Factsheet Denmark

Niels Bohr

Niels Bohr, the physicist, who was born in Copenhagen on 7 October 1885, is one of Denmark's famous sons and one of the most famous in the history of physics. In his epoch-making contribution towards an understanding of atomic structure and the mechanics of the atom, he made a revolutionary break with classical physics and he thus provided a deeper understanding of the unity of nature.

Niels Bohr was so to speak born into the world of science, as son of Christian Bohr, the physiologist, who was one of the pioneers in biology with its new advances at the turn of the century. Niels Bohr's mother, Ellen Adler, was the daughter of a well-to-do banker, and Niels Bohr grew up in a comfortable and secure upper-middle class atmosphere. However, both his maternal grandfather and his father, Christian Bohr, were to be found at the liberal point of the political spectrum, which was open to impressions from the outside world. Of particular significance to Bohr during his childhood and adolescence were the gatherings in his home, where leading Danish scientists from various scientific fields met regularly for discussions. Later in his life Niels Bohr stated that the significance of these meetings lay not so much in direct influence as in the inspiration it gave to an understanding of the unity there is in all human endeavours to search for knowledge, irrespective of the scientific discipline it came from. Harmony and unity became Niels Bohr's ideal endeavour, both in the field of science and in his own life.

During his childhood and adolescence he was closely attached to his brother Harald, who was later to become a famous mathematician. They were inseparable in their childhood and youth, and as an adult Niels Bohr sought his brother's advice in virtually all matters. During the development of Bohr's theories Harald participated in many discussions and here his mathematical insight was of importance. Niels Bohr's thoughts grew most vigorously when he could try them out in a dialogue with a talented opponent. And he could discuss with Harald better than

Niels Bohr was painted on a number of occasions in his lifetime. This is the earliest known portrait. It was painted by Otto Sievert in 1926 when Bohr was 41 years old. (Museum of National History at Frederiksborg Castle).

with anybody. When he was a student the two brothers made friends with another pair of brothers, Poul and Niels Nørlund, whose sister Margrethe Niels Bohr married in 1912. Poul Nørlund later became curator of the National Museum in Copenhagen and Niels Nørlund became director of the Geodetic Institute in Copenhagen and president of the International Union for Geodetics. A third friend from his youth was Niels Bjerrum, the chemist, who later became chancellor of the Royal Veterinary and Agricultural University in Copenhagen and chairman of the board of the Carlsberg Foundation. A fourth friend was H. M. Hansen, the bio-physicist, later chancellor of the University of Copenhagen. These were lifelong friendships, emphasising Niels Bohr's many-facetted interests.

He also numbered many contemporary artists and writers among his friends, such as William Scharff, Julius Paulsen and Johannes V. Jensen. They met together with numerous other *beaux-esprits* in the summer at Tisvilde in North Zealand where Bohr later had his summer residence. Still today there are scientists throughout the world who count their visits to Tisvilde among their most cherished memories.

Bohr's atomic theory

Towards the close of the 19th century physics was divided into two camps. The lesser, which still refused to believe in the concept of the atom, and the greater, to whom it appealed as a sound working hypothesis. At the turn of the century new discoveries gave clear evidence of the existence of atoms. In 1911 Niels Bohr, who was then 26 years old, travelled to Cambridge on a Carlsberg scholarship, and this was the year when in Manchester Ernest Rutherford carried out his first experiment in breaking into the world of atoms. Already in the following year Bohr was working in Rutherford's laboratory, and he introduced his famous atomic theory only one year later, in 1913. Rutherford's model of the atom was simple. He spoke of the nucleus of the atom as the heavy mass with electrons spinning around it like planets orbiting the sun, and in differing numbers according to the element involved.

There was, however, something in this picture which did not fit, and which was disturbing. At this point Bohr went into action. However convincing Rutherford's model might appear to be, it was disturbing that it could not, in fact, exist for longer than a fraction of a second. Electrons are, after all, electrically charged and must therefore with varying speeds and directions emit electromagnetic waves carrying away energy so that the electrons, because of the energy loss, must spin in shorter and shorter orbits and in the end collapse entirely into the nucleus of the atom. We must bear in mind at the same time that the elements have been stable for millions of years, and Rutherford's atoms would, according to hitherto known physical laws, behave quite differently. After an incredibly short lapse of time they would collapse into virtually the size of the nucleus with catastrophic effects on all matter and all life. Nevertheless, Bohr had absolute confidence in Rutherford's model of the atom. It was not the model there was anything the matter with. The affair was just as simple for Bohr as it was shattering for many physicists: that the classical laws are not valid inside the atoms. Bohr emphasised, on looking back over the development, that such a failure of the mode of description of classical physics when one deals with phenomena on atomic scale, did not come as a surprise. Max Planck had discovered in 1900 that radiation from hot bodies was not emitted continuously but in *packets* of the smallest units of energy, later called *quanta*.

An important prerequisite for Bohr's atomic theory was – apart from Planck's discovery – Einstein's interpretation of the so-called *photoelectric effect*. The effect is the following: when a metal surface is irradiated with light of a certain colour, electrons are emitted at speeds which depend on the colour of the light. Einstein demonstrated that this behaviour was incomprehensible on the basis of the classical concept of light as a spatially extended wave but it was easily explicable if in accordance with Planck's discovery it was assumed that light consists of individual quanta, photons, each having a definite quantity of energy depending on the colour of the light. This quantity of energy carried by the smallest packets, the quanta, is incredibly small. All phenomena in our everyday world are composed of a vast number of quanta, and here there is full agreement with the laws of classical physics. But where the smallest particles of the atom are concerned the dual nature of light – as wave-field and energy-particle – presented a paradox which found its solution only with the creation of quantum mechanics.

Quantum mechanics

In his epoch-making work from 1913 Bohr postulated that electrons can only revolve around nuclei in stationary orbits from which they do not emit light and thus do not suffer loss of energy. When, nevertheless, during experiments the emission of light had been observed, he imagined that this light appeared as a result of electrons jumping from one stationary state to another during the emission of a light quantum. The innermost stationary state is the normal state of the atom, from which electrons are *excited* at high temperatures or by electrical discharges so that they are forced out of their stationary state to return to this state again shortly afterwards. The emission of light ceases when the electron returns to its normal state and the atom therefore remains stable. With this postulate the structure of the atom was indicated and Rutherford's model of the atom was explained and rendered probable. With his postulates Bohr made a decisive break with classical physics, among other reasons because the stationary states are totally excluded in classical electrodynamics. Indeed, the existence of stable, solid matter and bodies like ourselves is inexplicable on the basis of classical physics. With Bohr's theory came the first indication of where the key to the riddle should be sought.

The atomic theory did not represent a logical, coherent description; many of its elements were strung together by intuitive guesses. The creation of the systematic quantum mechanics therefore meant a tremendous step forward. In it mathematical quantities are employed which symbolise the possibilities of transition between the stationary states. Many physicists have in the 1920s inscribed their names in the *Copenhagen School* and thus in the history of physics. However, it was especially the quintet of the two German physicists Werner Heisenberg and Wolfgang Pauli together with the Austrian Erwin Schrödinger and the English physicist Paul Dirac and Niels Bohr who gave quantum mechanics its final form. Heisenberg formulated the description from completely new mathematical viewpoints and reached in this way a final clarification supported by Bohr, who contributed completely new epistemological viewpoints.

The completion of quantum mechanics stretched through to 1927-28 with many dramatic climaxes. Prior to Rutherford/Bohr there had been virtually only the Greek philosopher Democritus' concept of the atom as the smallest particle of matter which could never be observed, never be known through our senses, but could only be conceived through reason. Not only new approaches but also enormously intense cogitation and a new philosophy were called for. When, after the hectic years, the father of the model of the atom, Lord Rutherford, characterised the progress that had been made, he said: "This was truly the triumph of mind over matter, or rather over radiation. Bearing in mind the extremely complex nature of just one single spectrum, before Bohr's contribution I believed it would take a century to grasp the coherence, and yet, led by Bohr's thoughts it was realised in less than a decade." And the great American physicist Robert Oppenheimer said of the same period: "It was not the work of a single individual, but rested on the cooperation between scores of scientists from many different countries. Nevertheless, from first to last it was Niels Bohr's originally creative, penetrating and critical mind which guided, defined, elaborated and finally transformed the entire work."

The concept of complementarity

The fact that light in some respects must be regarded as waves and in other respects as particles was not the only paradox in atomic physics. A corresponding paradox appeared when the concepts of velocity and position were to be described on the atomic scale. It became clear that it is impossible to measure the velocity of a particle and simultaneously determine its position without the particle being influenced by the measuring instruments employed. It is therefore impossible to predict the position of an electron and at the same time determine its velocity. Bohr called the phenomena which are described by the concepts velocity and position complementary because in certain respects they exclude each other, but nevertheless each on its own expresses important aspects of the behaviour of particles. It was Heisenberg's introduction of mathematical formalism and Bohr's analysis based on the concept of complementarity which finally completed the mosaic in the conceptual world of quantum mechanics. Bohr himself strongly emphasised Heisenberg's contribution, but in Heisenberg's own words we get first-hand knowledge of the part Bohr played. Heisenberg wrote: "For an elucidation of the physical principles of the quantum theory we are indebted to Bohr, who not only created through his general philosophic attitude towards the problem of reality, the spiritual atmosphere in which an understanding of the new, strange interrelationships could develop, but also through his own contributions was the first to become

Niels Bohr aged 25 in 1910, just before his first trip to England.

A photograph of Niels and Margrethe Bohr at their golden wedding anniversary in August 1962. They are sitting on the bench in front of their summer house at Tisvilde in North Zealand, where many foreign scientists came to visit throughout the years.

Niels Bohr and Einstein in 1927 in Brussels, where they started a life-long discussion on the scope of classical physics at the Solvay Congress. On their way to and from meetings they eagerly discussed hypothetical examples which could contribute to the solution of the problems raised by modern atomic physics in relation to classical physics.

completely clear about the broader implications of the quantum theory."

Einstein, who had immediately recognised Bohr's atomic theory from 1913 as a unique achievement, could not, however, accept Bohr's concept of complementarity. Even though Einstein had himself demonstrated the dualistic nature of light now appearing as waves, now as particles, he could not accept the radical break with the causal description of classical physics as something final. According to quantum mechanics only statistical evidence of the behaviour of individual particles is possible after many experiments. To which Einstein replied: "Do you think God takes recourse to diceplaying?" Einstein held the view that it must be possible to reach an unambiguous causal explanation of the atomic processes in accordance with the mode of description of classical physics. Although Einstein and Bohr met only on relatively few occasions, their discussions on these questions through letters and scientific papers stretched over a period of 25 years. Einstein proposed hypothetical experiments to refute Bohr, but Bohr parried them all and in the end Einstein had only this argument: "It goes against my instincts as a scientist." Einstein was, however, almost alone in holding this view and today the concept of complementarity in physics is part of the syllabus for students of physics.

For Bohr this point of view developed into a general feature in our description of nature. He pointed to examples to indicate that the idea of complementarity could be fruitful also within the fields of psychology and biology, and he saw in the concept of complementarity a possibility for greater understanding between different cultures and different nations. He stressed that even in everyday psychological experiences we meet the concept of complementarity in a choice between two attitudes which – even though they are mutually contradictory – can nevertheless be justified individually as e.g. the intuitive experience of a feeling as opposed to the conscious analysis of the cause of the feeling.

Bohr emphasised that if a concept like *unity of knowledge* is to have any meaning, all experience, be it science, art or philosophy, must be communicated by our common means of expression. And faced with the vast diversity of cultural forms, we have to look for those features in all civilisations which have their roots in our common human situation. "It becomes immediately obvious," he said, "that in itself the position of the individual in society possesses numerous, often mutually exclusive facets, which immediately lead to a mere discussion of the scope of concepts such as justice and mercy. All human societies seek to unite such concepts but there is no possibility of the free expression of mercy if the laws of the land are followed slavishly." Bohr pointed out, with reference to the writers of Greek tragedy, that it is equally correct that pity can bring us all in conflict with any clearly formulated view of justice. This was where Bohr added his favourite statement: "Here we are faced with complementary phenomena related to the human condition which, in an unforgettable way, is expressed in ancient Chinese philosophy which reminds us that in the great drama of life we are both actors and audience."

Niels Bohr and the Secretary-General of the United Nations Dag Hammarskjöld photographed together in 1954 at the bicentenary of Columbia University, where both were awarded honorary doctorates.

The brothers Niels and Harald Bohr in 1934. Few brothers in the history of science have been as close to each other as these two. Whenever Niels Bohr encountered a deep mathematical problem, he sought advice from Harald, who had made a name for himself in the world of international mathematical research. In their youth both Niels and Harald were keen footballers. Harald played for Denmark and was a silver medallist at the Olympic Games in London in 1908.

In 1948 Bohr visited the Institute for Advanced Studies at Princeton which was led by Dr. Robert Oppenheimer, who was in control of the atom bomb project during the war. Here Bohr is seen together with Oppenheimer and the prominent Japanese physicist, Professor Yukawa and his wife.

In 1954 Bohr was again a guest at the Institute for Advanced Studies at Princeton, where this picture was taken. Closest to Bohr is Professor James Franck, beside him is Einstein, and on the arm of the sofa sits Professor Isidor Rabi.

The Nazi challenge

When Hitler came to power, Bohr contributed to rescuing as many scientists as possible from the Nazi threat. His contribution was of inestimable value. He undertook a trip throughout Germany to locate those scientists among his colleagues who could expect to be dismissed from their posts as a consequence of the new racial discrimination laws, and soon his institute in Copenhagen became a transit camp to the free world for many men and women. All those for whom he was able to obtain financial support and employment in Denmark stayed as long as possible, and for others he found places in Sweden, Great Britain and the USA. He exploited all his contacts to help, first and foremost Jewish refugees, but also scientists who from a political point of view had become homeless in Germany.

At the end of 1938 the great event in nuclear physics was uranium fission and the release of atomic energy. This occurred during the study of radioactive products in the laboratory of Otto Hahn, the chemist, in Hitler's Germany. Where earlier nuclear processes – or transformation of elements – had involved the emission of single nuclear particles or very light nuclei, here it was a matter of breaking up the whole nucleus into two fragments. On the basis of Bohr's model of the nucleus as a revolving drop of liquid the fissionary process could clearly be determined, and on 1 September 1939, the date of the outbreak of World War II, Bohr's and J. A. Wheeler's article was published. In this article a detailed analysis of the fissionary process was given and it was demonstrated that fission occurred not as a result of the ordinary Uranium 238 but as a result of the rare Uranium 235. In the very same year Bohr mentioned the possibility of a bomb, but comforted himself with the fact that separation of the two isotopes of uranium would involve insuperable technical problems.

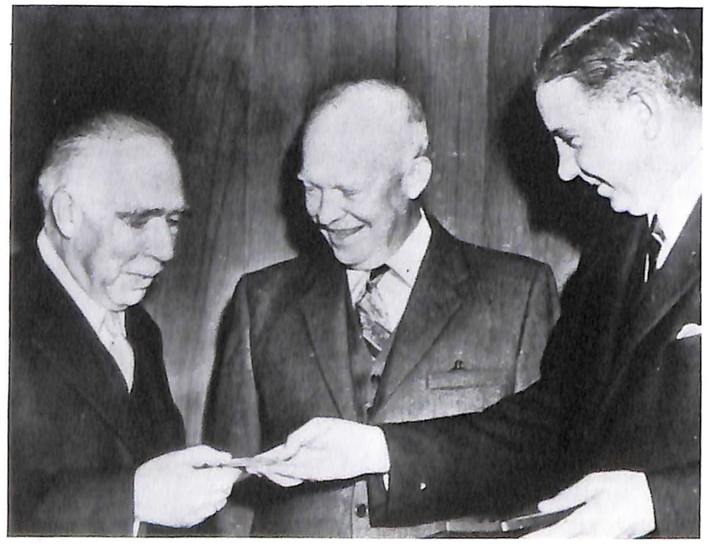
On the occupation of Denmark, Bohr was offered posts both in the USA and in Great Britain. He was promised the best research conditions and all the resources he needed and the American embassy in Denmark offered to assist him in leaving the country. However, he felt that he should remain in Denmark as long as he could be of any help. As a Dane, he felt he would be letting Denmark down by leaving. He showed his deep roots in Danish cultural life in the introduction to *Dansk Kultur ved Aar 1940* (Danish Culture by the Year 1940). The book was published in 1941 by the Danish Institute, the foundation of which Niels Bohr had keenly assisted as an expression of the Danish attitude towards the occupational power.

At the beginning of 1943, when relations with Germany had become extremely tense, he was still unable to decide whether he should leave the country. Then he received a secret message from Great Britain conveyed by British Intelligence. It came from Bohr's old friend, James Chadwick, the physicist, who later proved to be one of the leading figures in the British atomic energy project. He earnestly requested Bohr to come to Great Britain and it could be read between the lines that there were special problems that Bohr could be instrumental in solving. Bohr understood which special problems were being hinted at and in his reply stated that he wished strongly to be able to contribute to the common cause in the fight for freedom and human dignity, but: "In this, our desperate plight, I feel it is my duty to help in resisting the threats against our free institutions, and in protecting the exiled scientists who have sought asylum here. However, neither such duties, nor the danger of reprisals against my colleagues and members of my family would be sufficient to stop me if I felt I could really be of help in some other way, but that is

Bohr together with his two grandchildren in 1954. Bohr took great pleasure in playing with the youngest generation and always knew how to encourage them. He was often heard calling out: "How clever you are!"

hardly likely. Especially do I feel convinced that irrespective of what the future might hold, use of the latest wonderful discoveries in the field of nuclear physics is hardly possible in the immediate present."

Only a few months after his reply to Chadwick rumours reached Copenhagen of the production of metallic uranium and heavy water on a massive scale in Germany. Bohr immediately informed Chadwick of this. Now there were fears that Hitler would produce the atom bomb. In the letter, which was once again forwarded through the Intelligence Service, Bohr discussed the possibility of employing chain reactions with slow neutrons for the production of atom bombs. But he doubted whether there would be sufficient resources to separate U 235 from the vast quantity of Uranium 238 isotopes that would be necessary. He had no way of knowing that even before Pearl Harbour had led the USA to entering the war, the Americans had initiated separation in gigantic plant.



In 1957 Niels Bohr was awarded the Ford Foundation's Atoms for Peace prize which was handed to him in the presence of President Eisenhower.

Many foreign heads of state who have visited Denmark have at the same time visited Niels Bohr at the Carlsberg Honorary Residence. The picture is from President Nehru's visit at the end of the 1950s.

Escape

Shortly after this, at the end of September 1943, the Swedish ambassador in Copenhagen revealed to Bohr that the Germans were on the point of arresting him. The Danish Resistance Movement had already been alarmed and on the night of September 30 it arranged Bohr's safe passage to Sweden. Bohr had understood that the Germans would also start an action against all Jews in Denmark and the first thing he did on arrival in Stockholm the day after his escape was to visit the Swedish foreign minister and also the King. It turned out that the Swedish government had already informed the German government that the Swedish population would strongly resent an action against the Danish Jews. The reply from Germany was that it was all rumours. Nevertheless, on the night of 2 October the Germans arrested several hundred Danish Jews and herded them on board ships in the harbour of Copenhagen from where they were to be transported to Germany. Bohr ensured a Swedish request to Hitler to allow for the ships to be redirected to Sweden instead of Germany. The answer was no. In a final attempt Bohr prevailed upon the Swedish government to send a radio broadcast to the effect that Sweden was ready to receive the Danish refugees. As many of the refugees in Denmark had no idea as to whether Sweden would receive them or not, the radio broadcast may have been instrumental in saving them. Simultaneously with the radio broadcast Sweden sent ships to the limit of Swedish territorial waters in the Sound where they picked up refugees from the Danish boats which could then quickly return to collect new cargoes of refugees. All in all the Resistance Movement succeeded in getting over 5,000 Danish Jews across to Sweden. In more than one way Bohr had to fight against time as in Great Britain a Mosquito airplane waiting to collect him was held back only until a storm over Scotland settled down. Stockholm was crawling with German spies and all those involved feared that the Germans could catch Bohr at any moment, but Bohr managed to reach Great Britain safe and sound. The following night a different Mosquito airplane with courier mail was shot down by the Germans.

On arrival in London Bohr was greatly surprised to learn how far the atomic projects had developed. As a matter of fact it was the British progress that had seriously pushed the Americans ahead, but as the Americans could manage on their own, Anglo-American cooperation had dried up. After the meeting between Churchill and Roosevelt in Quebec in the late summer of 1943, cooperation became more effective and Bohr's arrival in London, and later in the USA, contributed greatly to closer cooperation. In October 1943 many British physicists went to the USA and Niels Bohr and his son Aage formed part of the British group. When Bohr arrived at Los Alamos he met many of the physicists he had

In 1960 Niels Bohr was made an honorary member of the Danish Students' Association at Copenhagen. Here he is seen on the speaker's rostrum at the University.

himself helped to escape from Europe. The Manhattan project impressed him profoundly. He admired the almost incredible achievements, but at the same time, he became more and more concerned with the problems which would most certainly arise once the atom bomb was a fact, and he immediately raised the question of future effective control. This he did in a letter to the Chancellor of the Exchequer, Sir John Anderson, who was responsible for the British atomic energy project and with whom he had discussed the question of an open world already in London. Control, he wrote now, should comprise not only administrative and technical problems on a broad scale but also an exchange of information and an openness about the industrial effort and military preparations of such a nature that control measures would stretch far beyond pre-war international relations.

An open world

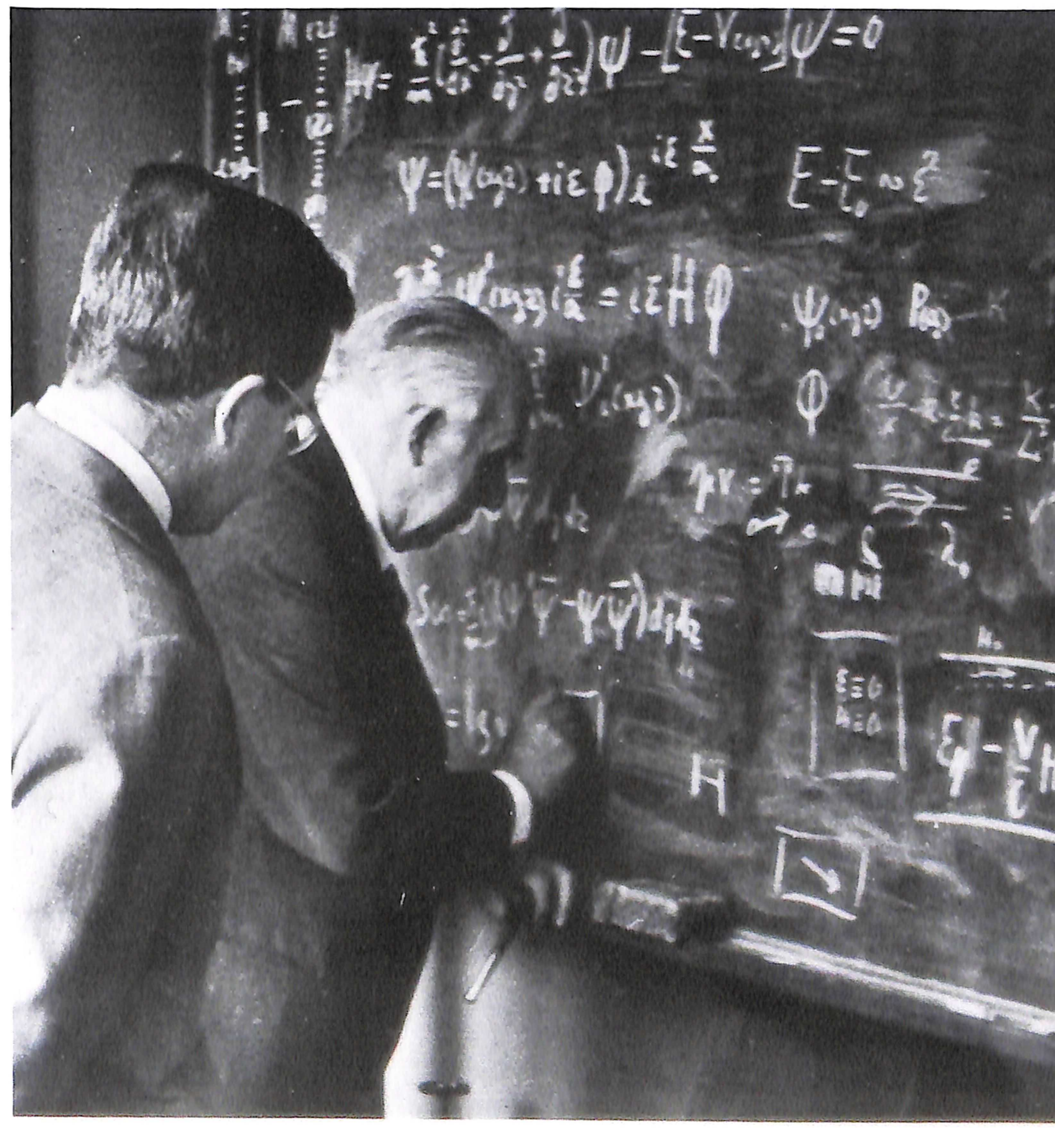
Niels Bohr made every human endeavour to awaken interest in an open world. He managed to get two interviews with Roosevelt who was deeply impressed by his ideas. Afterwards Roosevelt spoke enthusiastically of "a new era in the history of mankind". Bohr's principal idea was that the USA and Great Britain should inform Stalin of the atom bomb and its perspectives. This had to be done before the bomb was dropped. Roosevelt favoured the idea, and believed that Stalin was enough of a realist to understand what the scientific and technical revolution would involve. Failure to inform Stalin would, in Bohr's opinion, nourish the suspicion existing between nations before the alliance against Hitler. Roosevelt urged Bohr to raise the matter with Churchill to get his suggestion of how to cope with this important issue. Bohr's meeting with Churchill took place just prior to D-Day which Churchill was so occupied with that he was hardly aware of the scope of Bohr's message. Shortly after this meeting an extremely unfortunate event occurred. Churchill misinterpreted a letter which the Russian physicist Kapitza had sent to Bohr, inviting Bohr to the Soviet Union. The letter had first been sent at the time when Bohr had arrived in Sweden after his escape from Denmark, but only reached Bohr much later in London. Even though Bohr informed British Intelligence of this, Churchill regarded Bohr as both untrustworthy and dangerous. At the meeting between Roosevelt and Churchill shortly afterwards the thought of an open world was completely dropped. Roosevelt was by then so weakened by illness that he did not have the energy to break down Churchill's resistance which undoubtedly was most of all based on his distrust of Stalin's good will. The last speech Roosevelt dictated but did not manage to deliver before his death was, however, clearly inspired by Bohr.

Niels Bohr was at Los Alamos for eight months altogether. With his practical sense for experimental work he also contributed to, among other things, the design of the part of the bomb which started the chain reaction. However, just as he felt it was his obvious duty to contribute to developing the bomb, to be one step ahead of Hitler, he felt at the same time it was his duty to contribute to ensuring that atomic energy would be employed by mankind solely for peaceful purposes after the war. While still in the USA he sought out virtually every influential politician and this he did also in London on his frequent trips to Great Britain from the USA during the war. After the nuclear tests, the armed forces sought the advice of a panel of scientists. Should the bomb be exploded over Japan?

In 1959 Darwin's grandson, C. G. Darwin, visited Niels Bohr. In a way it was C. G. Darwin who accelerated Bohr's first work on atomic theory. When Bohr in Cambridge in 1911 came across a thesis by C. G. Darwin, he proved errors in it and this took him further in his own work. The two became life-long friends.

Niels Bohr also often received visits by royalty at the Carlsberg Honorary Residence. Here he is seen together with Queen Sirikit of Thailand who visited him together with Queen Ingrid.

At the Carlsberg Honorary Residence Bohr had a little study with a large blackboard on which he often wrote up his equations. Here he is seen in 1959 together with his son Aage, who is also a Nobel Prize winner in physics and today heads the Niels Bohr Institute in Copenhagen.



Bohr never participated in these military discussions. He was solely concerned with the thought of getting the Allies to agree on controls which would prevent the atom bomb from ever being used after the war. And he considered it an unfortunate mistake that it was used against Japan.

Time – and the politicians – did not work in Bohr's favour. When the Cold War succeeded World War II, Bohr sent a memorandum to General Marshall which said that the gloomier the prospects of international cooperation, the more it was necessary that a case be made which could appeal to the highest ideals of mankind: openness and free access to information on all aspects of life in every country. Two years later, in 1950, Bohr sent his *open letter* to the United Nations. It contained the memoranda he had sent to Roosevelt and Marshall. Everywhere in the West the reactions were virtually all negative. Everybody was concerned with the Korean War, and those who saw the seriousness of the situation felt powerless to do anything. It might well be regarded as evidence of the sporadic interest that politicians still took in his ideas that he was the first to be awarded the *Atoms for Peace* prize in 1957. The prize was handed to him in the presence of President Eisenhower at a time when Soviet resistance against joint control was very strong. Today, 35 years after his open letter, peace movements throughout the world understand Bohr's thoughts.

Central figure

In the post-war years Bohr's institute in Copenhagen grew as an international centre where over the years more than 500 foreign physicists stayed for longer or shorter periods of time. He participated actively in the establishment of the European Centre for Nuclear Research in Geneva, CERN, whose theoretical group was attached to his institute. When the group could be transferred to Geneva it was succeeded in Copenhagen by the Nordic Institute for Theoretical Atomic Physics, Nordita.

Niels Bohr was awarded every conceivable honour for his scientific work. He was awarded the Nobel Prize as early as 1922, and in 1931 was given the Carlsberg Honorary Residence. From 1939 until his death he was president of the Royal Danish Academy of Sciences in Copenhagen. He received honorary doctorates from 30 universities and was an honorary member of 24 academies and other scientific institutions throughout the world. He was an honorary citizen of Narssaq in Greenland, and was awarded numerous foreign and Danish orders and he was one of the few, who was neither head of state nor member of a Royal family, to receive the Danish Order of the Elephant.

Having many interests and actively participating in everything that interested him, he became a central figure in the cultural life of the nation. It became a tradition that state visitors, whether politicians or royalty, were received at the Carlsberg Honorary Residence. He participated in these official activities first and foremost to get the opportunity of meeting and talking to everyone who could spread his thoughts about an open world.

In spite of being so busy, Bohr never ceased to follow developments within the fields of physics and biology with a keen interest. During the weekly scientific discussions at the institute, he was not only an intensely interested listener but often with his comments was instrumental in starting stimulating debates. His last unfinished work was his thesis *Liv og Lys påny* (Life and Light anew) in which he elaborates on some of his earlier ideas concerning the role of the concept of complementarity in biology in the light of the fantastic development within molecular biology.

A group concerned with the history of physics worked at Carlsberg under the leadership of the American Thomas S. Kuhn during the last months of Bohr's life in order to gather material for a collection of studies in nuclear physics. In this connection Thomas Kuhn had Bohr's own account recorded on tape. However, the recordings remained incomplete. Having made only the first five tapes Bohr died on 18 November 1962 at the age of 77.

In 1947 Niels Bohr was created a Knight of the Order of the Elephant. He was one of the few Danes who was not a member of the Royal Family to be awarded this honour. It involved the hanging of his coat of arms at Frederiksborg Castle. As the motif of the coat of arms Niels Bohr chose the Tao symbol Yin and Yang, two equal-sized figures which together form a circle. Above the symbol are the words: Contraria sunt complementa, *which are the key words to the solution of the theory of quantum mechanics and Niels Bohr's philosophy of life. The words in translation mean:* Opposites are complementary. *The two opposite elements Yin and Yang complement each other, and together they form the world. Yin and Yang each encloses a point of the other's colour as a symbol that each of them contains within itself the germ of its antithesis, that each of them is a prerequisite for the other. Thus the sign is also a symbol for the rest of us of Niels Bohr's human and scientific attitude. Harmony and unity are preconditions for our being and knowledge. (Museum of National History at Frederiksborg Castle).*

Niels Blædel

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