Topic Page: Bohr, Niels, 1885-1962

Definition: **Bohr, Niels 1885-1962,** from *Dictionary of Energy*

Danish physicist who identified the fundamental structure of atoms and laid the groundwork for the field of quantum mechanics, which underlies modern physics. He escaped Denmark during the Nazi occupation and eventually worked on the Manhattan Project in the U.S. He later became a leading advocate for the peaceful use of atomic energy.

Image from: **Niels Bohr** in *The Cambridge Dictionary of Scientists*

Summary Article: **Bohr, Niels Henrik David (1885-1962)**
From *The Hutchinson Dictionary of Scientific Biography*

Place: Denmark

Subject: biography, physics

Danish physicist who established the structure of the atom. For this achievement he was awarded the 1922 Nobel Prize for Physics. Bohr made another very important contribution to atomic physics by explaining the process of nuclear fission.

Bohr was born in Copenhagen on 7 October 1885. His father, Christian Bohr, was professor of physiology at the University of Copenhagen and his younger brother Harald became an eminent mathematician. Niels Bohr was a less brilliant student than his brother but a careful and thorough investigator. His first research project, completed in 1906, resulted in a precise determination of the surface tension of water and gained him the gold medal of the Academy of Sciences. In 1911, he was awarded his doctorate for a theory accounting for the behaviour of electrons in metals.

In the same year, Bohr went to Cambridge, England, to study under J J Thomson, who showed little interest in Bohr's electron theory so, in 1912, Bohr moved to Manchester to work with Ernest Rutherford, who was making important investigations into the structure of the atom. Bohr developed models of the atom in which electrons are disposed in rings around the nucleus, a first step towards an explanation of atomic structure.

Bohr returned to Copenhagen as a lecturer at the university in 1912, and in 1913 developed his theory of atomic structure by applying the quantum theory to the observations of radiation emitted by atoms. He then went back to Manchester to take up a lectureship offered by Rutherford, enabling him to continue his investigations in ideal conditions. However, the authorities in Denmark enticed him back with a professorship and then built the Institute of Theoretical Physics in Copenhagen for him. He became director of the institute in 1920, holding this position until his death. The institute rapidly became a centre for theoretical physicists from throughout the world, and such figures as Wolfgang Pauli and Werner Heisenberg developed Bohr's work there, resulting in the theories of quantum and wave mechanics that more fully explain the behaviour of electrons within atoms.

The year 1922 marked not only the award of the Nobel Prize for Physics but also a triumphant vindication of Bohr's atomic theory, which he used to predict the existence of a hitherto-unknown element. The element was discovered at the institute and given the name hafnium.

In the 1930s, interest in physics turned towards nuclear reactions and in 1939 Bohr proposed his liquid-

droplet model for the nucleus that was able to explain why a heavy nucleus could undergo fission following the capture of a neutron. Working from experimental results, Bohr was able to show that only the isotope uranium-235 would undergo fission with slow neutrons.

When Denmark was occupied by the Germans in 1940 early in World War II, Bohr took an active part in the resistance movement. In 1943, he escaped to Sweden with his family in a fishing boat - not without danger - and then went to the UK and on to the USA. He became involved in the development of the atomic bomb, helping to solve the physical problems involved, but later becoming a passionate advocate for the control of nuclear weapons. Among his efforts to persuade politicians to adopt rational and peaceful solutions was a famous open letter addressed to the United Nations in 1950 pleading for an 'open world' of free exchange of people and ideas.

In 1952 Bohr was instrumental in creating the European Centre for Nuclear Research (CERN), now at Geneva, Switzerland. He died in Copenhagen on 18 November 1962. In addition to his scientific papers, Bohr published three volumes of essays: *Atomic Theory and the Description of Nature* (1934), *Atomic Physics and Human Knowledge* (1958), and *Essays 1958-1962 on Atomic Physics and Human Knowledge* (1963).

Bohr's first great inspiration came from working with Rutherford, who had proposed a nuclear theory of atomic structure from his work on the scattering of alpha rays in 1911. It was not, however, understood how electrons could continually orbit the nucleus without radiating energy, as classical physics demanded. Ten years earlier Max Planck had proposed that radiation is emitted or absorbed by atoms in discrete units, or quanta, of energy. Bohr applied this quantum theory to the nuclear atom to explain why elements emit radiation at precise frequencies that give set patterns of spectral lines. He postulated that an atom may exist in only a certain number of stable states, each with a certain amount of energy; the emission or absorption of energy may occur only with a transition from one stable state to another. Electrons normally orbit the nucleus without emitting or absorbing energy. When a transition occurs, an electron moves to a lower or higher orbit depending on whether it emits or absorbs energy. In so doing, a set number of quanta of energy are emitted or absorbed at a particular frequency. Bohr developed these ideas to show that the nuclei of atoms are surrounded by shells of electrons, each assigned particular sets of quantum numbers according to their orbits. Bohr's theory was used to determine the frequencies of spectral lines produced by elements and succeeded brilliantly. It also enabled him to explain the groups of the periodic table in terms of elements with similar electron structures, which led to the prediction and discovery of hafnium.

In developing a model for the nucleus, Bohr conceived of the nuclear particles being pulled together by short-range forces rather as the molecules in a drop of liquid are attracted to one another. The extra energy produced by the absorption of a neutron may cause the nuclear particles to separate into two groups of approximately the same size, thus breaking the nucleus into two smaller nuclei - as happens in nuclear fission. The model was vindicated when Bohr correctly predicted the differing behaviour of nuclei of uranium-235 and uranium-238 from the fact that the number of neutrons in each nucleus is odd and even respectively.

Niels Bohr gained not only a love of science from his father but also a philosophical insight into the nature of knowledge that enabled him to question accepted theories and seek new explanations. By reconciling Rutherford's nuclear model of the atom with Planck's quantum theory, he was able to produce a valid model for the atom completely at odds with classical physics. However, this did not

prevent him from using a classical model to explain the structure and behaviour of the nucleus. Our present knowledge of the atom and the nucleus thus rests on the fundamental discoveries made by Bohr's restless and ingenious mind.

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