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CONSERVATION OF COMBINED PARITY AS FUNDAMENTAL LOW OF THE SYMMETRY IN NATURE

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x) The report was made in October 3, 1958 at All-Union Conference on quantum theory of fields and theory of elementary partioles in Udzgorod.

The transformation of the combined inversion PC consists in the operation P of the reflection of space coordinates and in the operation C of transformation of particle into antiparticle. It follows from the Pauli-Lüders theorem that the quantities invariant with respect to the operation of the combined inversion are also invariant with respect to the operation of the time reversal . Therefore, the fundamental low of the symmetry in nature may be formulated as the low of invariance of the theory with respect to the operation of time reversal (in the Wigner sense).

Before proceeding to discuss the question of conservation of parity in strong interactions we shall consider one particularity of mathematical method, describing elementary particles. Basing on the Gell-Mann and Nishijima systematics of elementary particles we shall divide all the Lagrangians of the strong interaction of mesons and baryons into the two classes [6] . We attribute to the first class the interactions which have at least only one vertice at which not a single characteristic of a fermion such as mass, electric charge and strangeness is changed. These are the interactions of π -mesons with nucleons, π - mesons with Σ- hyperons and π - mesons with Ξ hyperons (and also electromagnetic interactions). We attribute to the second class the interactions which have only such vertices at which at least one characteristic of a fermion, such as mass, electrical charge, strangeness is changed. These are interactions of π - mesons with Σ and Λ -hyperons and also all interactions of K -mesons with baryons . The form of the interaction Lagrangians of the first class is determined by the behaviour of the field operators with respect to P and PC (or T) and the form of the Lagrangians of the second class is determined completely by the behaviour of the operators with respect to the operation P .

We formulate the main assertion of the considered conception as follows: <u>the low of conservation of combined parity reflects the fundamental properties of space-time</u> . <u>The conservation of parity in some interactions follows from supplementary requirements of invariance.</u> Indeed, as it is shown in [3, 4, 7] in case of quantum electrodynamics due to the gauge invariance condition the requirement of invariance with respect to the operation of combined inversion PC automatically leads to the invariance with respect to the operation of space inversion. Thus, the conservation of parity in renormalized electromagnetic interactions follows from the low of conservation of electrical charge [x)].

As it is shown in [3,4,7,11] in case of renormalized pseudescalar (or scalar) meson theory due to the condition of isotopic invariance the requirement of invariance with respect to the transformation of combined inversion PC leads to the invariance with respect to the space inversion operation P . Thus, the conservation of parity in meson theory follows from hypo-

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Then, as it is shown in [9,4] the requirement of invariance with respect to combined inversion operation PC of the renormalized and isotopicly invariant interaction Lagrangian of K - meson with baryons, of $\Sigma \pi \Lambda$ - interaction does not lead to the conservation of parity. Thus, the requirements of PC and isotopic invariance for the Lagrangians of the first class lead to the conservation of parity and for those of second class do not lead to the conservation of parity. It is possible that some supplementary requirements of invariance which ensure the conservation of parity in some form of the Lagrangians of the second class will be necessary. Let us note that the renormalized Lagrangian of baryons-mesons interaction invariant with respect to the combined inversion operation was determined completely. Indeed, since the behaviour of the operator of π -meson field under transformation of PC is known than the terms of the Lagrangian of the first class are determined completely . There is only one form of Lagrangian invariant with respect to PC for the interactions of the second class.

We shall restrict our consideration only by renormalizable interaction Lagrangians. It should be noted that the splitting of the interaction Lagrangian into renormalizable and non-renormalizable parts was carried out on the basis of an expansion of the S - matrix into a power series in the coupling constant. But, as it is known [10] there is an essential physical difference between the renormalizable and non-renormalizable theories because in non-renormalizable theories the interaction Lagrangians are "debris" of non-localized interactions represented as it were in a localized form.

When investigating the non-conservation of parity in strong interactions by means of analysis of baryon-meson collisions note should be taken that the effect from the non-conservation of parity in strong interactions must be greater than the contribution from virtual weak interactions which does not conserved the parity. Since we hold the classification of interactions given by Gell-Mann, than Zeldovich's example [8] is not the case of violation of parity in electromagnetic interaction and from our point of view illustrates the influence of the virtual graphs with weak interaction on the electromagnetic processes.

Let us proceed now to discuss the problem of experimental check of conservation of parity in strong interactions. The requirement of isotopic invariance for the Lagrangians of the first class invariant with respect to PC leads to the conservation of parity. Therefore, first of all let us investigate interactions of the particles the interaction Lagrangians of which are attributed to the second class. In order to check the conservation of parity in K -meson and hyperon production we shall consider the process $\pi + N \to K + Y$ with observation of the following decay $Y \to N + \pi$ (Y may be Λ or Σ - hyperon). As it is shown in [12] if the parity is not conserved in K - meson and hyperon production than the longitudinal component of vector of polarization of hyperon may arise which leads to the appearance of the asymmetry in distribution of π -mesons from the decay of hyperons (in center of mass system) both with respect to the plane perpendicular to that of production, which passes in direction of the initial π -meson and with respect to the plane perpendicular to that of production and perpendicular to the direction of the incident π - meson . If we have a longitudinal hyperon polarization than the asymmetry with respect to one of the above-mentioned planes x) must appear [12, 13].

The analysis of the experimental data [14] and investigation [15] of this asymmetry in the reaction $\pi^- + p \longrightarrow \Lambda^\circ + K^\circ$ at 1. 1. Bev which has been made by the Bubble Chamber group at Berkeley xx) did not detect the non-conservation of parity in K - meson and hyperon production. But the accuracy of the measurement results was not high. In connection with these experiments it should be noted that since the properties of the longitudinal polarization are not know (if it appears) than it is possible that this polarization may be different (by value and sign) at various angles of hyperon production and when integrating over angles the effect may be smeared out. In view of this it would be interesting to consider this process in the narrow angular range of hyperons production. The reactions $K + p \longrightarrow Y + \pi$ $\Sigma^- + p \longrightarrow \Lambda^\circ + n$ et al are of analogous interest.

The investigation of the reaction $\pi^- + p \longrightarrow \Sigma^- + K^+ + \pi^\circ$ [16] is greatly perspective. If the parity is not conserved in hyperon and K -meson production than the asymmetry in K -meson distribution with respect to the plane constructed (in centre of mass system) in the directions of the incident π -meson and hyperon will appear. The advantage of this reaction and analogous ones

$$K^- + d \longrightarrow p + \Lambda^\circ + \pi^- , \qquad \pi^- + p \longrightarrow Y^\circ + K^+ + \pi^-$$

consists in that the asymmetry does not depend on the properties of the longitudinal polarization. It is possible that the non-conservation of parity will exhibit at low energies when three or more mesons are producted.

The more precise investigation of non-conservation of parity was made by means of scattering of polarized nucleons by nucleons and nuclei. On the basis of analysis of the polarization experiment [18] made in [17] it is shown that the value F^2 which characterizes the gegree of violation of the parity conservation low is less or equal to 3.10^{-2} . In [19] on the basis of measurements of the longitudinal polarization of the neutron beam of 350 Mev energy one obtained $F^2 \leqslant 3.6 \; 10^{-6}$. In [17] the problem of non-conservation of parity in π^+ -meson production on aluminium by polarized proton with 209 Mev energy was studied. It was found

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x) The author is grateful to Prof. Drell for sending the preprint and expressing his thought on question of -conservation.

xx) The author is grateful to Prof. Steinbergen and M. Good for sending the preliminary results of the measurements.

that $F^2 \leqslant 2.10^{-3}$. The conservation of parity in nuclear reaction was confirmed more exactly. So, Tanner [20] found that $F^2 \leqslant 4.10^{-8}$ and Wilkinson [21] determined that $F^2 \leqslant 1.10^{-7}$ on the average in series of reactions.

If the violation of the isotopic invariance is absent than the non-conservation of parity may appear in nucleon-nucleon collisions and nuclear reactions due to the virtual K -mesons and hyperons and due to the non-local interaction. As the estimation shows in [13] the contribution of K -meson forces to the nucleon-nucleon potential is small hence the conservation of parity (with great degree of accuracy) in nucleon-nucleon interactions does not contradict the violation of conservation of parity in K - meson and hyperon interactions (i.e. for the interaction Lagrangians attributed to the second class).

In conclusion let us note that the experimental discovery of non-conservation of parity in strong interactions described by the Lagrangians of the second class would confirm all above conception and make possible to penetrate more deeply into the lows of the nature. For example, the appearance of non-conservation of parity resulting in scattering of π -mesons by nucleons will testify either the violation of the hypothesis of the charge invariance or the appearance of the non-local interaction. The appearance of non-conservation of parity in nucleon-nucleon interactions would allow, beside, to estimate the contribution of K - meson - hyperon forces.

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