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THIS collection of articles, devoted to Max Planck's birthday, is a good finish to the elapsed Planck Year with its Berlin festival and Leipzig congress of April 1958, and the sessions in various countries of the world. The foreword emphasizes correctly not only the scientific interest of the many articles, but also the moral significance of the get-together of scientists from both parts of Germany and scientists from eastern and western countries. At the same time, homage is paid to the memory of a great scientist and thinker, organizer of science, and humanist.

The collection contains more than 30 articles, devoted to classical physics and physical chemistry (10 articles), quantum theory (13 articles), and, finally, relativistic quantum theory and elementary particles (9 articles). Three articles are devoted to a philosophical analysis of quantum theory (N. Bohr, V. A. Fock, and L. Janossy).

We shall discuss briefly only several of the papers.

The collection opens with a long article by **G. Falkenhagen** (Rostock) devoted to an analysis of Planck's work on electrolytes and its further development. Leaning on the Arrhenius and Planck papers on ideal weak electrolytes, the author examines the theory of strong electrolytes and properties of solutions of high concentration, using illustrative models as well as statistical methods. He notes Planck's interest in electrolytes until his old age. In conclusion, the author emphasizes the importance of developing a theory of ionic conductivity as a function of the aggregate state. It must be considered, that a double mechanism of transfer of electricity is observed in electrolytes.

H. Hönl and **K. Westfahl** (Freiburg, West Germany) consider a diffraction theory, which is a development of the Kirchhoff's classical work. The integral equations for the case of plane screens are converted into singular integral equations; rigorous solutions are obtained for a half-plane, while asymptotic expansions are obtained in the case of a slit.

A. Rubinowicz (Warsaw) gives a mathematical and illustrative treatment of electric quadrupole and magnetic dipole radiation by considering a system that results from combining two dipole systems radiating antiparallel in directions. The quadrupole character of the Zeeman components is analyzed.

The foregoing three articles serve as a good example of the latest treatment of many classical problems.

H. Alfven (Stockholm) considers the timely problem of the mechanism of accelerating cosmic rays. It is proposed that charged particles can acquire an energy in alternating magnetic fields via the betatron (synchrotron) mechanism, taking into account scattering from small irregularities of the magnetic field. The accelerated particles diffuse in a magnetic field, which can be "frozen" in a medium of high conductivity. Its motion is connected with magnetohydrodynamic waves. Only particles with energies above a certain critical value are accelerated here, and consequently the injection process becomes important. The result is a cosmic-ray spectrum with an energy dependence in the form E^{-n}; the spectrum depends on a distance to the center of injection, while n ranges from 2 to 3 and depends little on the details of the theory. Alfven's theory, which he compares with the Fermi mechanism, agrees with the hypothesis of the "local" origin of cosmic rays (near the sun or inside the solar system), but is difficult to reconcile with the hypothesis of their galactic or extragalactic origin, in any case for particles with energies below 10^{14} electron volts. Particles of higher energy may originate, in the author's opinion, from supernovae, stars with variable magnetic moment, double stars, and colliding magnetic clouds.

V. A. Ambartsumyan (Byurakan Observatory, Armenian S.S.R.) considers the stellar association in the Perseus I Constellation and again states his arguments, which have attracted so much attention, in favor of the theory that the production of stars (the age of which is on the order of 15×10^6) continues to this day. He indicates the possibility of a latent stage in the lifetime of a future supergiant, in which the future star has a very low luminosity.

S. Chendrasekhar (Chicago, Enrico Fermi Nuclear Institute) gives a thermodynamic analysis of thermal instabilities in liquids. He considers a horizontal layer of liquid, heated from below, in which convection is produced. He gives a generalized variational treatment, which includes the influence of rotation and of the magnetic field.

L. Infeld (Warsaw) considers one of the forms of the variational principle of relativistic mechanics of a point, taking into account the additional condition which the velocity obeys, and applies this condition to motion in a field of a certain potential. He also considers the case of motion with the velocity of light.

C. Moller (Copenhagen, University Institute of Theoretical Physics and "Nordita," Nordisk Institut for teoretisk Atomfysik) considers in an interesting paper the problem of determining the energy of unclosed systems in general-relativity theory. Moller raises objections to the ordinary pseudotensor density

$$\theta_i^k = \sqrt{-g}\,(T_i^k + \vartheta_i^k),$$

which obeys the conservation law $\left(\frac{\partial \theta_i^k}{\partial x_k}\right) = 0$, where T_i^k is the energy-momentum tensor in the right half of Einstein's equations, and ϑ_i^k describes the gravitational portion), and indicates that this expression cannot be used to assign a definite meaning to the energy of any closed system, $\overline{E} = \int_\Omega \theta_4^4 (dx)^3$, for $\overline{E}$ turns out to be not invariant under purely-spatial transformations.

He proposes to introduce a new quantity G_i^k and to interpret T_4^4 as the energy density

$$T_i^k = X_{i,l}^{kl}; \text{ where } X_i^{kl} = \frac{\sqrt{-g}}{\varkappa}(g_{in,m} - g_{im,n})\, g^{km} g^{ln}.$$

To calculate the total energy of the system it is now no longer necessary to use quasi-Galilean coordinates. After calculating the energy of the gravitational waves, not in the approximation of a weak linearized field, but with the aid of any one of the two exact solutions of the field equations ("the only ones known to the author"), namely "the Bondi flat waves and the Einstein-Rosen cylindrical waves," Moller obtains a vanishing result for the gravitational radiation! True, the entire result was obtained for a field in the absence of ordinary matter. At the same time and for the same reason the problem of the possibility of the existence of gravitons becomes more acute. As is known, L. Infeld expressed himself against gravitational radiation, although many other authors, including (recently) Dirac, were in favor of the existence of real waves. Are the waves only "ripples" on the geometrical structure of space, or do they carry energy and can they be converted (in accordance with the hypothesis, which I touch upon in my own article in this collection) into ordinary matter — this problem acquires a particularly timely character in view of the ever tighter connection between physics and astronomy.

An article by **Dirac** is devoted to a general-relativity problem, specifically to the spinor equation in Riemann space. Emphasizing the convenience gained by treating his equation with Hermitian matrices (α, β), and not γ, Dirac, following the treatment used by V. A. Fock and myself,* introduces at each point a reference comprising four orthogonal vectors and, postulating invariance not only under general coordinate transformations, but also under arbitrary rotations of the references, leads to the general covariant form:

$$i h_a^\mu \alpha^a (\psi_\mu + 3K_\mu \psi) + \beta m \psi = 0$$

($K_\mu = \frac{1}{4} h_a^\nu h_b^\nu{}_\mu \alpha^a \beta_a^b$) ($h_a^\nu$ are the coefficients of transition from the coordinates to the components along the reference vectors); this is naturally equivalent to the previously-obtained general-covariant form of the spinor equation, expressed in terms of γ_ν.

A group of articles is devoted to statistical physics. **M. Sazaki** (Tokyo) gives a review of the development of relativistic hydrodynamics and kinetic theory of gases, taking Planck's paper of 1907 as the starting point.

A very elegant French paper by **L. Rosenfeld** (Copenhagen, "Nordita"), containing the text of a lecture delivered at Coimbra University (Portugal), is devoted to a statistical definition of entropy in Max Planck's work. After an informative historical analysis that touches upon the theory of radiation, statistics of gases, and the Nernst theorem the author examines successive variants of the definition of entropy and attempts of its absolute normalization in Planck's works, including

*See V. A. Fock and D. Ivanenko, Compt. rend. (Paris) 188, 1470 (1929) and the review paper by V. A. Fock, Z. Phys. 57, 261 (1929). Dirac indicates that it is easy to obtain from these the equation of the two-component neutrino in a gravitational field.

the trying argument concerning the factor N!, the discussion of the problem by Ehrenfest-Trkal, up to the modern concept of symmetry and the establishment of quantum statistics. At the end of the article Rosenfeld describes Planck, who reached atomism relatively lately, as a representative of a unique "formalistic" pragmatic position and almost positivistic idealistic understanding of statistical mechanics, like Gibbs, and contrasts this position with the materialistic frame of mind of Boltzmann and Ehrenfest. We cannot agree with this statement of Prof. L. Rosenfeld, who emphasizes at the same time the decisive struggle by Planck against neopositivists in defense of the reality of the outer world, since Planck in fact rapidly "overtook" Boltzmann, for example, in his final and fully exemplary acknowledgement and application of atomism.

K. F. Novobatskiĭ (G. Eotvos University, Budapest) considers the statistics of gas and of radiation from a new point of view and leads to a treatment of superfluidity in the spirit of the Tissa theory.

P. Caldirola and **A. Loindjer** (Physics Institute of the Universities of Milan and Pavia) analyze in their fundamental paper the development of the ergodic approach in statistical mechanics in connection with the work by Neumann, Birkhoff, Rosenfeld, Prigozhin, and particularly Van-Hove.

P. Gombas (Physics Institute, Technical University, Budapest) considers with his customary clarity, using experimental material, the equation of state for a substance under high pressure, using as a base the Thomas-Fermi-Dirac statistical atomic model with the Weizsaecker correction.

F. Zwicky (Mount Wilson and Mount Palomar Observatories, Carnegie Institution, Washington; California Technical Institute, Pasadena) treats the problem of supercompressed state of matter with nuclear density. Since ordinary nuclear reactions in stars do not explain the supernova and other explosions at which energies of $10^{26} - 10^{50}$ ergs are emitted for several hours or even seconds, it is proposed to make use of gravitation. It appears that matter of nuclear density (10^{13} g/cm^3), fully compressed by gravitation, is in the most stable thermodynamic state. The most important case is given by masses of solar order of magnitude, a neutron star (with a radius of ~ 1 km), and a "baby" with mass $\sim 10^{21}$ gram and a radius of ~ 3 meters.

The transition of a normal star into the neutron state may explain the phenomenon of supernovae; on the other hand, nuclear "babies" which can move inside a star, may give the answer to the problem of liberation of explosion-type energy in normal stars.

Ivan Zupec (P. Boscovic Physics Institute, Zagreb) adhering to Bloch's theory, discusses in detail the differential equation of electric conductivity in metals at low temperatures.

H. Fröhlich (Liverpool University) considers the phenomenological theory of energy losses of fast particles in solids, characterizing the latter by means of a complex dielectric constant, which depends on the frequency and on the wave vector; it becomes possible to analyze the energy levels in a solid by studying the influence of the Coulomb field of the particles.

O. Scherzer (Institute of Theoretical Physics, Higher Technical School, Darmstadt, West Germmany) considers the interference of incoherently scattered electrons in the case when initially coherent electrons experience inelastic scattering by the same atom.

D. I. Blokhintsev (Joint Institute for Nuclear Research, Dubna) analyzes the important problem of the structure of an elementary particle with the aid of scattering of other particles from it. He criticizes nonlocal theories, which in the case of large energies lead to a weak interaction rather than to a strong one, in contradiction to experiment. A relativistically-invariant definition of the "black sphere" is given.

A. A. Sokolov (Moscow State University) considering particles with oriented spin, gives a new treatment of the urgent problem of parity. Parity nonconservation is treated in connection with the choice of a definite orientation of the neutrino spin regardless of the properties of spatial reflections. The polarization of β electrons is explained in agreement with experiment. Only neutrino processes are dealt with.

Linus Pauling (California Institute of Technology, Pasadena) gives a survey of quantum chemistry, emphasizing the understanding reached here of the classical structural theory and the importance of the idea of resonance. Chemical resonance, in the words of the author, permits explaining such circumstances as the one- or three-electron bond, hyperbond, and resonance of molecules between different structures. Notice is taken of the severe criticism that the theory of resonance has been subjected to in quantum chemistry, which has operated with structures that actually have no independent existence.

Pauling emphasizes that resonance theory in chemistry is used in fields where there are no exact quantum calculations and that it is based essentially "on an empirical (inductive) basis."

The paper contains no literature references, in spite of the obvious influence of the discussions with Soviet scientists on resonance.

Jan Weissenhoff (Krakow, Jagiellonian University) gives a survey of papers devoted to the classical non-quantum treatment of spin, indicating that in spite of the progress in quantum theory, it has been found difficult to combine it with relativism and to construct a particle theory. Developing the Einstein-Grommer ideas on the derivation of equations of motion from nonlinear equations of the gravitational field, Matisson did not confine himself to poles only, but took into account the motion of singularities such as dipoles or multipoles. This problem is connected with the possible existence of negative mass (see the work by Lubanskiĭ, Hönl, Papapetrou, and Nagy). In Weissenhoff's opinion, classical equations similar to those of Dirac are obtained in the dipole approximation. The additional condition $S_{\mu\nu}u^{\nu} = 0$ (where $S_{\mu\nu}$ is the spin bivector and u is the 4-velocity) is analyzed. The theory of spinor continuous media or liquids, having an intrinsic (spin) momentum density, is close to the work of Bohm-Vigier-Takabayashi, and their associates. Written in broad calm outlines, the article urges attention to the curious nonlinear analogies with the Dirac theory in spite of the known absence of any real results among the adherents of such an "antiquantum" trend.

Among papers that go outside the framework of ordinary theory is an interesting article by **E. R. Cajaniello** (Institute of Theoretical Physics, Naples University), who considers the ultraviolet divergences in quantum field theory and concludes that the divergences are connected with the methods of the mathematical treatment. Upon suitable modification of the concept of the integral, the divergences are eliminated. In other words, the author's method of integration is tantamount to renormalization. In the author's opinion, the series used in quantum electrodynamics, for example, are convergent.

Another paper outside the scope of the usually accepted theory is by **Maria Schoenberg** (Faculty of Philosophy, Science, and Literature, San Paolo, Brazil) devoted to geometrization of quantum physics. The author attempts to find geometric analogues (point, vector, sphere) of the momentum, spin, commutation relations, iso-spin, etc., leaning on the geometry of spheres, since the inhomogeneous Lorentz group is isomorphous with the Laguerre group of spherical geometry. The article contains many interesting remarks, although the interactions of fields are not taken into account and no mention is made of specific results.

My own paper, devoted to "Remarks on Nonlinear Theory" of matter, is devoted essentially to many new results by A. M. Brodskiĭ, M. M. Mirianashvili, and D. F. Kurgelaidze; emphasis is placed, primarily, on the desirability of considering not only ordinary spinors, but also "pseudospinors," the transformation equations of which under reflection (either of time or of space) contain an additional pseudo-scalar factor γ_5 and "mixed" spinors, which transform normally (in a pseudo spinor manner) only under spatial (time) reflections. This gives rise to the anomalous Gel'fand-Tsetlin commutation rules $PT = +TP$ instead of the ordinary ones ($PT = -PT$). Similar anomalous spinors, and the bosons obtained from them and from the Yang-Tiomno spinors, should be taken in consideration when constructing a general theory of particles. Many results that give induced nonlinear additions to the Dirac equations and other equations are listed.

The exact wave and radial solutions are indicated for the nonlinear Klein-Gordon equation with the term $\lambda\varphi^3$ in the form of an elliptic cosine. We emphasize the convenience of introducing an 8-component spinor ($i\psi$, $\gamma_5\psi^c$) and an auxiliary space of 6 dimensions (4 ordinary and 2 isotopic).

We have attempted to proceed toward a formulation of a nonlinear theory of matter, based on generalization of the spinor equation by means of the term of type ψ^3, previously introduced by us, in the development of which such interesting results were obtained by Heisenberg. The objections raised by Pauli against the Heisenberg quantization rules, with an indefinite metric in Hilbert space, emphasize the difficulties that stand in the way of so tremendous a problem as the construction of a unified theory of matter, but do not nullify the likelihood of the nonlinear program. In fact only spinors can serve as a basis of a unified theory, and since the field interacts with itself, its equation should be nonlinear! "All that remains" (sic!) is to find the rules of quantization.

G. Heber (Jena) discusses the rules of commutation between the field intensities and the coordinates, indicating, from his viewpoint, the presence of similar "individual" (according to our own terminology) errors, generalizing the relations for canonical, paired, and Heisenberg errors, and interrelating the field intensities. Matters will be the same in nonlocal theory. The Hilbert space is analyzed.

An attempt at going outside the framework of existing field theory is discussed by **J. L. Detouche** (Institute A. Poincare, Paris), who introduces the concept of "functional" model of a non-point-like particle, in which a certain function u, characterizing the internal features of the particle, degenerates into a description of the spin or iso-spin only in the case when u is converted into a finite set u_i. Developing previous papers, close to many ideas of de Broglie, the author indicates many analogies with nonlinear theory of matter, without reaching, incidentally, any specific results.

In a paper written with the usual clarity and brilliance ("Max Planck's Great Discovery, the Mysterious Constant h") **de Broglie** notes various stages in the meaning of h: the quantum of energy and quantum of action, the quantum of light, and "the connecting link" between the wave and corpuscular properties. He cites here a little-known remark by Boltzmann who noted, in discussion with Planck, the impossibility of constructing a statistical theory of radiation without introducing discontinuities. De Broglie notes that this remark, by a scientist whom Planck treated with particular respect, probably played a great role in the preparation for his great discovery. In the words of the famous author, quantum physics has assumed a very abstract aspect during the last 25 years. "Taking a point of view close to the energy school of the end of the 19th century," writes de Broglie, "the present quantum theory establishes wave equations with terms containing Planck's constant and considers them simply as justified by the success in explaining experimental factors, completely dispensing with developing a concrete model of the wave-corpuscle dualism." In this way quantum mechanics is limited to stating the role played by h, but refuses to interpret the latter. Yet, along with brilliant successes, there are also serious difficulties as manifest in the divergences, and entirely new ideas are necessary. In de Broglie's opinion, it is necessary to develop a nonlinear theory whereby particles are extended formations, in which the wave field reaches very large values, with h entering into the nonlinear term, thus helping to explain the connection between the corpuscular and wave aspects.

The fact that many searches for new paths lead towards the nonlinear generalization from various directions is of great significance.

A short article that will be received with interest is one by **Niels Bohr** "On the Philosophical Problems of Quantum Physics," already translated from a manuscript copy by V. A. Fock (see Usp. Fiz. Nauk, Volume **67**, 208 (1959); Soviet Phys. Uspekhi 2, 599 (1959). After a brief review of the principles of classical physics (deterministic description in mechanics, electrodynamics, and theory of relativity), and after indicating the statistical character of the laws of quantum theory, the article emphasizes (in accordance with previous statements by Nils Bohr in the spirit of the Copenhagen school) the fundamental difference between the classical instrument and the investigated object. Here the interaction between the object and the instrument, according to Bohr, becomes in quantum physics the "inseparable part of the phenomenon." Again Bohr emphasizes the principal impossibility of a deterministic description. What is new, as we see it, is the repeated statement, in several forms, that "the description of the experimental setup and registration of the results of observation should occur with the aid of ordinary language, refined in a suitable manner in accordance with physical terminology. This is a simple logical requirement, since the word experiment alone may denote a procedure, in which we are capable of reporting someone what has been done and what has been learned." Bohr points out the "fully objective character of the description of atomic phenomena, in that sense that there is no explicit mention of an individual observer," and that in reporting the results of the experiment there is no ambiguity whatever. Again he emphasizes the unique character of complementarity, in which results obtained in quantum physics in the investigation of a given object with the aid of various instruments are found related to each other. As to the Heisenberg relations, we deal here, in Bohr's words, "not with the limitation and the accuracy of measurements, but with a limitation on the limits of applicability of both the description in space-time, and of the laws of conservation, this being caused by the necessity of distinguishing between the measuring instruments and the atomic objects." New notes are sounded in the statement that "the use of expressions of the type 'distortion of the phenomenon due to the observer' or 'attributing physical qualities to atomic objects by measurement' are hardly compatible with the usually employed language (Umgangssprache) and with a practical definition." Bohr reacts unfavorably to multi-valued logic (that of Weizsaecker, Detouche, and others) and assumes that it is possible to get along completely with the generally accepted language and ordinary logic. In conclusion, warning against distorting his ideas, Bohr indicates that from the general-philosophical point of view it is important to note the presence of analogies, that require typical expressions in the sense of a complimentarity not only in quantum physics, but also in other fields, for example, when investigating the "wholeness of living organism, characteristic features of conscious individuals and of cultural societies."

This difficult (in our opinion) article by one of the most outstanding physicists of the 20th century will undoubtedly be the subject of many discussions.

The next article of philosophical character is that by V. A. Fock "On the Interpretation of Quantum Mechanics" (see Usp. Fiz. Nauk, Vol. 62, No. 4, August 1957). It is possible to agree with the author's opinion, who emphasizes the confusion of terminology in the articles by N. Bohr. Confining himself only to nonrelativistic quantum mechanics, Fock interprets it in the spirit of statistical treatment, noting correctly that "the success of quantum mechanics will undoubtedly contribute to the development of dialectic materialism." Attempts of the de Broglie school to go outside the framework of the present theory are decisively refuted by Fock, who does not mention the nonlinear program and other widely-discussed attempts.

In the final article of the collection, **L. Janossy** (Budapest, Central Physics Institute of the Academy of Sciences) analyzes Planck's philosophical outlook in the light of modern physics, with emphasis on his polemics with Machism, unconditional acknowledgement of the reality of the external world, and Planck's closeness to materialism, the dialectic one at that, according to the author. The author points out the unfavorable opinion in which Planck (along with Einstein, de Broglie, and Janossy himself) held the "orthodox" indeterministic (i.e., the Copenhagen) treatment of quantum theory. We note that although, unlike Janossy, we hold to the statistical interpretation of quantum theory, we also consider it necessary to go far outside its scope in the case relativistic quantum theory of elementary particles.

We thus have in front of us a rich collection, full of new results and profound ideas, which give a great impetus to progress in science and to new principal discussions. Many of these articles should be translated into Russian.

Translated by J. G. Adashko