exclusive experiments [2], the direct interrelation between the production of the D_{03} resonance and the ABC effect was clearly established.

We investigated the basic 2π-fusion reaction in the ABC region within a framework of a new model [4] involving the D_{03}-dibaryon production and its subsequent decay via two interfering channels: $D_{03} \to d+\sigma \to d+\pi^0\pi^0$ and $D_{03} \to D_{12}+\pi^0 \to d+\pi^0\pi^0$. Here the D_{12} is the isovector dibaryon with quantum numbers $I(J^P) = 1(2^+)$, the mass $m_{D_{12}} \simeq 2.15$ GeV and the width $\Gamma_{D_{12}} \simeq 110$ MeV, which was also predicted in [3] and then found in the phase-shift analyses of NN and πd elastic scattering and $\pi d \to NN$ reaction [5]. We shall demonstrate in the talk that the constructive interference of the above two decay channels of the D_{03} resonance gives a strong near-threshold enhancement in the $\pi\pi$ invariant mass spectrum, i.e. the ABC effect.

In the above model, the σ-meson emission from the D_{03} dibaryon plays a crucial role in reproducing the shape and position of the ABC enhancement and is tightly connected to the idea of chiral symmetry restoration in dense and excited hadronic systems, such as the D_{03} state. In particular, the σ-meson parameters found by us are in a general agreement with models which predict the chiral symmetry restoration at high excitation energy and/or high density of matter, and they are essentially less than those accepted for the free σ meson. So, this result might be considered as an indication of the partial chiral symmetry restoration

in pn, pd, etc., collisions at intermediate energies.

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

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

[3] F.J. Dyson and N.-H. Xuong, Phys. Rev. Lett. **13**, 815 (1964).

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

[5] R.A. Arndt, I.I. Strakovsky, R.L. Workman, and D.V. Bugg, Phys. Rev. C **48**, 1926 (1993).

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