The Lesson of Quantum Theory, edited by J. de Boer, E. Dal and O. Ulfbeck

Niels Bohr and the Royal Danish Academy of Sciences and Letters

Bengt Strömgren

Nordita
Copenhagen, Denmark

Contents

1. Prize problem and dissertation

The Royal Danish Academy of Sciences and Letters in February, 1905, offered its gold medal for an investigation of jet vibration aiming at a determination of the surface tension of liquids. In answer to the prize problem two essays were submitted in November, 1906, and both were awarded the gold medal. One author was P.O. Pedersen, the later director of the Danish Technical University, —the other was Niels Bohr, then a student at the University of Copenhagen. The prize essays were judged by two members of the Academy, physics professors C. Christiansen and K. Prytz.

On February 24, 1907, Niels Bohr was notified of the award through a letter signed by the president of the Academy, Julius Thomsen, and its secretary, H.G. Zeuthen. However, already on January 26, Niels Bohr had received a letter of congratulation, revealing that he would be awarded the prize. This letter was from Harald Høffding.

Niels Bohr continued his work on the surface tension of liquids and published the results in 1909 in a paper in the Philosophical Transactions of the Royal Society of London, entitled "Determination of the Surface Tension of Water by the Method of Jet Vibration" [1]. On May 13, 1911, Niels Bohr publicly defended his dissertation "Studier over Metallernes Elektrontheori" for the doctor of philosophy degree. In his publications during the following years, Niels Bohr did not directly return to the subjects of his first papers. However, the intimate familiarity with problems of classical physics that he had gained through his early work became, as has been emphasized, of great importance as part of the background for the pioneering work that was to follow.

2. University professor and academician

During the centenary year of Niels Bohr's birth we have been reminded, in a multitude of ways, of his research contributions during the years 1911–1916. In 1916 Niels Bohr returned to Denmark after a two-year stay in Manchester to assume the duties of a newly created professorship in theoretical physics at the University of Copenhagen, and in 1917 he was elected a member of the Royal Danish Academy of Sciences and Letters.

All through the years of his membership Niels Bohr regularly attended the meetings of the Academy, except for the period of his involuntary stay in the United States during the last years of the Second World War. He rendered the Academy a great service by refereeing the very large number of physics papers, submitted to the Academy for publication. During the years 1917–1955 this amounted to a total of 90 papers published in the mathematical–physical publications of the Academy.

Relatively few of Niels Bohr's papers appeared in the publications of the Academy. However, one of his fundamental contributions "On the Quantum Theory of Line-Spectra I–III" was published by the Academy in the period 1918–1922, being reprinted in 1927 [2]. In 1933 Niels Bohr, in collaboration with Léon Rosenfeld, published the paper "Zur Frage der Messbarkeit der elektromagnetischen Feldgrössen" in the memoirs of the Academy [3], as was the case with works on the penetration of atomic particles through matter, the last of these in 1954, in collaboration with Jens Lindhard [4].

During the years from 1917 to 1955, Niels Bohr gave 29 lectures before the Academy or, in the terminology of the Academy, he made 29 communications. Doing this, he gave the members of the Academy a most valuable opportunity to follow the development of physics through epoch-making decades.

In order to give, on this occasion, an impression of Niels Bohr's unique research contribution, I shall attempt to describe investigations and results that constituted the background for some of these lectures.

In Volume I of "Niels Bohr, Collected Works", Léon Rosenfeld in his "Biographical Sketch" [5] has given a synopsis of the principal problems that dominated in Niels Bohr's work in successive periods: In 1913 the Quantum Postulates, during the years 1914–1925 Atoms and Radiation, from 1925 to 1935 Quantum Mechanics and Complementarity, from 1936 to 1943 Nuclear Physics, and finally from 1943 to 1962 Public Affairs and Epistemology.

3. Quantum postulates

Shortly after having become a member of the Academy, Niels Bohr—in 1917 and in 1918—gave two lectures, the first entitled "On the Quantum Theory of Line-Spectra", the second "On the Foundation of Quantum Theory". Through these lectures he submitted Part I of his above mentioned paper for publication by the Academy.

Part I appeared in April, 1918, while Part II followed in December, 1918 and Part III in November, 1922 [2].

Part I opens with a statement of the two fundamental assumptions of the quantum theory of line-spectra that were the basis of the breakthrough in 1913, the first being the quantum postulate of the stationary states of an atomic system, the second the quantum postulate on radiation absorbed or emitted during a transition between two stationary states, which states the frequency condition $E' - E'' = h\nu$, where h is Planck's constant.

In 1913 the correspondence principle introduced by Niels Bohr had played a very important role. Niels Bohr always emphasized that the quantum postulates meant a decisive break with classical physics, but he also stressed the consideration that a quantum theory, valid for description of atomic systems in the domain of atomic dimensions, necessarily gives results that converge toward those of classical theory in the limiting case of conditions under which dimensions are large compared to atomic dimensions. These considerations found expression in the correspondence principle.

In 1913 Niels Bohr had utilized the correspondence principle for the description of transitions in the hydrogen atom's stationary states with large neighbouring quantum numbers, corresponding to electronic orbits of relatively large radius with quantum emission of low frequency and correspondingly large wavelength. The correspondence principle led to an equation for the frequencies of the spectral lines of atomic hydrogen. The calculated values agreed with observation as closely as could be expected considering the precision with which the natural constants that entered, including Planck's constant, were known at the time. The correspondence principle had also led Niels Bohr to the correct interpretation of certain spectral lines, found in stellar spectra as well as in laboratory spectra, the so-called Pickering–Fowler lines, which for a time had seemed to present a problem for the theory. He showed that the lines in question are due to ionized helium and not to hydrogen, as had been assumed previously. Guided by the correspondence principle, Niels Bohr had computed the wavelengths of these ionized helium lines from the observed wavelengths of the hydrogen lines, taking into account the fact that the mass of the helium nucleus is four times as large as that of the hydrogen nucleus. The agreement with observation was perfect, with five-digit precision. In 1913 this result had made a great impression in the physics community. It is known from a letter written by George Hevesy to Niels Bohr (cf. Niels Bohr, Collected Works, Volume 2 [6]) that Einstein, when he heard about this result, exclaimed: "This is an enormous achievement! The theory of Bohr must be right then."

In 1913 the correspondence principle had been applied to electronic motion which, according to classical theory, was describable by simple periodic orbits. For elements other than hydrogen the situation is more complicated. In Part I of the paper submitted to the Academy during meetings in 1917 and 1918, Niels Bohr developed methods that made it possible to draw conclusions on the basis of the correspondence principle, even in more complicated cases. Here, the basis is the description of the electronic motion according to classical theory by Fourier analysis, and the correspondence principle then suggests that transition probabilities between two stationary states characterized by quantum numbers $n'_1, \dots n'_s$ and

$n_1'', \dots n_s''$, respectively, are directly related to intensities of radiations of frequencies $\omega_1(n_1' - n_1'') + \cdots + \omega_s(n_s' - n_s'')$ to be expected according to classical electrodynamics from the motions in these states. Niels Bohr emphasized that the estimate becomes more uncertain, the smaller the values of the n's are. These ideas are further developed in Part III of the paper in a discussion of the spectra of elements of higher atomic number. Part II contains a discussion of the hydrogen spectrum in which the fine structure of the lines, as well as the Stark and Zeeman effects, are considered.

During the years 1918 to 1924, the correspondence principle played an important role in a series of investigations, leading to the development of the new quantum mechanics. We shall return to this matter in section 5.

4. *Atoms and radiation*

In 1921 Niels Bohr gave a lecture at the Academy entitled "The Periodic System of the Elements Elucidated through Considerations of Atomic Structure", followed in 1922 by a lecture, "Atomic Theory and the Properties of the Elements". A short time later, on December 11, 1922 in Stockholm, Niels Bohr delivered his Nobel Lecture "On the Structure of Atoms". In these three lectures he gave an account of the great progress made and results obtained in atomic theory.

In the Nobel Lecture [7] the possibilities of elucidating the Periodic System of the elements are discussed in detail:

> "The ideas of the origin of spectra have furnished the basis for a theory of the structure of the atoms of the elements which has shown itself suitable for a general interpretation of the main features of the properties of the elements, as exhibited in the natural system."

Niels Bohr went on to say that the theory is primarily based on considerations of the manner in which the atom can be imagined to be built up by the capture and binding of electrons to the nucleus, one by one, and further that the optical spectra of elements provide us with evidence on the progress of the last steps in this building-up process.

While the optical spectra are of decisive importance for the understanding of the problems concerning the outermost electrons—the valence electrons—the results of X-ray spectroscopy, as emphasized by Niels Bohr in the Nobel Lecture, contribute significantly to the understanding of the inner parts of the electron configurations.

On the basis of the spectroscopic data, Niels Bohr was able to draw conclusions regarding the grouping of electrons and their changes as one proceeds through the Periodic System of the elements. The finding that a grouping of the outermost electrons repeats itself at regular intervals explains the periodicity in the properties of the elements. Thus, Christian Møller and Mogens Pihl express themselves in their contribution to the book "Niels Bohr", published in 1967 [8], and they continue:

> "A characteristic feature of Bohr's way of considering the problems is revealed here, namely, that intuitive understanding of the clues yielded by the empirical data was particularly important in guiding him to these results—results that were to pave the

> way for a more profound insight into the regularities, gained only after Pauli's formulation of the so-called exclusion principle."

From the theory, Niels Bohr concluded that an element with atom number 72, not yet discovered at the time, would have to be chemically similar to zirconium, and therefore could be expected to occur in certain minerals containing zirconium. This led to the discovery of the new element by Hevesy and Coster, then working at Bohr's Institute. The element was called hafnium. This development was the subject of a lecture that Niels Bohr gave at the Academy in 1923, entitled "A New Element".

During the last years of the period 1914–1925 Niels Bohr collaborated with an international group of outstanding scientists trying to find new approaches to the quantum theoretical description of atomic states and processes.

A lecture at the Academy in February, 1925, entitled "On the Law of Conservation of Energy" had as its background a paper published in 1924 by Niels Bohr, H.A. Kramers–who was a close collaborator of Bohr during these years—and the American physicist J.C. Slater [9]. This work, "The Quantum Theories of Radiation", took as its point of departure the dualism between the wave theory and the theory of light quanta. The waves were interpreted in terms of a probability field, even if this meant that the formalism developed here—in Bohr's words:

> "would not seem to allow a detailed description of atomic processes which presumes the law of conservation of energy, which occupies a central position in the classical description of Nature."

Shortly afterward, however, Niels Bohr reached the conclusion that these ideas could not be upheld, and an experiment by W. Bothe and H. Geiger did indeed indicate that the law of conservation of energy was valid for the individual atomic processes in question.

5. *Quantum mechanics and complementarity*

In 1925 a decisive breakthrough took place leading to further development of atomic theory and quantum theory, starting with a paper by Werner Heisenberg [10], followed by a long series of other contributions. During this period the Institute on Blegdamsvej was an important centre, and Heisenberg cooperated closely with Niels Bohr and Kramers. Regarding this whole development, and in particular with a view to the paper by Bohr, Kramers and Slater, Heisenberg has given the following evaluation:

> "This investigation represents the actual climax in the crisis of quantum theory, and although it did not show the correct way out of the difficulties, the paper contributed more than any other from this period to the clarification of the situation in quantum theory."

A second investigation of decisive importance, carried out at Bohr's Institute during the period immediately preceding the development of the new quantum mechanics, was Kramers' paper on the dispersion of radiation [11].

The new quantum mechanics was the subject of two lectures by Niels Bohr at the Academy in 1926 and 1927, one entitled "Atomic Theory and Wave Mechanics", the other "The Quantum Postulate and the Recent Development of Atomic Theory", A theory had now been developed on the basis of which it was possible to account quantitatively for the atomic states and the atomic processes in the electron configurations surrounding the nuclei of the atoms, and agreement had been obtained between theory and a broad range of observations.

The dualism between the wave picture and the particle picture entered the theory as an essential feature, closely connected with fundamental observations. To Niels Bohr this dualism became the starting point for an interpretation based on the idea of complementarity. In the lecture by Hendrik Casimir, certain aspects of the fundamental contributions by Niels Bohr to this central area will be discussed.

6. *Nuclear physics*

During the years 1937–1941, Niels Bohr gave a number of lectures at the Academy concerning his work on nuclear reactions (see also the review by B.R. Mottelson in this volume). In these lectures he discussed the problem of the penetration of a neutron into an atomic nucleus. The neutron, being neutral, is not repelled by the positively charged nucleus as is the case with protons or α-particles. The penetrating neutron will quickly lose its energy, which in the process is distributed over the nucleons. In this way what Niels Bohr called a compound nucleus is formed. Next, one possibility is that the neutron binding-energy is emitted in the form of radiation. If that occurs the neutron has been captured by the nucleus, and a new atomic nucleus with the same charge and larger atomic weight has been formed. Or, it may happen that the excess energy is concentrated on one of the nucleons of the compound nucleus which is then emitted. The probabilities corresponding to the two possible processes depend on the properties of the compound nucleus, and these are determined by its charge and weight. Because of the analogy between conditions in a compound nucleus and a drop of liquid, respectively, the model is referred to as the droplet model. It turned out to be of great value for the explanation of a broad category of nuclear processes.

In 1938 Otto Hahn and Fritz Strassmann carried out an experiment in which uranium atoms were bombarded with neutrons. Then, in December, 1938, Lise Meitner and Otto Frisch reached the conclusion that what had occurred in this experiment was a splitting of an uranium nucleus into two about equally heavy atomic nuclei, i.e. a fission of the uranium nucleus took place. Niels Bohr, thereafter, showed that the droplet model could serve as a basis for the explanation of fission. The two known processes, emission of radiation or of a nucleon, respectively, would here be in competition with a third process, namely the fission of the compound nucleus. The probabilities with which the three processes occurred would depend on the atomic weight and charge of the compound nucleus.

Shortly afterwards, it was shown in a paper by Niels Bohr and John Wheeler [12] that neutrons were emitted in connection with the fission process, and that these emissions could cause a chain reaction in the case where the bombarded nuclei belonged to the uranium isotope ^{235}U. However, for the uranium isotope ^{238}U, which on earth has a much higher abundance than the isotope ^{235}U, such chain reactions would not take place. Herewith, the theoretical basis for the future development was essentially given, a development that was to lead to a peaceful application of the release of nuclear energy as well as to the nuclear bomb.

In a lecture at the Academy in November 1939, entitled "The Theoretical Explanation of Fission of Atomic Nuclei", Niels Bohr gave an account of the development. In the lecture, which made a deep impression on the audience, he explained the possibilities of a peaceful use of nuclear energy as well as the terrifying, destructive application. I clearly remember this evening in the Academy, in particular also that Niels Bohr emphasized:

> "The enormity of the technical difficulties connected with the large-scale isotope separation that would necessarily have to precede the production of an atomic bomb."

7. Public affairs and epistemology

Niels Bohr's last lecture at the Academy was given on the occasion of a festive meeting held in October, 1955, to celebrate his seventieth birthday. The lecture, entitled "Atoms and Human Knowledge", was published in the Yearbook of the Academy, 1955–56 [13].

Niels Bohr opened his discourse thus [14]:

> "In the history of science, this century's exploration of the world of atoms has hardly any parallel in so far as the progress of knowledge and the mastery of that nature, of which we ourselves are part, are concerned. However, with every increase of knowledge and abilities is connected a greater responsibility; and the fulfilment of the rich promise and the elimination of the new dangers of the atomic age confront our whole civilization with a serious challenge which can be met only by cooperation of all peoples, resting on a mutual understanding of the human fellowship. In this situation, it is important to realize that science, which knows no national boundaries and whose achievements are the common possession of mankind, has through the ages united men in their efforts to elucidate the foundations of knowledge."

A detailed review of the development of physics followed and concluded thus:

> "Far from containing any mysticism foreign to the spirit of science, the notion of complementarity points to the logical conditions for description and comprehension of experience in atomic physics."

The remaining part of the lecture dealt with questions concerning the general conditions for human knowledge. At the end of the lecture Niels Bohr returned to the theme of the introduction:

> "We have here reached problems which touch human fellowship and where the variety of means of expression originates from the impossibility of characterizing by any fixed distinction the role of the individual in the society. The fact that human cultures, developed under different conditions of living, exhibit such contrasts with respect to established traditions and social patterns allows one, in a certain sense, to call such

cultures complementary. However, we are here in no way dealing with definite mutually exclusive features, such as those we meet in the objective description of general problems of physics and psychology, but with differences in attitude which can be appreciated or ameliorated by extended intercourse between peoples. In our time, when increasing knowledge and ability more than ever link the fate of all people, international collaboration in science has far-reaching tasks which may be furthered, not least by an awareness of the general conditions for human knowledge."

8. Niels Bohr as president of the Royal Danish Academy of Sciences

In March 1939 Niels Bohr was elected president of the Academy, and he served it in this capacity until his death in 1962. Already in 1927, and later in 1934 and 1938, Niels Bohr had been approached with regard to the presidency of the Academy, but he had declined referring to his commitments to research.

The first meeting of the Academy at which Niels Bohr presided took place on October 20, 1939, shortly after the outbreak of the Second World War.

On November 13, 1942, the Academy celebrated its second centenary, and the meeting which took place on that day was, of course, limited in its scope because of the prevailing conditions in Denmark. However, three major Academy publications were presented on the occasion, namely the first volume of the History of the Academy, prepared by the archivist, Asger Lomholt [15], further volume 1 of a work on the topographical survey of Denmark, by N.E. Nörlund [16], and finally a book by Johannes Pedersen [17], the Chairman of the Carlsberg Foundation, on the history and activities of the Foundation. Following these presentations Niels Bohr spoke on the subject of the Academy's place in Danish society [18]:

> "The direct stimulus for the foundation of the Academy arose, as we know, from the need for solving certain specific problems which required a general scientific insight. Also, in the Academy's first century, few organisations existed in this country for the furtherance of science and its applications. In both respects our Academy had an important mission."

Niels Bohr continued:

> "About the middle of the last century this situation had largely changed, since many independent Danish institutions had gradually been established to deal with such tasks. In this development it was not the Academy itself, but many of its leading men who played the decisive part.
>
> The importance of the fact that there existed in our country a permanent centre, not so much for the carrying out of scientific research, but for its general appreciation, can scarcely be overestimated."

Regarding the role and the work of the Academy at the time of its second centenary, Niels Bohr expressed himself as follows:

> "The fact that representatives of widely differing branches of science come to our meetings and take part in all our discussions has given our Academy its special character. The unique opportunity which is given to humanists and scientists to tell each other what they consider important within their own fields, excludes the one-sidedness which may often occur in a larger body where a further division according to

> the spheres of interest is necessary on practical grounds. Although not all branches of learning and research deserving the name of science are represented within the Academy, the contacts made here have definitely had and still have an importance for the harmonious development of scientific efforts in our country, in fact for the whole cultural life of Denmark."

Niels Bohr concluded his speech emphasizing the fact that the Academy had become an increasingly important link in international scientific cooperation.

Through his speech on the occasion of the second centenary of the Academy, in particular through his characterization of the role and the importance of the Academy, Niels Bohr did also clarify the general line which he as president, and in collaboration with the members, had followed and intended to follow during the years to come.

In the middle of the year 1943 Niels Bohr was forced by circumstances to leave Denmark, and he only returned in August, 1945. During his absence the chairmen of the two sections of the Academy—the section of science and the section of history and philosophy—presided over the meetings. The election of a president which, according to the rules of the Academy, should have taken place in the spring of 1944 was postponed, and at an extraordinary meeting in September, 1945 Niels Bohr was re-elected president. Re-elections again took place in 1949, 1954 and 1959, and so Niels Bohr remained president of the Academy until his death in 1962.

Through his efforts in careful planning and preparation of all the meetings over which he presided, Niels Bohr made a great contribution to the Academy. More than that, as president of the Academy he very effectively represented Danish science on important matters.

When UNESCO was established after the Second World War and a National Committee was set up in Denmark, Niels Bohr, on behalf of the Academy, took on the task of advisor to the committee, a task which at that time was of considerable importance.

Of particular importance, however, was an initiative which Niels Bohr took in 1951 in connection with the question of financial support for research in Denmark from the Danish government. In a critical situation in January, 1951, Niels Bohr, as president, proposed that the Academy would make a direct approach to the government. His proposal was unanimously adopted. There is no doubt that this initiative was of decisive importance to the further development which resulted in the establishment of a "National Science Foundation" in Denmark.

At a meeting of the section of science of the Academy in January, 1947, August Krogh, who as an outstanding scientist could speak with great authority, had proposed a radical change of the Academy to be brought about through a large increase in the number of members of the Academy, the aim being the election of many younger scientists. Through such a change the Academy should be put in a position to serve Danish society and to speak more effectively for science. The proposal, in this form, did not win approval by the Academy, and August Krogh then, in January, 1949, chose to relinquish his membership of the Academy.

In this matter the Academy followed Niels Bohr's line, and as a result there was during the following years a moderate increase in the number of members, corresponding to the increased number of people active in research in Denmark.

During the years after 1962 the Academy in its development continued to follow the lines in accordance with Niels Bohr's general ideas. The Royal Danish Academy of Sciences and Letters which Niels Bohr described in his speech before the Academy in 1942 has thus preserved its character and continued its work, and at the same time it has been able to strengthen its activities and position in Danish society.

Following Niels Bohr's death on November 18, 1962, the Academy held a meeting in his memory. Lectures were given by Christian Møller, Léon Rosenfeld and Johannes Pedersen.

Johannes Pedersen concluded with these words:

> "We felt secure and confident having as our leader a man such as Niels Bohr, outstanding in intelligence as well as in character. His memory will live for ever in our hearts, his name will remain for all times an honour to our Academy."

References

[1] N. Bohr, Determination of the surface tension of water by the method of jet vibration, Philos. Trans R. Soc. London 209 (1909) 281–317.

[2] N. Bohr, On the quantum theory of line-spectra I–III, Dan. Vid. Selsk. Skrifter Naturv.-Mat. Afd. 8. Række IV-1 (1918–1922) 1–3.

[3] N. Bohr and L. Rosenfeld, Zur Frage der Messbarkeit der elektromagnetischen Feldgrössen, Mat.-Fys. Medd. Dan. Vidensk. Selsk. 12-8 (1933) 1–65.

[4] N. Bohr and J. Lindhard, Electron capture and loss by heavy ions penetrating through matter, Mat.-Fys. Medd. Dan. Vidensk. Selsk. 28-7 (1954).

[5] L. Rosenfeld, Biographical sketch, in: Niels Bohr, Collected Works, Vol. 1, Early Work (1905–1911), ed. J.R. Nielsen (North-Holland, Amsterdam, 1972).

[6] G. Hevesy to N. Bohr, in: Niels Bohr, Collected Works, Vol. 2, Work on Atomic Physics (1912–1917), ed. U. Hoyer (North-Holland, Amsterdam, 1981) p. 532.

[7] Niels Bohr, Om Atomernes Bygning, Les Prix Nobel en 1921–22 (P.A. Norstedt & Söner, 1923). English translation by Frank Hoyt in Nature 112 (1923) 29; also in: Niels Bohr, Collected Works, Vol. 4, ed. J.R. Nielsen (North-Holland, Amsterdam, 1977) p. 467–482.

[8] C. Møller and M. Pihl, in: Niels Bohr, His life and work as seen by his friends and colleagues, ed. S. Rozental (North-Holland, Amsterdam, 1967) p. 240.

[9] N. Bohr, H.A. Kramers and J.C. Slater, The quantum theories of radiation, Philos. Mag. 47 (1924) 785–802.

[10] W. Heisenberg, Z. Phys. 33 (1925) 879.

[11] H.A. Kramers, Nature 113 (1924) 673–674 and 114 (1924) 310–311.

[12] N. Bohr and J. Wheeler, Phys. Rev. 56 (1939) 426–450.

[13] Niels Bohr, Atoms and human knowledge, Dan. Vid. Selsk. Oversigt (1955–56) 112–124.

[14] English translation by J. Pedersen, in: Niels Bohr, Atomic Physics and Human Knowledge (Wiley, New York, 1958) p. 83.

[15] A. Lomholt, Det Kongelige Danske Videnskabernes Selskab 1742–1942, Samlinger til Selskabets Historie, Bind I (København, 1942).

[16] N.E. Nörlund, Danmarks Kortlægning. En historisk Fremstilling, Bind I: Tiden til Afslutningen af Videnskabernes Selskabs Opmaaling (København, 1942).

[17] J. Pedersen, The Carlsberg Foundation (Copenhagen, 1956).

[18] Quoted in J. Pedersen, Niels Bohr og Det Kongelige Danske Videnskabernes Selskab, in: Niels Bohr, Hans liv og virke fortalt af en kreds af venner og medarbejdere (J.H. Schultz Forlag, København, 1964) pp. 261, 262. English translation in: Niels Bohr, His life and work as seen by his friends and colleagues, ed. S. Rozental (North-Holland, Amsterdam, 1967), the chapter by J. Pedersen, Niels Bohr and the Royal Danish Academy of Sciences and Letters, p. 268–269.