for atoms and nuclei. If also one assumes that the most general features of quantum mechanics are retained, one can expect the occurrence of superpositions with respect to the various internal properties of the elementary particles, i.e., the occurrence of states in which an elementary particle is not characterized by a definite value of one or another internal parameter.

A widely discussed example of superposition is that associated with the charge (or combined) parity and "strangeness" of K^0-mesons.[1] A second example relates to the spatial parity of "strange" particles.[2]* It is interesting to note that particles not having definite parity could in principle have a large electric dipole moment, of the order of 10^{-25} gm$^{-1/2}$ cm$^{5/2}$ sec^{-1}.

Nor can we exclude the possibility of the existence of particles not having a definite value of the spin. In applications to the "strange" particles such an assumption would essentially change the interpretation of many statements relating to this subject. Wide possibilities would be opened up in the discussion of various sorts of angular correlations, etc. As a consequence susceptible of direct experimental test, we suggest a change of the ratio of the numbers of long-lived and short-lived θ^0-mesons (cf. for example, Ref. 1).

If a conservation law holds for some internal property Ω (either absolutely or for strong interactions only), then in collisions of ordinary particles the particles described by superpositions with respect to Ω can be produced only in pairs or larger numbers. Similarly, if before a reaction there is one such particle, then also after the reaction there must remain at least one. For the "strange" particles we thus get conclusions that are usually connected with a law of conservation of "strangeness." This question is considered from a somewhat different point of view in Ref. 5, where the property Ω is that of spatial parity. But in general the property Ω can be of a different nature. Nor is it excluded that similar considerations can be applied not only in connection with the law of conservation of "strangeness" but also with other conservation laws.

The writer is grateful to A. Z. Dolginov, L. G. Zastavenko, L. I. Lapidus, A. L. Liubimov, V. I. Ogievetskii, and D. S. Chernavskii for participation in discussions.

*The parity nonconservation so far observed in β-decays[3,4] may have no bearing on the decays of hyperons and K-mesons into nucleon and π-mesons.

[1] Ia. B. Zel'dovich, Usp. Fiz. Nauk 59, 377 (1956).
[2] J. Schwinger, Phys. Rev. 104, 1164 (1956).
[3] Wu, Ambler, Hayward, Hoppes, and Hudson, Phys. Rev. 105, 1413 (1957).
[4] Garwin, Lederman, and Weinrich, Phys. Rev. 105, 1415 (1957).
[5] I. M. Gel'fand and M. L. Tsetlin, J. Exptl. Theoret. Phys. (U.S.S.R.) 31, 1107 (1956); Soviet Phys. JETP 4, 947 (1957).

Translated by W. H. Furry
148

ON THE PRINCIPLE OF LARMOR INVARIANCE

A. A. BORGARDT

Dnepropetrovsk State University

Submitted to JETP editor April 27, 1957

J. Exptl. Theoret. Phys. (U.S.S.R.) 33, 791-792 (September, 1957)

In present day field theory relativistic invariance of the basic equations, which includes invariance under four-dimensional displacements, rotations, and reflections, is considered sufficient. The remaining transformations of the conformal group are added if the rest mass of the particle vanishes. We note that electrodynamics includes also the so-called Larmor transformation, which is not contained in the conformal group transformations and which amounts to a simultaneous change of the parities of the field quantities. Huygens' principle cannot be correctly formulated in Maxwell's electrodynamics, which, although relativistically invariant, is not Larmor invariant. Such a formulation is possible only in the framework of a Larmor invariant theory which includes magnetic charges (Kottler's formulas).[1]

Recently Ohmura[2] has shown that magnetic charges must be considered to achieve stability for the classical electron.

The wave equations for a boson field, invariant under the Larmor transformation, can be written as follows[3,4]

$$\gamma_\lambda \partial\psi / \partial x_\lambda + k_0\psi = q, \quad -\partial\psi^+\gamma_\lambda / \partial x_\lambda + k_0\psi^+ = q^+, \tag{1}$$

$$1/2\,\{\gamma_\mu\gamma_\nu\} - \delta_{\mu\nu} I = 0, \qquad \psi^+ = \psi^* R_4, \tag{2}$$

(in the general case $\psi^+ = -i\psi^* R_n$, where $R_n = n_\lambda R_\lambda$, $n_\lambda^2 = I$).

In this theory Larmor conjugation is accomplished by means of the matrix $\overline{\gamma_5} = R_5\gamma_5$:

$$\psi^L = \bar{\gamma}_5\psi, \quad q^L = \bar{\gamma}_5 q, \quad \psi^{+L} = \psi^+\bar{\gamma}_5, \quad q^{+L} = q^+\bar{\gamma}_5. \tag{3}$$

Equations (1) are Larmor invariant because $[\overline{\gamma_5}\ \gamma_\mu] = 0$ and $\overline{\gamma_5} = I$. This is not the case in Kemmer's theory where the kinematic matrices are the β_μ — the "halves" of the γ_μ:

$$\beta_\mu = 1/2\,(\gamma_\mu + \bar{\gamma}_\mu), \qquad [\bar{\gamma}_5\beta_\mu] = \bar{\gamma}_5\bar{\gamma}_\mu. \tag{4}$$

Invariance of the (1) — (2) system under the transformation (3) leads to the interesting fact, pointed out in Ref. 4, that the wave equations can be deduced from two different Larmor invariant Lagrangians, a scalar L and a pseudoscalar $\tilde{L}$,

$$L = 1/2\,(\varphi^+ R_5\psi + \psi^+ R_5\varphi), \ \tilde{L} = 1/2\,(\varphi^+\gamma_5\psi + \psi^+\gamma_5\varphi) \quad (\varphi = \psi - q). \tag{5}$$

In actuality one apparently has to form a linear combination of the two and choose the action in the form

$$S = 1/4 \int (\varphi^+ R_5 (I \pm \gamma_5)\,\psi + \psi^+ R_5 (I \pm \gamma_5)\,\varphi)\,(dx). \tag{6}$$

The invariance under transformation (3) is connected with the intrinsically five-dimensional character of our space (γ_μ and γ_5 form a five dimensional representation of the Dirac algebra). Therefore it is logically unavoidable to require that both classical and quantum field theory be Larmor invariant.

The extension of these conclusions to the theory of spinor fields does not present any difficulties and requires merely a slight development of existing methods similar, for example, to those employed in Ref. 5.

[1] B. Backer and E. Copson, The Mathematical Theory of Huygens' Principle, Oxford, 1939.

[2] T. Ohmura, Progr. Theor. Phys. 16, 684, 684 (1956).

[3] A. A. Borgardt, Dokl. Akad. Nauk SSSR 78, 1113 (1951).

[4] A. A. Borgardt, J. Exptl. Theoret. Phys. (U.S.S.R.) 24, 284 (1953).

[5] Umezawa, Kamefuchi, and Tanaka, Progr. Theor. Phys. 12, 383 (1954).

Translated by A. Bincer
149

THEORY OF ELECTRON PARAMAGNETIC RESONANCE IN SUPERCONDUCTORS

M. Ia. AZBEL' and I. M. LIFSHITZ

Physico-Technical Institute, Academy of Sciences, Ukrainian S.S.R.

Submitted to JETP editor April 27, 1957

J. Exptl. Theoret. Phys. (U.S.S.R.) 33, 792-794 (September, 1957)

ELECTRON spin paramagnetic resonance has recently been observed in various metals.[1] The theory of the resonance has also been published.[2,3] The theory indicates that diffusion of conduction electrons into the depth of the metal plays an important part in the effect. The diffusion causes the attenuation of elec-