A PORTRAIT OF BOHR CAPTURES HIS LIFE AND TIMES

Niels Bohr's Times, in Physics, Philosophy, and Polity

Abraham Pais
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Reviewed by Roger H. Stuewer

Abraham Pais has now complemented his biography of Albert Einstein (*Subtle is the Lord . . .*, Oxford U. P., New York, 1982) with one of Niels Bohr. That he would be motivated to do so was inevitable because, as he notes, he is perhaps the last of those who knew both "rather well personally in their later years." As only he can, Pais devotes one chapter in the present book to an insightful comparison of the two men. But his task was very different for each man: Einstein's name has become a household word, Bohr's has not. Even many physicists today do not know what Bohr "really did," as Pais discovered when talking to a friend in the early 1980s. Thus he chose a broad canvas for his portrait, setting Bohr's life and work in the context of the physics of his time and in the context of Danish history and society.

Pais traces Bohr's ancestry back to the 18th century and describes how his father, Christian, a distinguished physiologist at the University of Copenhagen, and his mother, Ellen, née Adler, the daughter of a wealthy Jewish banker and politician, created a family environment of great security and comfort for their three children, Jenny (born in 1883), Niels (born in 1885) and Harald (born in 1887). Though the Bohrs were not a religious family, all three children, on their mother's suggestion, were baptized in 1891 into the Lutheran church. Niels resigned his membership in 1911, shortly before his marriage to Margrethe Nørlund. Based upon his extensive research and personal knowledge, Pais shows just how profoundly Bohr's childhood and family environment, his inseparability from his brother, his life with Margrethe and their six sons and his deep roots in the Danish soil, formed his character and career.

As a university student in Copenhagen, Bohr carried out important research on surface tension, and in 1913 he established his reputation in physics with his discovery of the Bohr atom. As background to this work, Pais provides chapters on the origins of relativity theory and quantum physics and describes the development of physics in Denmark preceding Bohr's entry into the field. He then analyzes Bohr's subsequent achievements: his enunciation of the correspondence principle as the guiding beacon of the old quantum theory (which Pais regards as Bohr's most important contribution to physics after his derivation of the Balmer formula); his role in the creation of quantum mechanics; his contributions to nuclear physics, especially his theory of the compound nucleus and his work on understanding fission; his probing of the foundations of quantum electrodynamics; and his studies on the penetration of charged particles through matter. Pais places this work within the context of the concurrent state of theory and experiment, taking pains to make his discussions understandable to nonphysicists, clarifying concepts, eschewing equations wherever possible and writing in an engaging personal style that conveys to his readers the excitement of these revolutionary developments.

Philosophy, Bohr said, "was, in a way, my life," but he disdained professional philosophers, who he felt never understood him. Pais shares Bohr's view, remarking, for example, that despite repeated attempts he cannot see why philosophers have made so much fuss over the so-called Einstein–Podolsky–Rosen paradox of 1935 and Bohr's response to it. But Pais's main concern in discussing Bohr's philosophical thought is to reveal its depth and significance. He sees Bohr as successor to Immanuel Kant, because Bohr's concept of complementarity and his formulation of a physical phenomenon as including both the object of study and the conditions of observation, forced the abandonment of Kant's concept of causality as a synthetic *a priori* judgment not derivable from experience. To Bohr the task of physics was not to try to penetrate to the essence of things—Kant's *Ding an sich*—but to describe phenomena in unambiguous and nec-

NIELS BOHR ARCHIVE

Niels Bohr takes a moment of rest. This photo dates from the late 1950s.

Roger Stuewer is a professor of the history of science and technology at the University of Minnesota. His current research is on the history of nuclear physics between the First and Second World Wars.

essarily classical language. Pais succinctly summarizes the core of the long Bohr–Einstein dialogue on quantum physics: "Bohr's usage of *phenomenon* was unacceptable to Einstein." Bohr, however, persisted, extending complementarity into the areas of psychology, biology and human cultures.

Pais reveals a very different side of Bohr when he discusses Bohr's involvement in polity. Here we see Bohr as a highly successful fundraiser for the construction, extension, outfitting and maintenance of his institute on Blegdamsvej, from its official opening in 1921 through its entrance into the new fields of biology and nuclear physics in the 1930s and beyond. [See PHYSICS TODAY, November, page 93.] Without this work, Bohr's institute could not have become a mecca for so many young theoretical physicists, including numerous refugees from Nazism and Fascism after 1933; he would not have been able to support adequately the small annual conferences he began organizing in 1929; and he would not have been able to establish flourishing experimental programs in atomic spectroscopy, biology and nuclear physics.

We also see Bohr as active and dedicated president of the Kongelige Danske Videnskabernes Selskab from 1939 until his death in 1962. Again, after the Second World War, Bohr's great organizational talents were called upon in the founding of CERN, Nordita and a new laboratory and new extension of his institute at Risø near Roskilde. But his main concern during and after the war was the radically changed international political climate brought about by the development and use of the atomic bomb. His "Open Letter to the United Nations" in 1950 made him, in Pais's characterization, a pioneer of *glasnost*.

These three dimensions of Bohr's life—physics, philosophy and polity—are Pais's major themes. But he interposes and relates to them a vast amount of supporting commentary. He includes, for example, a moving chapter on Bohr's travels and the sad events occurring between 1933 and 1937: the death of his sister Jenny, the suicide of Paul Ehrenfest, the brutal events in Germany, the death of Bohr's oldest son, Christian, in a sailing accident and the death of Ernest Rutherford, who had become a second father to Bohr and from whom Bohr learned how to lead a group of young researchers in the furtherance of common scientific goals.

Pais reveals Bohr as an indefatigable worker, a humane man of rare intuition, insight and power of concentration, an extraordinary teacher (but divinely bad lecturer) and a revered public figure who after 1932 lived with his wife and family in the palatial Carlsberg Residence of Honor. (Yet he never ceased inviting young physicists there and to the Bohrs' country retreat at Tisvilde.) Pais personally experienced all of these aspects of Bohr. His biography beautifully embodies Bohr's spirit and that of Copenhagen. It is certain to find a wide and appreciative audience.

The Weak Interaction in Nuclear, Particle and Astrophysics

K. Grotz and H. V. Klapdor
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In this book Klaus Grotz and Hans Volker Klapdor have succeeded in their objective of exhibiting the important role of the weak interaction in nuclear physics, particle physics, astrophysics and cosmology. The book describes the nature of the weak interaction and its role in the development of elementary particle physics. The book also relates the central importance of the properties and interactions of neutrinos to the resolution of current issues in astrophysics and cosmology.

The authors devote two chapters to nuclear beta decay and the weak interaction in nuclear physics; these chapters emphasize how double-beta-decay experiments in nuclear physics test the nature of the neutrino and the structure of grand unification theories. The authors devote one chapter to the Glashow–Weinberg–Salam theory of the electroweak interaction; one chapter to the weak interaction in the framework of grand unification theories; and another to the effects of the weak interaction in astrophysics, including its role in triggering a supernova explosion. The authors have also included a chapter on grand unification theories and cosmology and an intriguing chapter on neutrinos, which play a key role in grand unification theories.

This book is unique in the sense that it illuminates the diverse problems associated with the weak interaction in a variety of disciplines. It developed naturally from the research background of the authors, who have had several publications dealing with the nuclear-beta-decay strength distribution and its connection to some fundamental problems in nuclear and particle physics, astrophysics and nuclear technology. Currently, Klapdor is engaged in a major collaboration that is searching for neutrino mass using the world's largest germanium-76 gamma-ray spectrometer, located under Gran Sasso Mountain in Italy.

Although the authors do not claim to provide a comprehensive and self-contained account of all the topics treated, they do discuss the scientific issues and problems associated with the weak interaction. The authors invoke elements of quantum field theory to interpret experimental facts, but they assume a prior knowledge of only electrodynamics and quantum mechanics. This English translation of the original German edition includes an update of topics to early 1990. It is a welcome and unique addition to the literature and will prove useful to researchers and students in these disciplines.

RICHARD MADEY
Kent State University

Introduction to the Physics of the Earth's Deep Interior

Jean-Paul Poirier
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Mineral physics is finally coming of age. Despite decades of scientific activity, we mineral physicists have known what to call ourselves for little more than 10 years, and no book has yet served to define the field. *Introduction to the Physics of the Earth's Deep Interior* by Jean-Paul Poirier provides an important summary text and helps solidify the relationship between condensed-matter physics and Earth science.

With an interdisciplinary research agenda, mineral physics is rooted in the tradition of high-pressure physics as practiced during the first half of this century by Nobel laureate Percy Bridgman. A voice was given to the field in 1952 by Francis Birch, who identified a scientific program in his paper "Elasticity and Constitution of the Earth's Interior." Because what we know best about the Earth's deep interior is the variation with depth of densities and sound velocities, an understanding of the compositional and thermal state and of dynamical processes (plate tectonics and the