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Cosmology and Elementary Particles.

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Recent investigations pay more attention to the covariant formulation of the quantum field theory and to the role played by gravitation in elementary-particle behaviour. But gravitation, being a long-range force, may give us information about real cosmological conditions. One can explain them either more directly as boundary conditions or some kind of an effective, cosmological force (1), or indirectly through their eventual influence on the ground state (vacuum) (2). As an example of the first possibility we can point to the solution of the Schwarzschild problem with normalization at infinity not on flat Galilean but on Friedman metrics. Then one gets an exact solution of McVittie's type or of our type which at small distances is practically Schwarzschildean, but can represent the influence of universal expansion (3). In the same way one could introduce the gravitational potentials of the Friedman metrics, *i.e.* corresponding tetradic expressions into the fundamental nonlinear spinor equation of the unified theory. This nonlinear equation either for spinor-isospinor (HEISENBERG) (4) or spinor-unitary spinor (as we propose (5,6)), anyhow possesses too much symmetries and one must take into account the asymmetries of a degenerate vacuum to reach a more realistic description of elementary particles. For instance, if one admits the vacuum degeneracy with respect to the isospin group, which latter can be connected with the nonvanishing value of isospin (its 3rd component) in the universe, then from the Goldstone theorem we get as corresponding particle a photon. Although the Goldstone theorem has been proved as yet only in the case of Hilbert-space definite metrics (and supplementing it with the indefinite-metrics part seems necessary) and only for continuous transformations, let us admit its general validity perhaps in a modified form. Then it seems natural to express the

(1) D. IVANENKO: *Mesons and Cosmology*, in *Problems on Fundamental Physics*, Yukawa Theory Jubilee Volume (Kyoto, 1965).

(2) D. IVANENKO: cf. *Colloque Intern. sur Gravit.* (Paris, 1967).

(3) A. McVITTIE: *Ann. Inst. Poincaré* (1967); V. S. BREŽNEV, D. IVANENKO and B. N. FROLOV: *Transactions High School Russ.*, Tomsk, N. 6 (1966).

(4) W. HEISENBERG: *Introduction to the Unified Field Theory of Elementary Particles* (London, 1966).

(5) A. M. BRODSKY and D. IVANENKO: *Žurn. Èksp. Teor. Fiz.*, **24**, 348 (1953); cf. *Atti Convegno Relativ. Gener.* (Firenze, 1965).

(6) A. I. NAUMOV: *Transact. Moscow University*, N. 2 (1967).

hypothesis that, firstly, all symmetry features of the universe lead to the same asymmetries of the vacuum, and, secondly, that to all these asymmetries exist corresponding « goldstones ». After the photon (asymmetry due to cosmological nonvanishing isospin value), the next candidates for «goldstones» seem to be: gravitation (violation of Lorentz group due to curvature), neutrino(?) (spirality(?)). But due to the very close relationship between neutrino and electron entering the same lepton family, maybe the electron also is a « goldstone » (corresponding to violation of scale invariance?), the electronic mass being due to some supplementary causes.

The very preliminary character of these considerations is clear enough, but they seem to be heuristic and to stimulate further investigations on the Goldstone theorem, on the characteristic doubling inside the leptonic family (electron-muon and corresponding neutrinos), on the absolute or limited character of baryonic and leptonic number conservation and so on. Representing some modern version of Mach's principle, whose spirit is the search of connections between local and cosmological phenomena, the hypothesis of a relationship between cosmological asymmetries and elementary particles *via* vacuum seem to deserve attention. Anyhow it would be unnatural to limit himself to the photon alone as a « goldstone » generated by vacuum asymmetry, which in turn is due to a cosmological phenomenon.

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