

Comment to "On the field-theoretical approach to the neutron-antineutron oscillations in nuclei"

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Abstract

We briefly outline the present state of the $n\bar{n}$ transition problem and analyse the recent manuscript of the Vladimir Kopeliovich (arXiv: 0912.5065).

First of all we briefly sum up the present state of the investigations of this problem.

In the standard calculations of ab oscillations in the medium [1-3] the interaction of particles a and b with the matter is described by the potentials $U_{a,b}$ (potential model). $\text{Im}U_b$ is responsible for loss of b -particle intensity. In particular, this model is used for the $n\bar{n}$ transitions in a medium [4-10] followed by annihilation:

$$n \rightarrow \bar{n} \rightarrow M, \quad (1)$$

here M are the annihilation mesons.

In [9] it was shown that one-particle model mentioned above does not describe the total ab (neutron-antineutron) transition probability as well as the channel corresponding to absorption of the b -particle (antineutron). The effect of final state absorption (annihilation) acts in the opposite (wrong) direction, which tends to the additional suppression of the $n\bar{n}$ transition. The S -matrix should be unitary.

In [11] we have proposed the model based on the diagram technique which does not contain the non-hermitian operators. Subsequently, this calculation was repeated in [12]. However, in [13] it was shown that this model is wrong: the neutron line entering into the $n\bar{n}$ transition vertex should be the *wave function*, but not the propagator, as in the model based on the diagram technique. For the problem under study this fact is crucial. It leads to the cardinal

error for the process in nuclei. The $n\bar{n}$ transitions in the medium and vacuum are not described at all. If the neutron binding energy goes to zero, the result diverges (see Eqs. (18) and (19) of Ref. [11] or Eqs. (15) and (17) of Ref. [12]). So we abandoned this model [13].

In [14] the model which is free of drawbacks given above has been proposed. However, the consideration was schematic since our concern was only with the role of the final state absorption in principle. For this reason we continue consideration [15] of above-mentioned model as well as the model with bare propagator (in the notations of [15] the models **b** and **a**, respectively.)

In the recent e-print [16] the previous calculations [11,12] have been repeated. It is easy to verify that there is nothing new compared with [11,12], with the exception of Sect. 5. However, the main statement of this section is completely wrong. The author writes: "If the infrared divergence discussed in [10,13] takes place for the process of $n\bar{n}$ transitions in nucleus, it should take place also for the nucleus form-factor at zero momentum transfer", which is absolutely wrong.

In the model under consideration [11,12,16] the $n\bar{n}$ transition takes place in the loop. For the propagators in the loop the infrared divergence (for $n\bar{n}$ transition, nucleus form-factor, and so on) cannot be in principle. In order to obtain the infrared divergence, the neutron line entering into the $n\bar{n}$ transition vertex should be the wave function, but not the propagator, as in the model based on the diagram technique.

Thus, on the one hand, in the model based on the diagram technique the infrared divergence cannot be in principle for any process including the $n\bar{n}$ transition, and on the other hand this model is wrong. The model containing the vertex of virtual decay $A \rightarrow n + (A-1)$ is unsuitable for the problem under study [13]. In the correct model the neutron line entering into the $n\bar{n}$ transition vertex should be the wave function. In this case we inevitably get the infrared singularity for the plane wave or wave function of bound state.

Sect. 3 which pretends to the common character of consideration in our opinion has no need of comments. In particular, in the end of this section we read: "Technical reason for the strange result obtained in [10,13] is the wrong interpretation of the second order pole structure of any amplitude containing $n\bar{n}$ transitions." In reality, the technical reason is that we simply use the fundamentally different process model.

References

- [1] M.L. Good, Phys. Rev. **106**, 591 (1957).

- [2] M.L. Good, Phys. Rev. **110**, 550 (1958).
- [3] E. D. Commins and P. H. Bucksbaum, *Weak Interactions of Leptons and Quarks* (Cambridge University Press, 1983).
- [4] V. A. Kuzmin, JETF Lett. **12**, 228 (1970).
- [5] R. N. Mohapatra and R. E. Marshak, Phys. Rev. Lett. **44**, 1316 (1980).
- [6] K. G. Chetyrkin, M. V. Kazarnovsky, V. A. Kuzmin and M. E. Shaposhnikov, Phys. Lett. B **99**, 358 (1981).
- [7] J. Arafune and O. Miyamura, Prog. Theor. Phys. **66**, 661 (1981).
- [8] W. M. Alberico *et al.*, Nucl. Phys. A **523**, 488 (1991).
- [9] V. I. Nazaruk, Eur. Phys. J. A **31**, 177 (2007).
- [10] V. I. Nazaruk, Eur. Phys. J. C **53**, 573 (2008).
- [11] V. I. Nazaruk, Yad. Fiz. **56**, 153 (1993).
- [12] L. A. Kondratyuk, Pis'ma Zh. Exsp. Theor. Fiz. **64**, 456 (1996).
- [13] V. I. Nazaruk, Phys. Rev. C **58**, R1884 (1998).
- [14] V. I. Nazaruk, Mod. Phys. Lett. A **21**, 2189 (2006).
- [15] V. I. Nazaruk, arXiv: 0910.0516.
- [16] V. B. Kopeliovich, arXiv: 0912.5065.