An abundance of historical detail on quantum mechanics

The Historical Development of Quantum Theory

Jagdish Mehra and Helmut Rechenberg

Volume 1: The Quantum Theory of Planck, Einstein, Bohr and Sommerfeld: Its Foundation and the Rise of Its Difficulties, 1900–1925. (Parts 1 and 2)
372 pp. ISBN 0-387-90642-8. $44.00
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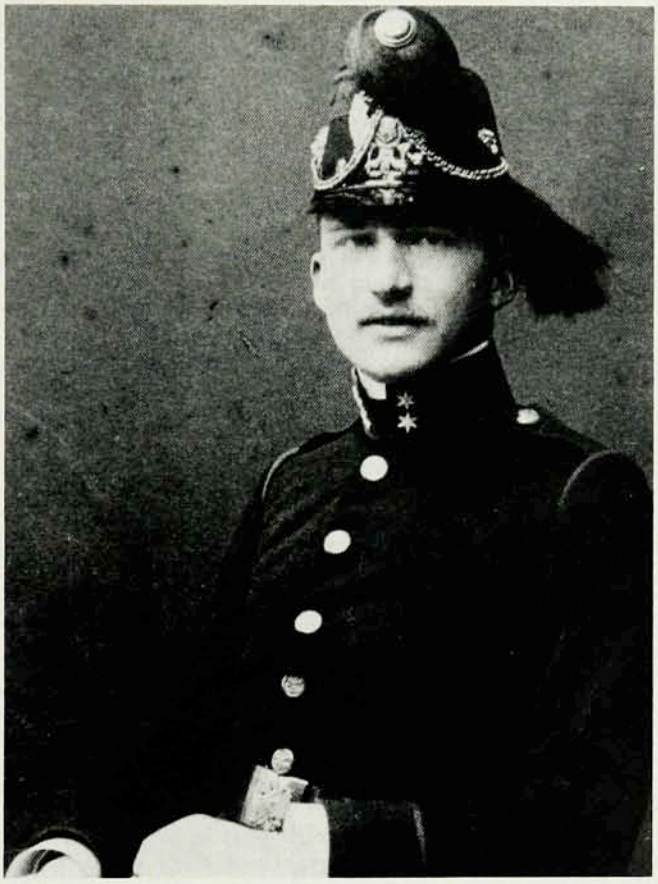
Reviewed by S. S. Schweber



Erwin Schrödinger, about 1916, as an artillery officer. This photograph (reproduced by permission of the publisher) is the frontispiece for volume 5, part 1, of *The Historical Development of Quantum Theory*.

Since the mid-1970s Jagdish Mehra and Helmut Rechenberg have been engaged in an ambitious project whose aim is to give a full account of the historical development of quantum mechanics from its inception at the beginning of the century to the establishment of the physical interpretation and epistemology of the new quantum theory in the late 1920s and early 1930s. As is to be expected the major emphasis is on the heroic period from 1925 to 1927. A volume on the genesis of quantum field theory and its subsequent developments is also promised (*The Completion of Quantum Mechanics, 1926–1935*).

To date five volumes have appeared. Volume 1 (which is in two parts) begins with Max Planck's work on blackbody radiation and concludes with an account of the discovery of electron spin in 1925. It presents all the "old" quantum theoretical investigations of atomic structure (Niels Bohr, Arnold Sommerfeld, Wolfgang Pauli, Alfred Landé and others). It also includes an account of the struggles to understand the quantum nature of electromagnetic radiation and to describe the interaction of atomic systems with the electromagnetic field (from Albert Einstein's classic paper of 1905 to the famous papers of H. A. Kramers and Werner Heisenberg, and of Bohr, Kramers and John Slater in the mid-1920s). Volume 2 deals primarily with Heisenberg. It analyses Heisenberg's researches and contributions from the fall of 1920 to his formulation of quantum mechanics. Volume 3 tells the story of Max Born and Pascual Jordan's elaboration of Heisenberg's insights; the completion of the matrix scheme by Born, Jordan and Heisenberg; and its extension in 1926 to the analysis of the structure of the helium atom. Volume 4 presents P. A. M. Dirac's momentous contribution of 1925–26 and concludes with a brief account of the reception of the new quantum mechanics. Volume 5 (which is again in two parts) deals with

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Erwin Schrödinger and the genesis of wave mechanics.

The project has been conceived on a grand scale. The books are perhaps best described as attempts at being encyclopedias, without trying to conform to the usual format of that literary genre. An immense amount of work has been invested in them. Their scope and sweep, the wealth of detail, the amount of new material presented and the bibliographical material included in each volume all attest to the efforts involved. Valuable features of all the volumes are the extensive biographical footnotes on all people mentioned in the text. The volumes thus constitute a mini-*Dictionary of Scientific Biography* of the first few generations of quantum physicists and allow one to readily find out who was doing what, where and when.

The authors have attempted to embed the scientific developments into the wider cultural and intellectual context. Thus, for example, a great deal of information is presented on *fin-de-siècle* Vienna as a prelude to the Schrödinger volume. Many similarly informative tableaux are delineated at appropriate places: of the German university system, the Göttingen culture, the Munich seminar, the Cambridge and the Cavendish laboratories. The authors are at their best when dealing with the various contributors individually. They have painted insightful portraits of the personalities involved—Sommerfeld, Bohr, Born, Jordan, Heisenberg, Pauli, Schrödinger, among others, and a particularly fine one of Dirac. (Incidentally, it is regrettable that these fairly lavishly produced volumes contain no photographs of the principal institutions or individuals—except Schrödinger.) Furthermore, not only are the scientific contributions of these individuals presented in rich detail, but they are also illuminated by accounts of the sources upon which they are based and of the intellectual tradition on which they draw. Thus, in their discussion of the novel features of Dirac's q number representation of observables the authors discuss his contacts at Cambridge with the mathematician Henry F. Baker and the influence of Baker's *Principles of Geometry* on Dirac. Similarly, Mehra and Rechenberg stress the importance of Hermann Weyl's gauge theory in Schrödinger's researches during the early 1920s, and particularly for his formulation of wave mechanics. Their account of Weyl's earlier work sheds light on Schrödinger's motivation in introducing complex numbers into his wave mechanics.

All the material is presented in its full mathematical detail. Often, the reader may be overwhelmed by the details and will fail to see the forest for all the trees. This problem is aggravated by the fact that the authors have been less than successful in their integration of physics, physicists and context. However, whatever the shortcomings of these volumes—and there are many—there is no question that they constitute valuable resources for anyone interested in the history of quantum mechanics. They will surely be the point of entry for anyone wishing to obtain information on the technical aspects of the subject. But there are caveats that the reader should keep in mind. The authors often rely heavily on interviews and on recollections many years after the fact—and memories can be treacherous. The discussions give very little emphasis on experimental practice. There are also important omissions of the secondary literature. For example, Sin-Itiro Tomonaga's insightful two-volume account of the genesis of quantum mechanics is not mentioned, nor are other important contributions by historians of the physical sciences. More generally, the authors fail to fully acknowledge their indebtedness to the many historians who have tilled these pastures before them and have given structure and meaning to the story. For example, a footnote in the volume on Schrödinger informs the reader that V. V. Raman and Paul Forman have also drawn attention to the role played by Schrödinger's notes on *Tensoranalytische Mechanik* in his subsequent discovery of wave mechanics. However, the pathbreaking research into Schrödinger's genesis of wave mechanics was done—before Mehra and Rechenbach's work—by Forman, by Paul Hanle and by Linda Wessels, among others. Although these authors receive references (usually only in brief footnotes), the importance of their work is not conveyed. Similar criticism can be made in many other places.

What is missing in the presentation thus far is how the pieces fit together. Thus readers would have to reconstruct for themselves an assessment of the impact of general relativity on the development of wave mechanics in the period 1920–1927. Similarly, although the relevance of the Hilbert–Minkowski mathematical physics tradition and the importance of the Courant–Hilbert volumes are detailed when discussing various individuals—such as Born, Jordan, Schrödinger and Cornelius Lanczos—no general discussion is given. It is such integrations that would transform these informative volumes into genuine histories.

In his preface to volume 1 Mehra notes that several accounts dealing with parts of the history of quantum mechanics already existed in print. "Our aim, however, goes much beyond such works. We want to give the full story of all significant problems and their interplay in leading to the discovery and completion of quantum mechanics and to discuss the role and contributions of individual quantum physicists properly and adequately." Therein, perhaps, lies the greatest flaw in the enterprise, since the story is greater than the sum of such parts.

The authors seem to believe that it is possible to give *the* full story and *the* definitive interpretation of the events we call the quantum mechanical revolution, events which so deeply transformed so many different disciplines and whose impact on our culture has yet to be assessed. Alexander von Humboldt in a letter to the young Charles Darwin in 1839 commented that "works are of value only if they give rise to better ones." By having chosen to write in a way that closes the discourse the authors have diminished their accomplishments and the value of these volumes. By not giving greater emphasis to the diversity and the richness of other interpretations, they not only have impoverished their own presentation but have lessened the magnitude of the intellectual upheaval they are attempting to recount.

The Anthropic Cosmological Principle

John D. Barrow and Frank J. Tipler
706 pp. Oxford U. P., New York, 1986.
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What is one to make of this extraordinary book? How is one to encompass some 682 pages, annotated with 1512 footnotes, that contain, among other things, a short history of the colonization of the Azores, a detailed treatment of modern cosmology, another of the physical and chemical properties of water, and a discussion of the human rights of von Neumann probes, all in support of a principle that many scientists feel is devoid of physical content?

While the principle in question has several forms, which come under the general rubric of the "anthropic principle," the main distinction appears to be between what I would call a necessary and a sufficient version. The necessary version says in effect that the observed structure and properties of the universe must be consistent with our existence. The sufficient version says that these properties require our existence or at least require the existence of some kind of intelligent observers.

Although there are earlier references to these principles, their modern