Colloque International de Physique Theorique, Particules Fondamentales, et Noyaux: Paris, April 24–29

F. J. Belinfante
Department of Physics, Purdue University, Lafayette, Indiana

A COLLOQUIUM ON THEORETICAL PHYSICS was held at the Institut Henri Poincaré in Paris, April 24 to 29. At this conference, sponsored by the Centre National de Recherche Scientifique, various aspects of the theories of elementary particles were discussed. Among the many people participating or attending there were Ashkin, Auger, Bauer, Belinfante, Bhabha, Camerini, Casimir, DeBoer, DeBroglie, D'Espagnat, Destouches, Dirac, Feynman, Fierz, Glauber, Halban, Heitler, Hoang Tchang Fong, Iskraut, Janossy, Kallen, Kemmer, Klein, Kofoed Hansen, Leprince Ringuet, Møller, Pauli, Peierls, Proca, Rosenfeld, Serpe, Valatin, Wataghin, and Wouthuysen.

Of the most important subjects discussed, we mention here only a few. *Rosenfeld* reported on the limitations imposed on the measurability of electric charge and current densities. By using heavy elementary particles as test bodies, the charge distribution of electrons might be measured in regions smaller than the Compton wavelength.

Dirac reported on a new method of describing interacting particles. States were defined on parametrized hypersurfaces in space-time; ψ is considered constant if field variables for given parameter values u_1, u_2, u_3 on different hypersurfaces (different generalized time τ) are the same. There is one Schrödinger equation giving $\partial\psi/\partial\tau$; there are similar equations describing the change of ψ when the parametrization is changed, or, in the case of quantum electrodynamics, also when the gauge of the longitudinal part of the vector potential is changed. Further, expressions for canonical conjugates of field variables in terms of time derivatives of field variables are generally considered as auxiliary conditions or Schrödinger equations rather than as q-number relations. In this way, classical quantum electrodynamics can be quantized without use of Fermi's methods, and the Lorentz condition need not be imposed. The large numbers of Schrödinger equations thus obtained is finally reduced to only one by fixing the choice of the parametrization by making the charge density independent of τ, by considering the charge density as the canonical conjugate of a new variable ϑ and expressing the scalar potential in terms of $d\vartheta/d\tau$, thus avoiding the auxiliary condition expressing the vanishing of the canonical conjugate of the scalar potential, and by finally choosing ϑ as the time variable τ. As a consequence, the choice of hypersurfaces $\tau = \text{constant}$ is linked up with the gauge of the longitudinal vector potential, and a change of the gauge necessitates a change of the hypersurfaces.

Pauli reported on difficulties met when one tries to apply the method of renormalization of mass and charge to meson theory. He also discussed the method of regularization, by which meaningless (divergent) integrals may be avoided. One would like to consider the "D-functions" thus introduced as describing the action of actual particles of finite (large) mass rather than take their masses to infinite as it is now done for avoiding ambiguities. But the theory remains unsatisfactory, as charge renormalization cannot be avoided by it.

Kallen showed how one can obtain recent theoretical results just as well by use of Heisenberg's representation as by use of interaction representation.

Heitler discussed a theory proposed by Gupta and Bleuler for avoiding the inconsistencies in Schwinger's definition of the "photon vacuum" in quantum electrodynamics. By use of an indefinite metric for the calculation of matrix elements, it is possible to interchange the creation and annihilation operators for the "scalar" photons described by the scalar potential. Thus, Schwinger's covariant photon-vacuum definition gets a meaning. It is made consistent with the Lorentz condition by making the latter condition less rigorous, referring only to operators annihilating photons. It is hoped that this less rigorous Lorentz condition may be sufficient.

Belinfante stressed the disadvantage of the noncovariant definition of the "photon vacuum," which states only the absence of transverse photons. So-called proofs of the "equivalence" of this definition with the covariant one seem to be wrong. Application of Umezawa and Kawabe's guess at a covariant cut-off of the now divergent integrals in a future theory shows how the noncovariant definition of an electron without free photons leads to a noncovariant result for the electron self-energy. The question was discussed whether there would be any experimental method of detecting the small effects of the noncovariant terms on the properties of the electron. It seemed best to make an accurate check of the theoretical formula for the Rydberg constant. (Note added: Birge has in the meantime shown that indeed such effects from noncovariant terms on the Rydberg constant do *not* exist. This would thus show the necessity of a new covariant definition of the photon-vacuum consistent with quantum electrodynamics.)

Feynman discussed the dualism between the "field" point of view and the "action at a distance" point of view in electrodynamics. An "integrovariational differential equation" was derived for the S-matrix describing the collision of a number of electrons in an external field in absence of free photons before and after the process. In this equation one of the D-functions occurs. Smearing out this D-function in order to avoid infinities gives a method of calculation, but does not lead to a consistent theory.

Rosenfeld reported on the nucleon-nucleon interaction, in particular on Blatt and Jackson's discussion of the low energy scattering cross sections and on the possibility of finding range and depth for an effective triplet state potential and for an effective singlet state potential separately. Both ranges can be made equal and a charge dependence of nuclear forces in the low energy region can be avoided by choosing a potential with sufficient tail at large r. For this purpose, an exponential well is just as good as a Yukawa potential, and the range of the potential fits nicely with the present mass of the π-meson, but square wells or Gaussian potentials would not work. With the correct potential-with-tail, the effect of tensor forces on low energy scattering can be considered as small.

The present data on the angular distribution in scattering can certainly not be explained by a pseudoscalar meson field alone. For the rest, relativistic effects should be particularly strong, by cross terms, when different couplings of a meson field with nucleons are combined. Pauli remarked that besides tensor forces a "spin-orbit" coupling may have to be taken into account.

Møller reported on the present ideas about the nature of π-mesons and μ-mesons. He mentioned some experimental evidence for the existence of neutral π-mesons, which rapidly disintegrate into a pair of gamma quanta.

Ashkin gave a report on new results obtained in this regard in Berkeley. The observed angular distribution of the gamma ray coincidences can be explained theoretically under the assumption that the gamma rays are emitted in a spherically symmetric way in the rest system of the neutral π-meson. The mass of the neutral π-meson is only slightly less than that of the charged π-meson. From measurements of the total intensities in the gamma spectrum for energies corresponding (a) to half the rest energy of the π-meson, and (b) to the entire rest energy of this meson, one can obtain some information about the nuclear coupling constants for the neutral π-meson.

Bhabha attempted to avoid the $1/r^3$ difficulty in the deuteron problem by deriving an exponential instead of a Yukawa potential for the proton-neutron interaction, from a new type of meson theory. He stressed that this theory was of a type not discussed by Pais and Uhlenbeck. *Feynman* pointed out that Bhabha's theory might lead to inconsistencies, if one considers the emission of real mesons, instead of the virtual meson field connected with the nucleon-nucleon interaction. *Casimir* remarked that the $1/r^3$ difficulty is not taken seriously in the magnetic dipole-dipole interaction of an electron, say with the nucleus, because r is large for these particles anyhow. Is a similar reasoning not possible in the deuteron problem?

Heitler discussed a simple theory of multiple meson production by high energy nucleons traversing nuclei. The energy spectrum of the cosmic ray primary nucleons is given. It is assumed that for each separate collision against a nucleon bound in the nucleus, only one meson is created, with an energy equal to a given fraction of the energy of the primary, as long as the latter energy lies above a certain critical value. About the same amount of energy is taken up by the recoil nucleon inside the nucleus. If this recoil energy is higher than the critical energy, this recoil nucleon also can start creating mesons.

Each primary traverses about two nuclei of the type considered before it slows down below the critical energy. The cross section for energy loss then decreases, and it will increase again at still lower energies, owing to ordinary scattering.

By use of statistics, the probability for creation of from 1 to over 30 mesons by one primary inside one single nucleus was calculated. The result is in nice agreement with experimental results obtained by counting the number of meson tracts in stars found in photographic emulsions.

D'Espagnat discussed the theory of meson production and compared it with the theory of Bremsstrahlung. He remarked that if a given fraction of energy goes into meson production in the center of gravity systems, this fraction is no longer constant in the laboratory system.

The last two days of the conference were used for reports on cosmic ray experiments and on the neutrinos.

The colloquium opened with a reception in the rooms of Unesco in Paris. It closed with a luncheon at the Cercle Interallié, where *Rosenfeld* expressed the gratitude of the foreign visitors for the excellent way in which this conference had been organized by the French hosts, and in particular by *Proca*.