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Niels Bohr - A survey of some of his contributions  
to science and international co-operation

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**NIELS BOHR AND THE SPIRIT OF CO-OPERATION**

by

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(The views expressed by the author do not necessarily  
reflect the standpoint of Unesco.)

Niels Bohr was not only the great scientist whose work marked an epoch in physics and the philosophy of science; he was a great man. He was convinced that scientists should fight for a harmonious world, for peace and international understanding. He was one of the first who recognized the value of co-operation for the progress of civilization -- and he never spared efforts to this end. In his wisdom and understanding of the future, Niels Bohr was certainly far ahead of most statesmen.

There are evidences that Bohr realized the advantages of co-operation in physics during his work in Rutherford's laboratory, where many talented physicists from several countries were working at that time. He believed in the importance of international co-operation in physics for the solving of difficult problems.

In 1913, in a remarkable paper, Niels Bohr introduced a new concept, that of the quantum state; he developed the theory of quantum orbits, including the mechanism of transition between them. This paper was a landmark in physics. It was followed by many others, which in ten years explained atomic structure and spectral regularities as well as (at the same time) the laws governing the properties of chemical elements and the Mendeleev table of elements. Einstein wrote in his Autobiographical Sketches: "I always felt it was a miracle that this shaky and contradiction-ridden foundation was enough to enable Bohr, a man with brilliant intuitiveness and a fine flair, to discover the basic laws of the spectral lines and electron shells of atoms, explaining their importance for chemistry. I still consider it a miracle today. It is supreme melodiousness in the realm of thought."

Bohr's theory used the correspondence principle, which establishes a relation between quantum regularities and their description in terms of classical physics. As we know now, the problem was that the correspondence principle was not formulated in

mathematical form -- while the interpretation of orbits and quantum transitions was still lacking. In other words, there was no quantum mechanics, and Bohr understood this formidable problem.

Fortunately, by this time (1921-1922), the Institute for Theoretical Physics in Copenhagen began its work under Bohr's leadership. The Institute became famous for its role in the development of quantum mechanics and its interpretation. But the Institute became, very soon, also a brilliant example of fruitful international collaboration in science. With the foundation of the Institute, Bohr got an opportunity to bring to life his ideas about the importance of international co-operation in science. He invited the most active physicists from many countries, and he worked in close collaboration with them.

Bohr believed that the immense task to understand completely quantum theory could be accomplished only through the concentrated efforts of the best physicists of the world. It was to this end that he organized such unique collaboration. His personality brought a great impact on the whole atmosphere at the Institute: its discussions, its intellectual level, its democratic climate. Bohr created his special style, the Kopenhagener Geist, which left a deep impression on the physics community. It would not be an exaggeration to say that Bohr wanted to see an international community in physics united and strong -- more like an international fraternity. The spirit of co-operation that Bohr wished to introduce on a worldwide scale was for him a part of the Spirit of Copenhagen.

The success of Bohr and the Copenhagen group in understanding quantum physics was, at the same time, the success of the spirit of co-operation. It was clearly demonstrated to the whole scientific community that international collaboration in science can lead to outstanding progress. Thanks to Bohr, an international community in physics emerged by the end of the 20th century as a body in being. With his grasp of reality and his humanistic approach, Niels Bohr insisted on the importance of co-operation in all domains of science because he considered science as a human activity of the greatest value. He stressed that "... international co-operation in science



was important in an even broader context". (According to Bohr, co-operation in the natural sciences, more than in history or economics, promotes greater mutual understanding and co-operation between peoples of the world. He considered international scientific co-operation as a means of overcoming individual national or political prejudices. Already in 1922, Bohr concluded his Nobel speech by a toast to the "vigorous growth of the international work on the advancement of science".

It was natural therefore that, when physicists began to flee from Nazi Germany, many of them chose to go first to Bohr for help.

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Later, Niels Bohr was one of the first to realize the urgency of large-scale, international co-operation in physics. He was one of the founders of NORDITA, and he participated in the organization of CERN. Bohr repeated that new scales of energy cannot be usefully (or economically) investigated by individual countries.

When the first atomic bomb had not yet been created, its feasibility was already evident to Bohr. He evaluated its political consequences and brought his views to the attention of the American and British governments. Bohr wrote in a memorandum to President Roosevelt, dated 3 July 1944: "Ever since the possibilities of releasing atomic energy on a vast scale came in sight, much thought has naturally been given to the question of control, but the further the exploration of the scientific problems concerned is proceeding, the clearer it becomes that no kind of customary measures will suffice for this purpose and that especially the terrifying prospect of a future competition between nations about a weapon of such formidable character can only be avoided through a universal agreement in true confidence". We find in these words, for the first time, the question of control, with its difficulties, the necessity of a universal agreement, and the word "confidence".

It was as early as this that Bohr launched the idea that the A-bomb might start a new era in international relations necessary to preserve civilization: "The establishment of effective control measures will of course involve intricate technical and administrative problems, but the main point of the argument is that the accomplishment of the project would not only seem to necessitate but should also, due to the urgency of mutual confidence, facilitate a new approach to the problems of international relationship".

The closer came the date of an A-bomb explosion, the more energetic became the warning by Bohr -- that measures should be taken to avoid competition and to introduce control. In a memorandum dated 24 March 1945 (and found later on the table of President Roosevelt, after his death on 12 April 1945), Niels Bohr wrote: "Humanity will ... be confronted with dangers of unprecedented character unless, in due time, measures can be taken to forestall a disastrous competition in such formidable armaments and to establish an international control of the manufacture and use of the powerful materials".

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Immediately after Hiroshima, Bohr published in the Times of London an article, "Science and Civilization" (11 August 1945), in which he repeated publicly his proposals for control measures and for a new type of international relations. (See also his article in Science, in August 1945). But no statesman in the United States and Britain responded favourably to Bohr's appeal. As it is well known, his attempt to explain the problem to Churchill was almost a disaster. But Bohr did not let slip any opportunity to explain to the world the urgency of co-operation of a new type. Later, in an open letter to the United Nations dated 9 June 1950, he formulated his position in the following manner: "The necessity of a readjustment of such (international) relations was even further accentuated by the great scientific and technical developments which hold out bright prospects for the promotion of human welfare, but at the same time have placed



formidable means of destruction in the hands of man... The fact that this challenge to civilization presents the nations with a matter of the deepest common concern should offer a unique opportunity for seeking continued co-operation on vital problems."

In this famous message to the United Nations, Bohr proposed a new possible model of the world: an open world, a world of co-operation. He himself felt that his ideas might appear utopian, in that the changing of international relationships in recognition of a new situation requires from governments the revolutionizing of standard approaches.

At that time Bohr's struggle for peace and new ways and means of co-operation for avoiding mortal menaces to civilization was "a one-man campaign", as qualified by Victor Weisskopf. Now, many millions of people realize the perils of nuclear war and share Bohr's ideas.

In this situation, Bohr's appeal for a co-operative spirit in international relations, for mutual confidence, for disarmament, and for global international scientific co-operation reflects the present-day imperatives of the world.

A world without nuclear wars, a world living in a harmonious relationship between countries, animated by a profound spirit of co-operation -- this is Bohr's ideal of the future, and an ideal for which we all agree to make a maximum of effort, now and in the years to come.