Letters to the Editor

CONCERNING THE PAPER "EVALUATION OF PHASE INTEGRALS IN THE COVARIANT FORMULATION OF THE THEORY OF MULTIPLE PRODUCTION OF PARTICLES" BY L. G. YAKOVLEV

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THE paper by Yakovlev[1] contains basically a proposal to utilize the simple integral (12), over the multidimensional region defined by Eq. (16) and Fig. 1, for the phase volume evaluation. We shall show that the integral (12) is incorrect and that it is impossible to regard (16) as representing the limits of integration.

Deriving Eq. (12) from (11), the author integrates over the directions of the particle momenta after fixing their magnitudes. While doing so, he assumes the possibility of having arbitrary angles between the momentum which is being integrated and the vector sum of those not yet integrated. However, when one of the momenta is close enough to the limiting value, the angles mentioned above cannot differ very much from 180°. In the case of similar (and many other) states there exists a limiting angle which is a function of the chosen momentum values. In the presence of such a limiting angle [cf. reference 2, Eq. (17)] the limits of integration become variable, and one cannot derive Eq. (12).

Further, it is easy to show that the portions of the region of integration (16) close to the vertices of the hexagon in Fig. 1 of reference 1 do not correspond to physical states of a system consisting of three zero-rest-mass particles. In the region close to the right lower vertex, particle 3 should come almost to rest and simultaneously move at almost the limiting velocity. It is equally true that when $n > 3$ (16) does not represent the region of integration but a polyhedron circumscribed around it. The author errs here by accepting the necessary conditions imposed on the energy (16) as necessary and sufficient. If the sufficient conditions are also taken into account, the region of integration is not bounded by planes but by some very complicated curved surfaces (plotted roughly in Fig. 1 of reference 3 and given analytically by Eq. (2.13) of the same paper). The character of these surfaces does not permit simple integrations as those attempted by Yakovlev.

It follows from the above that the simplicity of the method for evaluation of covariant weights was achieved by means of an incorrect extension of the region of integration to nonphysical states, i.e., to impossible values of angles and energy. Inaccurate are, in particular, Eqs. (12), (13), and (17) to (19), and the estimate of the applicability of the correct formula (9) is questionable.

[1] L. G. Yakovlev, JETP **37**, 1041 (1959), Soviet Phys. JETP **10**, 741 (1960).

[2] Yu. N. Blagoveshchenskiĭ and G. I. Kopylov, Preprint R-213, Joint Institute for Nuclear Research (U.S.S.R.) (1958).

[3] G. I. Kopylov, JETP **35**, 1426 (1958), Soviet Phys. JETP **8**, 996 (1959).

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SIGNS OF CONSTANTS OF STRONG INTERACTIONS

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STRONG interactions of known elementary particles are characterized by eight vertices

$$N N\pi,\ \Lambda\Sigma\pi,\ \Sigma\Sigma\pi,\ \Xi\Xi\pi,\ N\Lambda K,\ N\Sigma K,\ \Xi\Lambda K,\ \Xi\Sigma K, \qquad (1)$$

to each of which corresponds a respective coupling constant. The only one known for the present is the $NN\pi$-interaction constant. The determination of the remaining seven constants represents one of the basic tasks of high energy physics. A fundamental characteristic of a vertex is not only the absolute magnitude of the coupling constant but also its sign. The knowledge of the signs of the constants is of special importance in inquiries into various symmetry properties characterizing strong interactions.

It is obvious that the absolute sign of a particular constant does not have physical meaning, since it can always be associated with the field of one of the particles entering the vertex. Only a product of signs of vertices whose aggregate contains any particle an even number of times has physical meaning. One sees easily that from the eight vertices (1) one can choose independently only four products, e.g.,

$$a:(\Sigma\Sigma\pi)(NN\pi),\quad b:(\Sigma\Sigma\pi)(\Xi\Xi\pi),$$
$$c:(\Sigma\Lambda\pi)(\Sigma\Sigma\pi)(\Sigma NK)(\Lambda NK),\quad d:(\Sigma\Lambda\pi)(\Sigma\Sigma\pi)(\Sigma\Xi K)(\Lambda\Xi K). \tag{2}$$

Here $(\Sigma\Sigma\pi),\ldots$ denotes the sign of the $\Sigma\Sigma\pi,\ldots$ vertex. Further products of vertex signs having a physical significance can be obtained from (2) by multiplying again among themselves a, b, c, and d.

As a consequence of (2), one can choose arbitrarily the signs of four vertices, while the signs of the remaining four can be determined experimentally. It is, for instance, convenient to choose as arbitrary the signs of the four vertices containing the Σ hyperon. The signs of $a:(\Sigma\Sigma\pi)(NN\pi)$ and $ab:(\Xi\Xi\pi)(NN\pi)$ (and consequently of $b:(\Sigma\Sigma\pi)(\Xi\Xi\pi)$ can be fixed by investigating the scattering of the Σ and Ξ hyperons by nucleons. At the same time, one has to determine (e.g., using the interference with the Coulomb scattering) the sign of the single-meson (polar) scattering amplitude (see Fig. 1). The signs of c and d are much harder to fix, because they require the determination of the sign of a more complex amplitude.

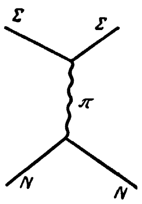

FIG. 1

Let us show how to find out which amplitudes correspond to a particular product of signs of constants.

Let us examine, for example, the product $ac:(\Sigma\Lambda\pi)(NN\pi)\cdot(\Sigma NK)(\Lambda NK)$. We compare it to the closed diagram in Fig. 2. The Feynman diagram of the amplitudes in question may now be obtained by cutting two arbitrary lines in Fig. 2. If the figure is cut at points x and y, we obtain a diagram corresponding to the two-meson amplitude of the Σ-hyperon scattering by a nucleon, shown in Fig. 3.

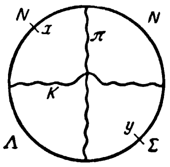

FIG. 2

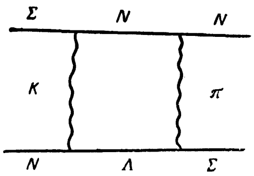

FIG. 3

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ELECTROMAGNETIC RADIATION FROM ELECTRON DIFFUSION

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WE shall study the emission of electromagnetic radiation in the multiple elastic scattering of electrons formed in a medium by some ionizing agent (e.g., an ionizing particle).

We assume that the molecules of the medium have a small probability of electron capture and that a number of free electrons are formed which rapidly multiply and lose energy so fast that they soon have insufficient energy to excite the molecules in the medium. Subsequently the collisions become elastic, and in each strong scattering event an electron loses only a small part of its energy: $\Delta\epsilon \approx \epsilon m/M$, where ϵ is the kinetic energy of the diffusing electrons and m/M is the ratio of the electron mass to the molecules of the medium. The reciprocal gives the number of collisions necessary for the electron to dissipate its energy.

If the average time between collisions exceeds the periods of the wavelengths that are of interest, then radiation pulses will have time to form in each collision, and the energy radiated will be comparable with that radiated in an instantaneous stop: $\Delta\epsilon_r \sim r_0\epsilon\Delta\omega/c$ (see, e.g., reference 1) where $r_0 = e^2/mc^2$ is the classic electron radius, c the velocity of light, and $\Delta\omega$ the width of the spectrum detected.

However, the necessary condition between the frequency of collisions and the wave frequency is not always fulfilled, especially in condensed media. For example, for a mean free path $l_s \simeq 3\times10^{-8}$ cm and an electron velocity $v = 3\times10^{8}$ cm/sec, the collision frequency is $v/l_s \gtrsim 10^{16}$, which exceeds the frequency of light oscillations by almost an order of magnitude. Therefore, for waves to be effectively generated by these elec-