Symposium "Niels Bohr and science of the XX century"

V. P. Vizgin, A. T. Grigor'yan, M. A. El'yashevich, and O. V. Kuznetsova

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An All-Union Symposium devoted to the 100th anniversary of the birthday of Niels Bohr was held in the city of Pushchino from 5 to 7 October 1985. The symposium was organized by the Institute of the History of Science and Technology of the Academy of Sciences of the USSR, the I. V. Kurchatov Institute of Atomic Energy, the Philosophical Society of the USSR, the Scientific Center for Biological Research, and the Institute of Biological Physics of the Academy of Sciences of the USSR.

More than 120 scientists from 15 cities of the USSR participated in the symposium. There were representatives from the Institutes of the Academy of Sciences of the USSR and from the Academies of Sciences of other union republics, from other scientific-research organizations, and from a number of the higher educational institutions of our country. Four plenary sessions and two sessions in each of three sections took place.

The plenary sessions were opened by an introductory speech by L. S. Polak. He dealt with three aspects of Bohr's creative work which, in his opinion, have not yet received sufficient attention.

First of all, Bohr's fundamental complementarity principle is frequently regarded as having been transferred into physics from psychology. This is, at the very least, insufficient to explain its origin, but, more likely, it is also not quite correct. Bohr, who in his youth devoted much attention to the history of philosophy, of course knew about the work and the concepts of Nicolaus Cusanus which were based on the "principle of compatibility of opposites" (coincidentia oppositorum). Many, and the most basic, philosophical statements of Bohr are very close to the propositions of Nicolaus Cusanus.

Secondly, the introduction in the course of generalization and mathematical development of Bohr's theory of the "action-angle" variables opened up the path for the introduction of topological concepts and methods into classical mechanics, affecting its subsequent development in an essential manner.

Thirdly, Bohr was a convinced atomist, who not only intuitively, but also rationally understood the atomistic approach and made use of it in order to apprehend the world. But he also understood that the atomistic approach by itself is insufficient to construct a multifaceted picture of the real cosmos. He considered that in addition it is also necessary to show how nature gives rise to its inifinite variety. From this arose Bohr's great interest in the problems of biology, where the process of the appearance of new structures on the basis of atomic-molecular combinations is manifested with unusual clarity, and this also is the origin of his interest in the problem of "the arrow of time".

I. S. Alekseev in his report "The Creative Biography of Niels Bohr" noted an important feature of Bohr's creative personality, which manifested itself in the persistence with which Bohr could over a long period of time contemplate problems that captured his interest in their different aspects and interconnections with other problems. After quantum mechanics had been created Bohr occupied himself with problems of its interpretation, he formulated the complementarity principle which he then attempted to extend beyond the bounds of physics. Bohr's characteristically deep approach to problems posed before him by science and by life manifested itself in the fact that already during the work in the U. S. A. on the construction of the atomic bomb Bohr began to give thought to problems of international collaboration in the matter of peaceful utilization of atomic energy, and participated in the active struggle for peace. In 1950 he published his "Open Letter to the United Nations"[1]. N. Bohr's style of work with his pupils was a remarkable one which stimulated the best human qualities and creative activity.

In his report "Neils Bohr's development of the quantum theory of the atom and the correspondence principle (his 1912–1923 work in atomic physics and its significance)" M. A. El'yashevich analyzes the sources of Bohr's papers which laid the foundations of the quantum theory of the atom. M. A. El'yashevich discussed in detail Bohr's famous article on the theory of the hydrogen atom and on the origin of spectra, and then examined the subsequent development of Bohr's ideas, with special attention being paid to Bohr's postulates on stationary states and on the frequencies of radiative transitions, and also on the development of the correspondence principle. El'yashevich paid particular attention to the question of how well Bohr understood the difficulties of the model theory and how he strove to understand quantum phenomena more deeply.[2]

R. L. Sorochenko in his paper "Bohr's theory of the atom and modern research on the spectra of highly excited atoms" spoke of the research carried out in the USSR during the last 25 years which has significantly extended our knowledge of atomic structure the foundations for which were laid by Bohr. In 1964 it was discovered by methods of radio astronomy that in interstellar space under conditions of high rarefaction hydrogen atoms emit spectral lines which are due to transitions between neighboring highly excited levels with $n \sim 100$. The frequencies of these lines lie in the range of centimeter waves. In subsequent observations over a broad range of radio waves from millimeter to decameter a large number of spectral lines of hydrogen, helium, and carbon were recorded which correspond to excited levels with $n \sim 50$–730. The lines of highly excited atoms turned out to be the most frequently encountered ones in the spectrum of cosmic radio emission. As a result of the investigations that were carried out it was established that under the conditions of the Galaxy the atom as a quantum system can exist in

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excited states right up to values of $n \sim 1000$. In such a case its dimensions in accordance with Bohr's theory amount to 0.1 mm. The reason that limits the possibility of existence of still more highly excited atoms is the nonthermal radiation of the Galaxy.

In the interval between the plenary sessions an inspection of the two radio telescopes of the Radioastronomical station of the Physics Institute of the Academy of Sciences situated in Pushchino was organized for the participants in the symposium: the twenty-two meter RT-22, working in the range of centimeter and millimeter waves and the cross-type radio telescope DKT-1000 operating in the meter range.

An important stage in Bohr's scientific activity was associated with the physics of the atomic nucleus. S. I. Larin's report "N. Bohr's development of the concept of the compound nucleus" was devoted to this concept and its influence on the development of nuclear physics. Having described the situation in nuclear physics in the middle 1930s and the initial premises for Bohr's development of the concept of the compound nucleus, the speaker outlined the content of this concept and the statistical description of nuclear processes associated with it, the problems of the collective motions in the nucleus, and the development of the liquid drop model. Bohr's ideas exerted a deep influence on the development of the theory of nuclear reactions and nuclear models and facilitated the introduction of collective models of the nucleus. This direction turned out to be very fruitful for the understanding and development of the theory of nuclear fission. The contribution of Soviet scientists to the development of nuclear models and the theory of nuclear fission was noted in the report.

D. V. Shirkov in his paper "Renormalizations in quantum field theory and the completeness principle" discussed the physical essence of the renormalization procedure in quantum field theory, its connection with the renormalization group and the presence of ultraviolet divergences. The speaker showed that renormalization is quite natural even in the absence of infinities, and its principal characteristic—the scale parameter—is due in its origin to quantization and is an illustration of Bohr's completeness principle which requires for the full specification of a quantum system the description of its "macroscopic surroundings".

Ya. A. Smorodinskiĭ in his paper "The argument which has no end. The Einstein-Podolsky-Rosen paradox" emphasized that at present the interpretation of quantum mechanics once again has become the subject of a large number of articles. The expectation has not been justified that a new generation "unspoiled" by classical traditions will accept quantum mechanics as a completely natural description of the real world. The beginning of this was the article of Einstein, Podolsky, and Rosen on the meaning of the concept of reality itself. This article which did not cite a single reference brought forth hundreds of new articles. The impossibility of describing a quantum system by a local classical theory provoked a beautiful interpretation of the quantum "paradox" in the language of the theory of probability in which the problem is reduced to quantum correlations of "independent" variables.

The report by B. I. Spasskiĭ and A. B. Moskovskiĭ "The polemic between Bohr and Einstein and modern views" examined the problems of the discussion between Bohr and Einstein, and also the polemic associated with the Einstein-Podolsky-Rosen paradox (EPR-paradox) in which Bohr also took part. The report discussed the modern interpretations of the EPR-paradox in connection with Bell's theorem and the experimental test of Bell's inequality.

A number of reports at the plenary sessions was devoted to the philosophical-methodological analysis of Bohr's views and his interpretation of the connection between physics and biology and humanitarian sciences.

In his paper "The philosophical-methodological component of Bohr's creative output" I. S. Alekseev noted that the principal theme which occupied Bohr as a philosopher and a methodologist was the theme of an adequate description of quantum mechanical regularities of the microworld in terms of the exceptionally rich and flexible language of classical physics. The "correspondonce argument" formulated by Bohr enabled him to "guess" quantum formulas on the basis of classical ones. In its full extent the problem of adequate utilization of classical concepts in the quantum domain is contained within Bohr's complementarity principle. According to this concept in order to obtain a full description of complete quantum phenomena it is necessary to use two mutually exclusive "semiclassical" sets of concepts in order to introduce definiteness into the existence of microobjects. Bohr assumed it to be possible to extend the concept of complementary beyond the bounds of physics.

In his presentation "The principle of the unity of knowledge in the scientific creative output of N. Bohr" N. S. Ovchinnikov emphasized that in the situation of demolition of scientific concepts Bohr strove to retain classical principles among which he ascribed particular significance to the unity of knowledge. The correspondence and complementarity principles formulated by Bohr are a means of generalizing the classical description of nature. Bohr introduced radical changes into the method itself of changing a scientific paradigm. In the speaker's opinion Galileo's method consists in rejecting what came before, while Bohr's method consists in retaining what came before on the basis of the correspondence and complementary principles. Bohr emphasized that the gnosiological lesson extracted from the development of quantum physics enables one to note the common features of different forms of human knowledge and thereby to aid in the striving towards its unity.

In his report "The problem of the relationship between physics and biology" M. B. Vol'kenshteĭn noted that in the course of many years Bohr treated the relationship between physics and biology on the basis of his concept of complementarity, considering the study of the atomic-molecular structure of an organism and the study of its as a whole system to be complementary. Bohr regarded that life is not subject to be explained in the usual sense of the word, but should be regarded as a primay postulate similar to the quantum of action. These views of Bohr have become widespread and have been used by some physicists and philosophers as arguments in the struggle against the so-called reductionism. However, in M. V. Vol'kenshteĭn's opinion the concept of reductionism in modern biology is senseless, not constructive, and the struggle against it leads to vitalism. Subsequently Bohr reconsidered his views completely. In an article which was published in translated form in Usp. Fiz. Nauk [**76**, 21 (1961)] he already spoke concerning the practical and not the fundamental complementarity between physics and biology, and in a posthumous publication in "Naturwis-

senschaften" [**50**, 725 (1963)] he did not speak of this complementarity at all. Vol'kenshteĭn noted that testimony to this is contained in Bohr's letter to him published in his book "Crossroads of Science" (in Russian) (Nauka, M., 1972). The change in Bohr's views was directly connected with the successes of molecular biology.

In the report "Niels Bohr and Erwin Schrödinger" prepared by M. B. Zykov, A. M. Molchanov and R. V. Smirnov on the basis of a study of Schrödinger's book "Meine Weltansicht" the characteristics of the styles of thinking of Bohr (key theme—discrete nature) and of Schrödinger (continualism) were contrasted.

M. A. Rozov in his report "The principle of complementarity in the humanities" expressed his idea that for Bohr there existed no boundaries between subjects: he borrowed the principle of complementarity from psychology, but extended it far beyond the bounds of physics. These ideas of his have found followers also in the humanities (R. Yakobson, M. M. Bakhtin). The speaker considered that by using the concept of social chain discussions (reconstruction of an activity based on samples) and the facts of psycholinguistics it is possible to distinguish between macro- and microworlds in the humanities, to introduce the concept of a macrodevice and to establish a qualitative isomorphism of situations in quantum physics and in humanities research. In this case in the opinion of the speaker the description of mechanisms and of the content of social memory appear as additional descriptions.

A separate plenary session was devoted to the contacts between N. Bohr and Soviet physicists and to meetings with them in the course of his visits to the USSR.

An atomosphere of a valid story was evoked by the report by E. L. Feĭnberg "Niels Bohr in Moscow in 1961", who read aloud notes of his impressions of meetings with Bohr made while "hot on the trail" in those very days when he saw Bohr and participated in discussions with him. Records of this kind turn out to be particularly valuable for the history of science; as is well known, memory often trips up writers of memoirs, and, moreover, an unrecognized feeling forces one to correct one's memory in accordance with a certain inner logic which to a certain degree of accuracy can be reconstructed retrospectively, but which is difficult to recognize in the dazzling variety of the immediate present. E. L. Feĭnberg participated in meetings with Bohr at the Physics Institute of the Academy of Sciences and in Dubna at a conference on weak interactions. In his notes are reproduced Bohr's discourses on the complementarity principle, on the Copenhagen interpretation of quantum mechanics from which Bohr, according to his words, did not retreat a step, on hidden parameters in quantum mechanics in the existence of which Bohr did not believe, on his discussion with Einstein, all the convolutions of which excited him deeply even after passage of many years. In the course of conversations with Bohr subjects were also broached concerning his relationships over many years with Heisenberg and his attempts to establish contact between Roosevelt and Churchill for discussions on the peaceful utilization of nuclear energy. E. L. Feĭnberg noted that Bohr examined with great interest the experimental installations in the laboratories of the I. V. Kurchatov Institute of Atomic Energy and in Dubna. The entire audience listening to E. L. Feĭnberg experienced the feeling of immediate contact with Bohr's personality.

In the presentation prepared by members of the Institute of Atomic Energy Yu. V. Gaponov, T. Yu. Grammatikati, S. K. Kovaleva, R. V. Kuznetsova, and S. V. Rylov "A Photographic Record of the Visits of Niels Bohr in the USSR" approximately 50 photographs were used from the I. V. Kurchatov Museum at the Institute of Atomic Energy and from private collections. Bohr visited the Soviet Union three times—in 1934, 1937, and 1961. In 1961 Bohr together with members of his family spent more than two weeks in the USSR from 3 to 17 of May. During this time Niels Bohr and his son Aage Bohr who is now the Director of the Copenhagen Physics Institute visited the Institute of Atomic Energy, the Physics Institute of the Academy of Sciences, the Institute for Physics Problems, the Joint Institute for Nuclear Research in Dubna, and met with leading scientists of our country, and examined the experimental installations. On the invitation of E. L. Andronikashvili Bohr together with his family visited Tbilisi, the Institute of Physics of the Georgian S.S.R., visited the ancient capital of Georgia Mtskheta and made a trip to Kakhetiya. On May 7 Bohr was present at the festival of the Physics Faculty of the Moscow State University "Archimedes Day", took part in the carnival, made an improvised speech and heard the opera "Archimedes". During his visit to the USSR in 1961 Bohr was accompanied by I. D. Rozhanskiĭ. After the presentation by the members of the Institute of Atomic Energy a film was shown taken by I. D. Rozhanskiĭ concerning Bohr's trips to Zagorsk and into the Alazani Valley.

In the report by V. Ya. Frenkel' "Niels Bohr and Soviet physicists (based on correspondence)" Bohr's contacts with the leading Soviet physicists—A. F. Ioffe, P. L. Kapitsa, L. D. Landau, I. E. Tamm, V. A. Fok, and Ya. I. Frenkel' were discussed. On the basis of an analysis of the scientific correspondence of these scientists their first meetings were dated. With justification particular attention was paid to the 1930's when Bohr came to the USSR twice, and especially to 1936, when Bohr proposed the compound nucleus model, which was then developed in the papers by Soviet theoretical physicists.

In the report by T. M. Chernoshchekova "Niels Bohr and the Leningrad Physics School" the contacts of Bohr with the principal Leningrad Physics School of A. F. Ioffe were discussed, and also the scientific contacts and the encounters of Leningrad physicists with Bohr.

A large number of reports was presented at the sessions of individual sections.

Meetings of three sections took place: "Niels Bohr and the Problems of Modern Science" (at which 10 reports were presented) "Niels Bohr and the History of Physics" (9 reports were presented) and "The Complementarity Principle in the Spiritual Culture of the XX Century" (8 reports were presented). Interesting discussions arose at these sectional meetings.

One should note the high scientific level of the majority of the reports in which the newest investigations in the physics of elementary particles, in quantum mechanics, astrophysics, biological sciences and humanities were reported. Bohr's universalism, the cultural context of his thought found their reflection in the fact that at the symposium professionals in different fields—physicists, biologists, philosophers, historians and methodologists of science, and sociologists found a common language. Discussions and sharp

arguments continually arose, which had a business-like and at the same time a democratic character. Due to the showing of documentary films concerning Bohr, of photographs, reading of diary notes and reminiscences of many people who had seen Bohr, who had talked to him, an impression was created as if of a direct contact with the great man. On one of the evenings the opera "Archimedes" which Bohr saw and heard in 1961 at the spring festival of the physics faculty of the Moscow State University was shown to the participants in the symposium. The members of the first presentation of "Archimedes" also appeared in this colorful presentation.

A number of events devoted to the 100th anniversary of the birth of N. Bohr occurred in the course of the entire 1985 (and particularly in September–November) in many countries of the world. In Copenhagen, in Bohr's native country a conference on nuclear disarmament and on Bohr's open letter to the U.N. took place on 27–29 September. A representative of the USSR E. P. Velikhov was present at that conference. On 4–9 October an anniversary symposium "Lessons of the Quantum Theory" took place in Copenhagen at the Niels Bohr Institute sponsored by the Danish Academy of Sciences and Languages. At this symposium papers were presented by V. L. Ginzburg, S. T. Belyaev, and I. M. Khalatnikov. An international symposium also took place in Rome on 25–27 November, and also in the GDR, U.S.A. and in other countries.

[1)]Science **112**, 1–6 (July 7, 1950) [Russ. Transl. Usp. Fiz. Nauk **147**, 357 (1985)].

[2)]El'vashevich's report was published in Usp. Fiz. Nauk **147**, 253 (1985) [Sov. Phys. Usp. **28**, 879 (1985)].

Translated by G. M. Volkoff