

Epistemological Dimensions in Niels Bohr's Conceptualization of Complementarity

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typical textbook presentations

Led by the empirical fact of the dual nature of matter, Bohr has elevated this program to a *principle of complementarity*. Wave and particle nature are considered complementary aspects of matter. Both are equally essential for a full description, and, although they may appear to be mutually inconsistent, they are assumed capable of coexistence.

Merzbacher, 1961
page 7

Thus, in any given measurement, either the particle aspect will be displayed or the wave aspect, but not both together. This principle of complementarity was formulated by Bohr.

Ohanian, 1990
page 15

The so-called **wave-particle duality**, which Niels Bohr elevated to the status of a cosmic principle (**complementarity**), makes electrons sound like unpredictable adolescents....

Griffiths, 2005
footnote, page 420

Bohr's actual words

On one hand, the definition of the state of a physical system, as ordinarily understood, claims the elimination of all external disturbances. But in that case, according to the quantum postulate, any observation will be impossible, and, above all, the concepts of space and time lose their immediate sense. On the other hand, if in order to make observation possible we permit certain interactions with suitable agencies of measurement, not belonging to the system, an unambiguous definition of the state of the system is naturally no longer possible, and there can be no question of causality in the ordinary sense of the word. The very nature of the quantum theory thus forces us to regard the space-time coordination and the claim of causality, the union of which characterizes the classical theories, as complementary but exclusive features of the description, symbolizing the idealization of observation and definition respectively.....the quantum postulate presents us with the task of developing a “complementarity” theory.....

Bohr, 1927
from the published
version of the Como
lecture

some observations

- complementarity is **not** a “principle”
- the fundamental complementarity in Bohr’s thinking is between space-time coordination and causality
- Bohr’s argument rests on two premises, one physical and one epistemological
- Bohr’s real question here is about what we can know, i.e. the possible content of physical theory
- Bohr’s ideas are not equivalent to the Copenhagen Interpretation of quantum theory

more words of Bohr (1929)

....we may notice the role which the elucidation of the laws of mechanics has played in the development of the general theory of knowledge
....our experience in recent years has brought to light the insufficiency of our simple mechanical conceptions and, as a consequence, has shaken the foundation on which the customary interpretation of observations was based, thus throwing new light on old philosophical problems.

....we are concerned with the recognition of physical laws which lie outside our ordinary experience and which present difficulties to our accustomed forms of perception.

We come here upon a fundamental feature in the general problem of knowledge, and we must realize that, by the very nature of the matter, we shall always have last recourse to a word picture, in which the words themselves are not further analyzed. As emphasized in the article, we must, indeed, remember that the nature of our consciousness brings about a complementary relationship, in all domains of knowledge, between the analysis of a concept and its immediate application.

further evidence

- the influence of Harald Høffding on Bohr's thinking
- Bohr's writings on the application of complementarity to problems of psychology and biology
- Bohr's reply to the EPR paper
- work on subsequent refinements of the ideas
- exegesis of Bohr by philosophers (e.g. Folse, Petersen, Faye, and MacKinnon)

examples

Throughout his career Niels Bohr manifested an abiding concern with the foundational problems generated by atomic physics and quantum theory. This concern gradually led him from a consideration of particular theories and concepts to the more general question of the nature of concepts and the way they function to make descriptions and explanations possible.

E. MacKinnon

Guided by the insight into description problems provided by quantum physics, Bohr again set out to investigate general epistemological problems and paradoxes. As before, these investigations took the form of tracing and analyzing logical analogies.

A. Petersen

both excerpts from the Bohr centenary volume, 1985