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Meetings and Conferences

PLANCK CELEBRATIONS IN BERLIN AND LEIPZIG

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AT the end of April of this year the physicists of the whole world celebrated the hundredth anniversary of the birth of the outstanding theoretician and thinker, the founder of quantum theory, Max Planck. The German Academy of Sciences in Berlin (German Democratic Republic), the Physics Society of the German Democratic Republic, and the Union of Physics Societies of the German Federal Republic have organized on this occasion a joint celebration in Berlin on April 23 and 24. Timed with these was the annual Congress of Physicists of the German Democratic Republic and a theoretical conference held in Leipzig (April 27-30). Participating in the Planck anniversary congress and the Leipzig conference was a Soviet delegation, headed by N. N. Bogolyubov, and comprising, in addition to the author of this article, S. A. Azimov, A. F. Ioffe, A. V. Ioffe, G. P. Keres, V. I. Mamasakhlisov, A. B. Migdal, G. I. Rakhmaninov (secretary of the delegation), A. A. Smirnov, B. I. Stepanov, and Zh. S. Takibaev. In addition to participating in this congress, the members of our delegation inspected the Physics Institutes and delivered several scientific and popular papers.

In attendance at the anniversary celebrations, the congress, and the conferences were the entire membership of the physicists of the German Democratic Republic headed by Nobel laureate Gustav Hertz, the Director of the Physics Institute of the Leipzig University; R. Rompe, Secretary of the Division of Mathematics, Physics, and Engineering of the German Academy of Sciences (German Democratic Republic); Professor Barwich, Director of the Dresden Nuclear Center; Professor Herlich, Scientific Director of the Zeiss Enterprises, and others.

Of general interest was the extensive representation on the part of physicists from the German Federal Republic, including Nobel laureates W. Heisenberg, M. Laue, M. Born, O. Hahn, and also the outstanding theoreticians Hund, Bopp Hönl, Sauter, and Bagge. It was also pleasant to meet at the congress our close friends, physicists from China (Hu Ning) Poland (L. Infeld, W. Rubinowicz, and others) Hungary (L. Janossy, Budo), Bulgaria (Datsev), Rumania (Titeica).

Western science was represented by Nobel laureate P. A. M. Dirac (England), H. Møller (Denmark), Lise Meitner (Sweden), Nobel laureate J. Frank, V. Weiskopf, R. Courant (U.S.A.) and others. France was represented by a delegation comprising Prof. Bauer, Prof. J. P. Vigier, Professor M. A. Tonnela, and Dr. Kahan. Twelve countries were represented in Berlin.

The Planck celebrations were held in East Berlin on April 23 and in West Berlin on April 24. In the German Democratic Republic they had a national and state character. They were extensively covered in the national, local, and student press, and also on radio and television. The Peoples Parliament sent a special message to the Physics Society. The central organ "Neues Deutschland" carried a message from the Central Committee of the United Socialist Party of Germany. W. Ulbricht and Otto Grotewohl attended the celebration reception, held at the State Opera House.

An imposing session, which was broadcast, was organized in West Berlin by the Physics societies of the Federal Republic in the recently remodeled 1700-seat House of Congress. The press of various western countries paid considerable attention to the Planck anniversary. We note that the U.S.S.R. Academy of Sciences held a special session in Moscow in Planck's honor, and that scientific gatherings took place at Moscow and Tbilisi Universities and other Soviet scientific institutions.

Such a tremendous attention to the Planck anniversary is quite understandable, since Max Planck's discovery of the quantum of action and the formulation of the principles of the quantum theory of radiation was a momentous accomplishment, which opened the road to the recognition of atomic and nuclear phenomena and their further application. Furthermore, Planck stands before us as a deep thinker, who did not confine himself to the solution of individual problems, no matter how important, but attempted to interpret the entire structure of physical science, and led the struggle against the "Machistic" positivistic tendencies. Planck's extensive organizational and pedagogical activity is also well known. Finally, in our time, when humanity is threatened by atomic war, physicists and all men of good will cannot fail to be impressed by his passionate appeal for the utilization of the forces of nature only for the good of humanity, an appeal he voiced shortly before his death, frequently recalled in the speeches at the celebration.

Before proceeding to a more detailed description of the Planck celebration, it is appropriate to cite briefly some biographical highlights.

Max Planck was born on April 23, 1858 in Kiel, to a family with a long tradition of interest in science. From 1875 to 1877 he studied at the Munich University. It is known that Planck hesitated before choosing a profession for his interest in music was very great. Lise Meitner recalled in her address that Planck devoted much of his leisure time to music, gathering about him a large circle of scientists. Professor Westfahl recalled one remarkable home concert, in which pianist Planck and violinist Einstein were joined by singer Otto Hahn. In 1878 Planck attended lectures by Kirchhoff, Helmholtz, and Weierstrass in Berlin. In his memoirs, which were recently made available in Russian translation (see Usp. Fiz. Nauk, **64**, No. 4, April 1958) Planck notes that the courses in theoretical physics were not as useful as one might expect from the famous lecturers: Kirchhoff read, rather too glibly, a written text; to the contrary, Helmholtz, who prepared little for his lectures, was endlessly confused at the blackboard. Later on Planck struck up a deep friendship with Helmholtz, who was instrumental to the young scientist's being invited to join the Berlin University after Kirchhoff's death in the middle of 1892. In the preceding years, Planck's principal interests, starting with his doctoral dissertation (equivalent to the Soviet candidate dissertation) of 1879 ("Equilibrium State of Isotropic Bodies") were in the field of thermodynamics. Planck's early works, akin to physical chemistry, attracted no particular attention in science. Planck himself recalled that Clausius answered none of his scientific letters. The first decade of his professorship at Berlin was the blossoming time of Planck's creativity. Keeping close contact with experimenters who investigated the properties of equilibrium electromagnetic radiation at various temperatures, Planck announced his famous formula and soon derived it by introducing the quantum of action. Planck first lectured on his formula on October 19, 1900, at the session of the German Physical Society, as recalled with justified pride by Professor F. Trendelenburg, present President of the Union of West-German Physical Societies.

Planck's subsequent scientific activity was connected with the justification of the fundamental relations he derived and an analysis of the new world constant, with various problems in statistical physics, and also with the newly created relativistic mechanics. Planck himself understood the tremendous significance of his discovery. In his Nobel prize address and in many other speeches and articles he frequently returned to the arguments that led to the discovery of the quantum of action. Together with his autobiography, these papers by Planck represent material of exceeding value to the history of science and to the psychology of scientific creativity. In Berlin, Planck went through all stages of an advanced scientific career. In 1903-1904 he has the Dean of the so-called Faculty of Philosophy (which included the physical-mathematical division), and in October 1913 he was chosen Rector of the Berlin University. In 1926 Planck retired but continued to lecture, conduct seminars, and deliver numerous papers on general scientific themes. As is well known, Planck was not only an outstanding scientist, but a first-class teacher. He wrote a valuable text on theoretical physics, which was also translated into Russian. Along with his work at the university, Planck was active in the Berlin (then the "Prussian") Academy of Sciences to which he was elected in 1894, nominated by Helmholtz, Kundt, and Betzold. For 26 years he was the secretary of the Natural Science and Mathematics Division of the Academy. Planck was among those responsible for inviting Einstein to Berlin and for his election to the Academy, and was one of Einstein's close friends.

It must be emphasized that Planck was one of the outstanding scientific organizers not only within the framework of the university and the academy, but also as the President of the Kaiser Willhelm Society. This society, thanks to its relations with industry, included the better scientific centers of Germany. In its time the society included the Institutes of Otto Hahn, W. Heisenberg, and others. At the present time the society, which has been renamed after Max Planck, continues its activity in West Germany. One of the focal spots of the Berlin celebrations was the presentation of a bust of Planck to Otto Hahn, present President of the Max Planck Society, from the Academy of Sciences (German Democratic Republic) at the session held in the eastern sector of Berlin. The audience, who saw in this act a gesture of unity of scientists of both parts of Germany on the basis of Planck's humanistic legacy, reacted to this with a loud ovation.

Along with the scientific and organizational activity, mention must be made of Planck's work on the philosophy and history of physics. His struggle against the "Machistic" positivism, which was popular among many scientists at the end of the 19th century, is well known. Planck's services in the establishment of atomism are tremendous. He succeeded, in particular, in deriving on the basis of his formula the then best value, of the electronic charge 4.59×10^{-10}, which is quite close to the present-day value 4.80×10^{-10}, instead of the experimental $(6.15 \pm 1.5) \times 10^{-10}$, obtained by the better experimenters of that time. A recollection of this fact in the lively paper by Gustav Hertz, devoted to the experimental foundations of quantum theory, incited a heated reaction in the audience at the celebration session in West Berlin.

Many features of Planck's personality were outlined in beautiful addresses by Lise Meitner, at the relatively restricted session in the small hall of the Physics Society in Berlin, and by Professor W. Westfahl at the session in West Berlin. Along with his love for music, Planck was to his last days a passionate sportsman, interested in skiing, mountain climbing, and systematic long hikes. Lise Meitner spoke of an impression of a certain dryness and reserve that Planck exhibited at first acquaintance, and compared it to the live and jovial Boltzmann whose lectures she attended in Vienna before she began working in Berlin, first with Planck and then with Hahn. For all that, his closer friends found Planck to be a soft, responsive person of very high ethical principles. Meitner dwelled also in sufficient detail on the unique, nearly pantheistic religious feelings of Planck, quoting by Goethe on this topic.*

The last years of Max Planck's life were clouded by the coming to power of the Fascist Regime and by the second world war. In the speeches at the celebration sessions, H. Fruehauf, Vice-President of the Academy of Sciences (German Democratic Republic) and Lise Meitner touched in detail on Max Planck's manly and noble behavior during these difficult years. Planck's first son was killed in Verdun in the first world war. At that time Planck, not succumbing to the chauvinism that infected the country and many scientists, proposed to delay the expulsion of the French members of the Academy until after the war. His second son, a general, was executed in January 1945 for his participation in the anti-Hitler conspiracy. Planck's house in Berlin-Grünewald was destroyed by bombs, and Planck himself was saved during one of the air attacks from a buried shelter in Kassel.

Planck died in Göttinger on October 4, 1947. His words on the "danger of self-destruction that threatens all humanity should atomic bombs be used in considerable quantities in the next war" serves as a call to all men of goodwill.

Let us now dwell on some high spots of the Planck celebrations.

As already mentioned, they began in a session in the rebuilt opera house in Unter den Linden. The program included the greetings by the M. Vollmer, President of the Academy of Sciences (German Democratic Republic), a speech by H. Fruehauf on Planck's activity as the permanent secretary of the Academy, a paper by M. Laue on Planck's scientific work, and the presentation of a bust to O. Hahn. This was followed by a session of the Physics Society in the historical building in Kupfergraben, in which Magnus founded in 1842 the first physics institute in Germany, where Kirchhoff, Helmholtz, Dubois Raymond, Warburg, and many other great scientists worked. It was visited by many Russian physicists of the 19th century,— Umov, Golitsyn, and Lebedev. In the name of the City Council of Greater Berlin, Mayor Ebert transferred this building to the Physics Society of the German Democratic Republic. A. F. Ioffe, warmly greeted by the audience, transferred to the Society Planck's personal library, which was in safekeeping the the Soviet Union. As already mentioned, Lise Meitner delivered at this session her stirring recollections of Planck. This was followed by the celebration reception and banquet in the Apollo Hall of the State Opera, where greetings were read from the Academy of Sciences of the U.S.S.R. (N. N. Bogolyubov), the Royal Society (P. A. Dirac), the Academy of Sciences of the U.S.A. (V. Weisskopf), and other scientific institutions of Germany and foreign countries.

The crowded first day of the Planck celebration, which was the central one, concluded with the delegates attending Gluck's "Iphigenia in Aulis."

On the morning of the next day, April 25th, a celebration in the honor of Planck was held in the Humboldt Berlin University, at which a concert was given (Bach's Brandenburg Concerto No. 1 and the first part of a Mozart quartet), and which concluded with the unveiling of a memorial plaque. The rector and professors of the university paraded in academic procession.

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* It is interesting to note in this connection that W. Heisenberg, who lectured on April 28 in Kotbus (German Democratic Republic), at the invitation of the local Lutheran Society, on the ethical consequences of modern atomic physics, emphasized the need of unification of humanity on the basis of peaceful utilization of nuclear energy and other scientific accomplishments and indicated the similarity between such views and Christian morality. Apparently traditions of a unique religious feeling, in part pantheistic, in part of the Lutheran type, are in general quite strong in certain circles of the German intelligentsia.

Simultaneously, in one of the auditoria of the West Berlin so-called "free university," under the chairmanship of Professor Ludwig, a theoretical seminar was held at which Heisenberg answered many questions, submitted beforehand, on the development of nonlinear field theory.

The focal point of the celebrations during the second half of this day was in West Berlin, at a session consisting of the an introductory address, by the Chairman of the Union of the Physical Societies of West Germany, F. Trendelenburg (Erlangen), a lecture by Gustav Hertz (Leipzig) on the significance of the Planck theory to experimental physics, a lecture by W. Heisenberg (Göttingen) on the discoveries of Planck and philosophical problems of atomic theory, and a speech by W. Westfahl (West Berlin) on Planck as a person. At the start and the end of the session the symphony orchestra performed Planck's favorite compositions (Bach's Brandenburg Concerto No. 3 and Mozart's Adagio and Fugue in C Minor).

As is known, Laue, Heisenberg, Born, and Hahn headed the list of 17 German scientists of West Germany, who addressed an appeal for peaceful use of atomic energy and who refused to participate in military nuclear research. Shortly before the congress Laue made a similar appeal at one of the sessions in West Berlin, while Born did the same in Hameln. These appeals were also supported by the Union of Physics Societies.

Among the papers delivered during the Planck celebrations in Berlin, one that attracted much attention was W. Heisenberg's "Planck's Discovery and the Principal Problems of Atomic Theory," very interesting and full of deep yet controversial ideas.*

We do not plan here a critical analysis of Heisenberg's paper, and restrict ourselves only to a few remarks. What is curious is Heisenberg's refutation of orthodox "Machism" and positivism. Yet Heisenberg's emphasis of the advantages of Platonism and of the preeminence of form and symmetry laws is not convincing. In the final analysis, some sort of invariance requirement (symmetry) must be obeyed by the equation of motion of any primary matter, in this case spinor matter, although naturally one cannot exclude the appearance of new invariance requirements, which can change the equation somewhat and modify it, for example, by including the iso-group. What is surprising is the silence concerning Planck's negative approach to "Machism" and the absence of any mention of the modern philosophy of dialectic materialism in connection with quantum theory, in spite of Heisenberg's sufficiently complete coverage of the entire history of philosophy.

On the whole, the two days of the Berlin Planck celebrations must be considered as a perfectly organized international congress, the scientific, moral, and political significance of which will undoubtedly be noted in the annals of the scientific events of our time.

Let us now proceed to the Leipzig congress of the Physics Society of the German Democratic Republic and the associated Theoretical Conference. The congress opened on Sunday morning, April 27, in the magnificent auditorium of the recently constructed Physics Institute of the Karl Marx University. The auditorium, with 450 seats, was filled with delegates and students, who broke through the cordons of ushers. After the greetings by the rector, the floor was turned over to Heisenberg, who was greeted with a noisy ovation. The warmth of the greetings was due not only to the universally known value of Heisenberg's work and his position in the struggle for peace, but also in recollection of Heisenberg's many years of service as professor at Leipzig in the thirties. Heisenberg himself began his lecture with remarks on his pleasure of finding himself again in the reconstructed Physics Institute of the University, where he worked earlier and where he now meets many of his colleagues.

In his long paper Heisenberg expounded on the principal ideas and advances of unified nonlinear theory of matter. The present communication differed from an analogous paper delivered to the congress in Venice in October 1957 in the considerable assurance of success, owing to the inclusion of the iso-spin group, developed in 1957-1958 jointly with Pauli. At the same time, Heisenberg noted the existence of differences of opinion with Pauli and warned that the theory is far from complete and that many difficult and unexplained points are contained in it. As is known, news of the success of the nonlinear theory has produced in the past winter a unique sensation among physicists of the whole world, along with exaggerated hopes voiced in the periodical and popular press.

Let us summarize the principal premises of this paper, which was the central point of the whole session. The fundamental difficulties in the reconciliation between relativism and quantum theory is seen by Heisenberg to lie in the presence of a sharp boundary between the past and the future (light cone), called for by the theory of relativity, while the quantum uncertainty principle speak against the possibility of such a sharp boundary. As is known, many methods have been proposed to eliminate

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*A translation of this paper was printed in Usp. Fiz. Nauk, Vol. 66, No. 2 (–Ed.)

these divergences: the introduction of various cutoff multipliers, a change to non-local field theory, nonlinear generalization of the field theory, quantization of space-time, and a few others. All these mean essentially a departure outside the framework of ordinary relativistic quantum theory. It appeared at one time that the divergencies which manifest themselves in the singularity of the Greenians on the light cone could be eliminated in some manner by renormalization. However, Kallen and Lehmann (1952-1954) have proved, on the basis of quite general premises, that the divergence of renormalized Greenians cannot be lower than the singularity of the Green's functions of the free field. At the same time the Kallen-Lehmann theorem has proved it impossible to eliminate the divergence with the aid of the renormalization method. Along with the impossibility of obtaining finite values of field masses and field charges of particles, a weak spot in the ordinary theory was, until recently, the absence of a unified description of elementary particles. Such a situation has indicated the desirability of reviewing the most fundamental premises of the theory.

By way of a solution to all these difficulties, many authors have proposed that the nonlinear spinor equation be made the basis of the field theory. As indicated many times, Heisenberg and his associates were able to attain most noticeable successes in this direction. First, the reciprocal transformation of the particles clearly indicates that they are excited states of some general substance. In accordance with the arguments of de Broglie, the simplest basic field, from which it is possible to construct all the others, should be a spinor field of Dirac particles with spin $s = \frac{1}{2}$. Actually, by combining spinors, it is possible to obtain wave functions with spin 0, 1, etc., while it is impossible to obtain "rotating" particles from the "non-rotating" Klein-Gordon spin-zero particles, although they are describable by a simpler single-component function. A clear example of the method of "joining" is the idea of construction of the neutrino theory of light by de Broglie (developed by Kronig, Jordan, A. A. Sokolov, and others). Progressing in a similar direction were the ideas of the models of complex particles (Fermi-Yang, Sakata, Mackey, M. A. Markov, Goldhaber, and others). By using nucleons, anti-nucleons, and hyperons as a base, it is possible to attempt to construct from these the pions, K mesons, and other particles. If we generalize these ideas and adopt the point of view of a unified theory, then, obviously, its base should be some sort of nonlinear generalization of the Dirac equation. In fact, to yield excited states, the fundamental world spinor field should interact with something, but in the unified theory it can interact only with itself! Later on we, jointly with A. M. Brodskiĭ, established the form of all possible nonlinear generalizations of Dirac's equation, not including the derivatives, on which Heisenberg indeed leans in his paper. Then, taking into account the invariance under Pauli and Salam-Touschek transformations (from the neutrino theory), Heisenberg arrives at the Lagrangian

$$L_{NL} = \psi^{*}\gamma_{\nu}\frac{\partial}{\partial x_{\nu}}\psi \pm \frac{l^{2}}{2}\sum_{\mu}(\psi^{*}\gamma_{\mu}\gamma_{5}\psi)^{2}$$

from which he obtains the fundamental nonlinear spinor equation of matter

$$\gamma_{\mu}\partial_{\mu}\psi \pm l^{2}(\overline{\psi}\gamma_{5}\gamma_{\nu}\psi)\gamma_{5}\gamma_{\nu}\psi = 0$$

(the matrices γ_5 and γ_ν were absent from the original nonlinear term).

After establishing the fundamental nonlinear equation, it is necessary to consider the rules of quantization of the field. In this connection Heisenberg made a very bold and original step, by modifying the commutation rules through introducing a Dirac indefinite metric in Hilbert space so that these equations come into agreement with the new nonlinear equation. In this way Heisenberg hopes to eliminate simultaneously the infinities from the field theory, since now the new relations for anticommutation no longer give functions on the light cone, but simply vanish there. Heisenberg indicates that the indefinite metric of the Hilbert space II, which supplements the usual Hilbert space I, leads only to unobservable intermediate states. As noted by Heisenberg, the concept of probability will apparently be to some extent "supplementary" to the space-time description at very small distances (where the Hilbert II manifests itself). Undoubtedly, analysis of the new rules of quantization will require much more effort! Given a basic nonlinear spinor equation and new quantization rules, we can in principle, solve any problem.

Among the results of Heisenberg and his associates, let us recall their derivation of the fermion state with mass $k = 7.426/l$ (where $k = Mc/h$), determined by the interaction constant (when the calculations are made with the new nonlinear term, the coefficient is 7.08 in the first approximation and 6.67 in the second approximation)

$$\lambda = h'cl^{2}$$

and several excited states with masses

$$\begin{array}{rcccc} \varkappa = & 0.33, & 0.95, & 1.74, & 3.32 \\ \text{spin } s = & 1, & 0, & 0, & 0 \\ \text{parity } \eta = & -1, & +1, & -1, & +1 \end{array}$$

the new calculations gave for the meson masses values that are very sensitive to the choice of the nucleon mass. It became also possible to obtain a value for the fine-structure constant in the form

$$\alpha = \frac{2\pi e^2}{hc} \cong \frac{1}{267}.$$

A variant of the approximate Tamm-Dancoff method was used in this case.

Among the new results of the Heisenberg version of the nonlinear spinor theory, let us emphasize the interpretation of the iso-spin (I), the strangeness $S = l - l_N$, the hypercharge or the iso-fermion number l, and the lepton number (l_N) $(Q = I_3 + \frac{1}{2})$. In this case the following conservation laws take place:

I_3 is conserved in modulo 2 l is conserved in modulo 4 I_N and l_N are conserved without limitation	in the "electric" approximation (thus predicting the decay of Λ_0 into 4n, owing to electromagnetic forces).

For weak interactions: I_N is conserved in modulo 2 and l_N is conserved in modulo 4.

In the final analysis we obtain a classification for all the known elementary particles in the following form:

Nucleons $(p, n, \bar{p}, \bar{n})$:	$\Psi^+\Omega$, where Ω is a function of the vacuum state);
Leptons $(\bar{e}, \nu, \bar{\nu}, e_+)$:	$\Psi^+\Omega$ (lepton masses are zero if electromagnetic forces are neglected);
Pions (π^+, π^0, π^-):	$\Psi\Psi^+\Omega$;
Hyperons $(\Lambda_0, \Sigma^+, \Sigma^0, \Sigma^-)$:	$\Psi\Psi^+\Psi^+\Omega$;
Cascade hyperons (Ξ^-, Ξ^0):	$\Psi\Psi^+\Psi\Psi^+\Psi\,\Omega$;
Heavy mesons $(K^+, K^0, K^-, \bar{K}^0)$:	$\Psi\Psi^+\Psi\Psi^+\Omega$;
Light mesons (muons) (μ^+, μ^-):	$\Psi\Psi^+\Psi^+\Omega$;
Photons (γ):	$\Psi\Psi^+\Omega$.

Analogies with the Fermi-Yang and other models of complex particles are easily seen here. In spite of the convincing general arguments in favor of the nonlinear spinor equation as the basis of a unified description of matter, and of the undoubted successes of the Heisenberg version, based on the new quantization rules and on the alluring prospect of obtaining all particles, charges, and all coupling constants from a single theory, we naturally cannot yet speak of a closed formalism. What is striking is the absence of any exact agreement with experiment in the values of the masses and charges. Later on, several specific objections to particular points were presented. Fierz believes that the violation of causality in the smallest regions near the light cone should involve a violation of the same principle at large distances and that, independent of the character of the metric in the Hilbert space, new anti-commutation rules lead to a contradiction with causality. Pauli, who again departed from the nonlinear theory, judging from communications from the Geneva "Eight Rochester" Conference on High Energies (June-July, 1958), points out the danger of choosing the commutation rules in the Heisenberg form, which, apparently, involves the vanishing of the anti-commutator ψ at all points. Touschek remarks that the proposed Lagrangian of the nonlinear theory postulates a complex character for ψ, but would have a meaning also for the Majorana real spinor; in such a case the invariance with respect to the Pauli group and the connection with the iso-spin drop out. Pauli and Touschek believe it difficult to obtain fermions with integral iso-spin, and consider the degenerate vacuum, introduced by Heisenberg, to be an artificial assumption. Heisenberg himself warns against excessive hopes and has emphasized in Leipzig that the theory is still in the exploratory stage and a few years' work will be necessary to clarify matters. Yet his lecture had a tone of quiet optimism (he, too, did not consider the subsequent Geneva objections of Pauli as decisive).

Much interest was paid at the Leipzig Conference to gravitation, owing to the basic paper by Dirac, devoted to the Hamiltonian form of gravitational theory. The discussion of gravitation was continued at a special seminar, at which I had to preside at the suggestion of L. Infeld who, half in joke, desired to continue the tradition of the Padua Conference. Dirac emphasized the importance of presenting the theory in the Hamiltonian form, because of the great possibilities of application of tangency transformations and the clarification of the problem of what variables are physically realizable and which are connected with the coordinate systems. Yet the basic concept in the Hamiltonian theory is the state at a given instant of time, a relativistic generalization of which is the specification of the state on a three-dimensional space-like surface. Then the Hamiltonian equations of motion determine the character of variation of the dynamic variables, which decide the state when the surface is changed. In spite of the complete violation of the four-dimensional symmetry, it is convenient to choose a coordinate system in such a way, that the surfaces $x^0 = \text{const}$ are all space-like, and consider only states on such surfaces.

The work of Dirac is a continuation of the investigations of Pirani, Schild, Bergmann, Skinner, and Saukis (Physical Review **80**, 81 (1950), Physical Review **79**, 986 (1950), Physical Review **87** (1952)). Starting out with the Lagrangian of the gravitational field

$$L_g = J_g^{\mu\nu}(\Gamma^{\rho}_{\mu\nu}\Gamma^{\sigma}_{\rho\sigma} - \Gamma^{\sigma}_{\mu\rho}\Gamma^{\rho}_{\nu\sigma}), \quad (|g_{\mu\nu}| = -J^2),$$

Dirac determines the momentum $p^{\mu\nu}$ conjugate with $g^{\mu\nu}$, and obtains then an expression for the Hamiltonian

$$H_g = \int (g^{00^{-\frac{1}{2}}} H_{GL} + g_{\nu 0} e^{\nu\beta} H_{G0})\, d^3x,$$

where H_{GL}, H_{G0}, and analogous terms in the Hamiltonian that describes ordinary matter are all independent of $g_{\mu 0}$. By definition

$$H_G = \int (p^{\nu 0} g_{\nu 0,0} - L_G)\, d^3x.$$

It is important, that in addition to the variables that describe the ordinary matter, the Hamiltonian contains only six degrees of freedom. In the weak-field approximation, Dirac obtains by a new method gravitational waves (2 degrees of freedom: 12, 11 − 22) (corresponding after quantization to gravitons of spin $s = 2$) and an expression for the Newtonian energy of the gravitation of the particles together with the intrinsic energy of gravitation of each particle (degree of freedom: 11 + 22). On the other hand, the degrees of freedom 13, 23, and 33 do not enter into the Hamiltonian of the equation of motion. The exclusion of the degrees of freedom 13, 23, and 33 (11 + 22) can be made with the aid of the tangency transformation even without restriction to the case of slowly-moving particles, in analogy with the transformations that exclude the longitudinal waves in electrodynamics. In conclusion Dirac noted that the Hamiltonian of the gravitational theory is simpler than would be expected, starting with the ten quantities $g_{\mu\nu}$. However, such a simplification is attained at the expense of foregoing the four-dimensional symmetry. To the general enlivenment of the somewhat surprised audience, Dirac announced again that in his opinion it is necessary to forego the four-dimensional form of the description of the world ("One must go back from Einstein") and return to the three-dimensional one, since the four-dimensional symmetry is in his opinion not a basic property of the physical world! The physical state, Dirac notes, is not determined by the particular individual solution of the equations of motion (each of which has four-dimensional symmetry), but by a family of solutions. It is exactly such a family that corresponds to the wave function in quantum theory. On the other hand, individual solutions do not have a quantum analogue. In Dirac's opinion, the Hamiltonian method forces us to forego the four-dimensional symmetry, but, this is offset by the great possibilities of using tangency transformations. Undoubtedly, it is necessary to weigh carefully the technical advantages of the Hamiltonian method against the four-dimensional method and their physical consequences before dispensing with the four-dimensional symmetry, particularly considering the successes (and difficulties) of the covariant description in quantum field theory.

The fact that Dirac joined those "voting" for the predicted existence of gravitational waves has raised objections on the part of L. Infeld, who cited many new arguments in favor of his own theory, that there exists no energy-carrying gravitational radiation. In this connection, the problem was touched upon of the derivation of the gravitational radiation not only through the weak-approximation methods, but also through the method of Einstein-Grommer, Infeld, Hoffmann, and Fock, who derived the equation of motion of particles from the field equations themselves. Professor M. A. Tonnela (coworker of L. de Broglie) reported on a comparison of the Einstein-Infeld methods (motion of singular point) and that of V. A. Fock (motion of extensive particle). In the discussions at the sessions of the conference and at the seminar, Dirac has indicated that his theory leads to the possible transmutation of gravitons into ordinary matter (photons or electron-positrons), which we predicted. According to a well-aimed remark by Professor Rompe, the interesting discussions of gravitation had the "romantic" air of discussions of problems of the physics of tomorrow.

The third fundamental theoretical paper was delivered by N. N. Bogolyubov on his new method in the theory of superconductivity and superfluidity. The audience listened with great attention to the substantial communication and warmly greeted the lecturer, who was recently awarded the Lenin prize. As is known, in developing his method of canonical transformations, previously proposed (1947) for the formulation of a microscopic theory of superfluidity and to account for the interaction between bosons, and in now applying it to fermions, N. N. Bogolyubov comes close to Fröhlich's work on superconductivity, in which the substantial role of the interaction between the electrons and the phonons is emphasized, in connection with the discovery of the isotopic effect in superconductors. He also comes close to the work of Bardeen and Cooper and their associates. He shows here the essential correctness of the simplified picture of the existence of paired correlation ("attraction") between electrons that interact through phonons, particularly near the Fermi surface, leading to the Bose-Einstein condensation of similar formations with zero total momentum.

N. N. Bogolyubov and his associates (V. V. Tolmachev, D. V. Shirkov, S. V. Tyablikov, D. N. Zabarev, and Yu. A. Tserkovnikov) succeeded in giving a complete, mathematically correct theory of the no-longer mysterious phenomenon of superconductivity, with allowance, in particular, not only for single-fermion excitations, but also for collective excitations and for the role of Coulomb forces. This leads to interesting prospects of applying similar methods to atomic nuclei and of accounting for the unique "superfluidity" of the nucleonic fermions.

The paper by J. P. Vigier was devoted to the relativistic hydrodynamics developed by the associates of L. de Broglie (Loschak, Takabayashi, Halbwachs, and others) and D. Bohm. Briefly speaking, the matter concerns an attempt to follow not Dirac's path of the relativistic quantum equation of the point fermion, (for all its spectacular well-known success), but to return to a sort of starting point in the form of the work of Ya. I. Frenkel' on the classical theory of the rotating electron, and subject it to quantization after developing the relativistic theory of rotating formations. In this connection, we point to the work by Matison [Acta. Phys. Polonica **6**, 163 (1957)]; Møller [Ann. Inst. Henri Poincaré **11**, 251 (1949)], Weissenhoff [Acta. Phys. Polonica **9**, 7 (1947)], and Price [Proc. Royal Society, London **A195** (1948)]. In accordance with the Vigier-Bohm opinion, the Weissenhoff equation and those of others (connected by the condition $M_{\alpha\beta}u^{\beta} = 0$, where $M_{\alpha\beta}$ is the anti-symmetrical internal angular momentum tensor, and u^{β} is the four-velocity) correspond to a relative motion of the center of mass and the center of density of the matter. In the final analysis, quantization of rotating non-pointlike "drops" of a relativistic liquid leads Vigier et al. [Compt. rend. **241**, 692 (1955)] and Takabayashi [Phys. Rev. **102**, 282 (1956)] to a certain classical hydrodynamic model of the Dirac and Klein-Gordon-Kemmer equations, while the quantization of the excitations of such drops gives quantum numbers that can be compared with the strangeness numbers etc., especially in view of Tiomno's recent particle scheme. In spite of the preliminary character of such a theory, attention should be paid to several useful and interesting analogies and to the possibility of obtaining, even from this end, nonlinear equations of the same type that are considered in the nonlinear spinor theory.

Of considerable interest was the paper by L. Janossi on experiments, performed by him and his associates (S. Narai, P. Varga, A. Adam, and others) in the Optical Laboratory of the Central Physics Institute of the Hungarian Academy of Sciences, Budapest, located 30 meters underground. Janossi undertook to compare the interference patterns, obtained with the aid of a Michelson interferometer (length of arms 10 cm in some experiments, approximately 14 m (!) in others) in the case of the ordinary "high" intensity, and also in the case of the extremely low intensity, when in instrument contains, so to speak, less than one photon. Such experiments, which border on the well known experiments of S. I. Vavilov with photons and those of V. A. Fabrikant and associates on the interference of electrons at low beam intensities, are of obvious principal interest. Do photons (or electrons), simply speaking, interfere with each other or with themselves? The photons were registered with a special photomultiplier. As announced by Janossi to the general excitement of the audience, his own new unprecedently precise experiments, in spite of his assumptions, gave a result that agrees with the deductions of the quantum theory, i.e., his interference pattern is independent of the intensity. Heisenberg praised Janossi's experiment, noting that it is now possible really to realize several experiments, previously considered as only "hypothetical."

We shall not dwell in detail here on other numerous experimental papers, noting only a few of these. Many investigations concerned mass spectrography (K. G. Krebs, F. Bernhard, Chr. Keck); these included the important communication by M. Ardenne on a new precision mass spectrograph for high-molecular negative ions. A group of papers concerned magnetism (V. Holzmuller: Magnetic Processes in Ferrites; D. Unangst: Observation of Weiss Regions in Thin Single Crystals of Iron). A group of papers was devoted to x-ray structural analysis (G. Mueller and his associates, E. Schoene and his associates); the cycle of papers pertain to low temperatures (L. Beviloga, F. Eder).

Worthy of particular mention are the papers delivered by the associates of the Laboratory of the First German Reactor in Dresden, headed by G. Barwich. Prof. G. Barwich and N. Gessel delivered a paper on the solution of equations for the concentration of various decay products for many stationary and non-stationary cases in a homogeneous reactor (uranium plus heavy water). Another paper by G. Barwich was devoted to a survey of methods of isotope separation. G. Abel and W. Bredel (Dresden) considered the detection of neutrons with the aid of scintillation counters. From among the other papers on nucleonics, we note the report by P. Goerlich and his associates [A. Kross, G. I. Pohl, G. Reichel and L. Schmidt (Jena)] on the measurement of gamma spectra of Cs^{137} and Co^{60} with the aid of a new multiplier (M12FS) made by Zeiss. Among the theoretical papers, we note the report by Professor Heber (Jena) on individual and paired errors in the measurement of the size of field; the survey article by Professor B. Kokkel (Leipzig) on parity, a report by M. Meier (Bucharest-Dubna) on weak interactions in the theory of elementary particles of Schwinger, a paper by I. Zupeca (Zagreb) on the differential equation of the theory of electric conductivity at low temperatures.

Zellner (now in Dubna) considered in his paper the dispersion relations for the process $\pi + N \rightarrow 2\pi + N$ in the approximation of the nucleons at rest. A paper by F. Kaplun (Dubna) was devoted to the dispersion of relations for elastic scattering of pions by deuterons. K. S. Zeiten discussed the systematics of possible neutrino theories. A. B. Migdal lectured on the use of quantum-field-theory methods in the many-body problem. Dr. G. Kahan (Paris) reported on the quantum theory of the Faraday effect. G. Henl (Freiburg, Federal Republic of Germany) delivered a paper on the theory of potential in spherical space. In the author's absence a paper was delivered by T. Kakushadze (Tbilisi) on K_α and K_β satellites in x-ray spectra. V. Kofnik (Karlsruhe, Federal Republic of Germany) reported on the theory of anisotropic scattering of neutrons.

On the whole, it can be stated again that the conference in Leipzig was very successful and was able both to focus attention on several of the most urgent problems that now engage the universal physics fraternity (nonlinear spinor theory, and others), and to permit discussion of many interesting and important problems. The members of the Soviet delegation delivered many papers devoted to the development of physics in the U.S.S.R. More than a thousand persons gathered in Leipzig to hear N. N. Bogolyubov and D. D. Ivanenko on the Development of Soviet Science, on the Novosibirsk Scientific Center, and on the Progress of Soviet Nuclear and Accelerator Physics. Numerous remarks concerned individual details of the papers, but there were also other questions, for example, whether the Moscow University has a theology faculty (sic!). We note that at the Berlin University (German Democratic Republic) and certain others do have theological faculties. For example, at the May day parade in Berlin, the teachers and theology students marched with their flags. Many members of the delegation delivered papers on the state of science in some Union Republics, such as Georgia (Prof. V. I. Mamasakhlisov, corresponding member, Academy of Sciences, Georgian S.S.R.) and Estonia (Prof. G. P. Keres). Professor A. A. Smirnov (corresponding member, Academy of Sciences, Ukrainian S.S.R.) reported on progress in metal physics in the Ukraine; Dr. Zh. S. Takibaev lectured in Halle on research done on cosmic rays in Kazakhstan; Prof. B. I. Stepanov (active member Academy of Sciences, Belorussian S.S.R.) lectured in Jena on optical research in Minsk. I delivered a survey paper in Leipzig on the development of Soviet physics, and also lectured to the members of the Academy of Sciences in Berlin, at the Berlin University, on attempts to formulate a unified (principally nonlinear) theory of matter. I also lectured at the Jena and Halle universities on the results of the Leipzig conference. A. B. Migdal lectured in Dresden on the application of the method of superconductivity to the nucleus.

Members of the delegation spoke over the radio and appeared on television, and also gave several interviews. The scientists of the German Democratic Republic and the student youth showed tremendous interest in our reports, to which much space was devoted in the national, local, and student press. As a rule, a small circle of persons always remained after the lectures and the question sessions, and the discussions ceased only when it became necessary to present another paper or to proceed the next session of the conference. Such interest is undoubtedly due essentially to the present high rank of Soviet science.

Through the graciousness of the German colleagues, the members of the Soviet delegation became acquainted with the scientific centers of physical science in Germany. Its organization and state can be described in the briefest outline as follows. The key position in the organization of science is occupied by the German Academy of Sciences, the successor to the Prussian Academy, which in turn dates back to the time of Leibnitz

(1700). An exhaustive outline of the history of the academy was published during the days of the Planck celebrations. The academy is headed by a president, the well known physical chemist M. Vollmer, and four vice-presidents, including one of the oldest of its members, the physicist and biophysicist Walter Friedrich, who discovered the diffraction of x-rays by crystal lattices. Professor W. Friedrich is now known for his active social activities and his struggle for peace. The secretary of the Division of Mathematics, Physics, and Engineering is Professor Robert Rompe, who speaks a beautiful Russian, and who is the director of the Institute of Light Sources, some interests of which lie in the field of solid-state physics. The academy institutes that engage in the natural sciences, engineering, and medicine are unified into a single organization headed by a presedium (chairman G. Fruhauf, members R. Rompe, K. Schröder, E. Tilo, G. Hummel, and G. Neels) and a scientific secretariat, headed by the energetic Doctor Hans Wittbrodt.

The Academy of Sciences comprises the following: (1) The Heinrich Hertz Institute of Oscillation Processes (director, Professor Haganberg; the institute has two radioastronomical observatories, which have several small telescopes, and a new 36-meter radio telescope is under construction. (2) The Institute of Optics and Spectroscopy. (3) The Institute of Crystal Physics. These three institutes and observatories are located in one large country place outside of Berlin, in Adlershof. In addition, the Academy of Sciences includes: (4) The Institute of Sources of Light. (5) The Solid State Institute. (6) The Nuclear Institute (the latter located in Miersdorf below Berlin). (7) The Professor Steenbeck (known for his pioneer work on the betatron) Institute of Magnetic Materials in Jena. (8) The Low Temperature Laboratory in Dresden. (9) The Professor Seeliger Institute of Gas-Discharge Physics in Greifswald.

Of the six universities of the German Democratic Republic, physics is most advanced in Berlin (The Humboldt University, founded in 1809), Jena (The Friedrich Schiller University, founded in 1508) and Leipzig (The Karl Marx University, founded in 1409). To these should be added one of the important centers of German physics of the German Democratic Republic, in Dresden, home of the great Higher Technical School, in which a special nuclear faculty was organized, headed by Professor Macke a student of Heisenberg. In Dresden-Rosendorf there is in operation, under the leadership of Professor Barwich, the first nuclear reactor in all Germany, constructed with Soviet help, while the private Ardenne Laboratory is in operation in Dresden. Of great importance are the Laboratories of the well known Zeiss Company in Jena, which became a national enterprise and has again resumed not only its commercial activities, but also its scientific activities in the field of optics, spectroscopy, and precision instrument building, now under the scientific leadership of Professor P. Herlich, Doctor G. Schrade, and others. Some of the papers by the Zeiss staff are published in the excellently edited "Jena Annuals" and "Jena Survey." A new physics institute has been constructed by the University in Jena.

The Physical Society of the German Democratic Republic has been intensifying its activities, calling congresses and individual sessions. It is headed by G. Hertz (chairman) and an energetic young secretary, Dr. Buchner.

The principal physics centers of the German Democratic Republic in Berlin, Dresden, Jena, and also Leipzig are thus at the forefront. It is there that new institutes have been organized and the better staffs are concentrated. Reconstruction has not yet been completed in the two northern universities in Rostock and Greifswald, or in the Physics Institute in Halle, where Prof. Messerschmidt continues his research on variations of cosmic rays.

The higher schools of the German Democratic Republic are now going through a unique transition period. The higher institutions of learning have accepted representatives of a young generation of workers, and members of the labor classes of the population, who are full of enthusiasm. The higher institutions of learning are solidly turning towards the building of socialism. One of the causes that prevent a more rapid development of science is apparently the considerable shortage of staffs. There is a striking shortage of lecturers or young professors. In some way or other, strengthened by its traditions, German physics of the German Democratic Republic is now on the rise.

The trip to the congresses in East Germany enabled us to become acquainted with many cites of the German Democratic Republic. To complete the picture of the conditions of the progress of science we must mention briefly our impressions. The gloomy picture of a destroyed city, which is presented by Berlin, is well known. The city is still full of waste areas, many quarters full of destroyed buildings. The present central street of East Berlin, the Stalin Allee, has been reconstructed extensively and is of architectural interest. In Treptow Park there is a common grave for the Soviet soldiers; the statue of a soldier trampling on a Svastika, the work of Vuchetich, makes a very great impression. Treptow Park is frequently visited by Berlin residents from both sectors and by tourists. Immediately upon arrival, the members of the Soviet delegation visited this memorable place. Many interesting Berlin museums have already been reconstructed, namely the Museum of National Creative Work, the outstanding museum of excavations from Troy and Babylon, and a small picture gallery. The state opera and the comic opera, where we attended interesting performances — Mozart's "Abduction from the Seraglio" and one-act pieces of Milo and Bartok — serves as a center of attraction even for West Berlin. In Dresden, terribly bomb damaged right after the end of the war, now has the restored Zwinger, where a noted gallery is located. Leipzig (the center of the chemical industry) suffered much less, and the old city hall, with the market square in front of it, has been fully preserved. Fortunately, the Thomaskirche, to which the remains of Johann Sebastian Bach who was the cantor there, have now been transferred, has also been saved. The memorial to the great composer is in good harmony with the tremendous Gothic windows of the church. From the inscription on the gates we learn that Martin Luther preached in this church and that Richard Wagner was christened there. No far from the city hall in Leipzig there is a statue for young Goethe (with a bas-relief of his sweetheart), who was a student in the university here.

The cities of southern Germany have been almost completely preserved, including the great university and industrial center in Halle, with the well-known cathedral, adorned with four towers, which face the lively square with a statue of Handel, a native of this picturesque city, located on the banks of the Saale River. Very interesting is little Weimar with the museum rooms of Goethe, Schiller, and Liszt, which attract many tourists and excursion students. The first-floor rooms of the Goethe house, adorned with antique statues and pictures, are in keeping with his rank as a Minister of the Duchy, although tiny by present standards. A great impression is made by Goethe's more modest and by the multitude of mineralogical and zoological collections, along with the physical instruments on the second floor. The picture of a universal genius emerges, that of a writer, scientist, philosopher, and organizer. Schiller's house is an example of a much more modest "professorial lodging." As evidence of fascism's deepest insult to the national dignity and to general human morals, the remnants of the Buchenwald concentration camp, located on a hill about 10 km from Weimar, have been retained. Moving at a speed of 110 to 120 km/hr on a splendid auto road, probably the best in Europe (a wide divided highway running outside the cities and villages, without grade crossings), we could reach the most remote localities of the German Democratic Republic.

One recalls the well-known Wartburg castle on the hill near Eisenach, the center of the automobile industry. Here are retained the old halls, dating back to the 12th century, the room in which Luther translated the bible, with its desk and possessions. The gem of the valuable collections of the castle are several dozens of portraits by Kranach (Luther, his wife, Melanchton, and others). Very attractive is the quiet lyric Jena (pop. approximately 80,000), located on the hills of Thuringia. The university institutes are scattered over the entire city. Memorials to scientists are everywhere: on the Helmholtzweg, Goethe Allee, and on other streets. A surprise is the eleven-story building of the Zeiss main offices. Even a cursory visit in the German Democratic Republic, after an absence of 13 years, shows the great progress in the restoration and considerable progress in both industry and science.

A perfect ending to our two week trip in the German Democratic Republic was our attendance at the tremendous five hour first of May demonstration in East Berlin, in which residents of West Berlin also participated, carrying placards with names of their regions. The demonstrations were preceded by a brilliant parade of the army of the young democratic republic.