CLASSICAL PARTICIPATION IN THE QUANTUM REVOLUTION

H. A. Kramers: Between Tradition and Revolution

Max Dresden
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Reviewed by S. S. Schweber

Dutch physics can boast of a long line of distinguished practitioners—from Christian Huygens to Nicolaas van Kampen and Gerard t'Hooft—as well as a long-standing tradition of great teachers. Very often the great physicists were also the great teachers. Hendrik Antoon Lorentz and Paul Ehrenfest immediately come to mind, but they are merely the two who set the high standards. With Abraham Pais's biography of Albert Einstein, *'Subtle Is the Lord . . . '* (Oxford U. P., New York, 1982; reviewed in PHYSICS TODAY, January 1983, page 81), and Max Dresden's recent biography of Hendrik Antonie Kramers, another distinctive trait must be added to the list of achievements of Dutch-trained physicists: They are setting impressive standards for the writing of scientific biography.

Pais's inclination to eschew psychology makes *'Subtle is the Lord . . . '* an intellectual biography *par excellence*; he has masterfully analyzed the originality, power and importance of Einstein's scientific contributions, and insightfully assessed their impact.

In some ways Dresden undertook a more difficult task than Pais by attempting to integrate Kramers's inner life with his intellectual life. In his introduction Dresden stresses that a scientific biography must be concerned with the scientist's emotional life, his social relations, "his personal hopes, dreams, expectations and disappointments." Only in this way, Dresden says, can the biographer give a "thoughtful, illuminating analysis of the major technical contributions made by the subject of the scientific biography." Dresden has succeeded magnificently.

Dresden's biography of Kramers must be ranked among the great biographies of modern physicists. With his mastery of the technical details of the physics, his fine craftsmanship in relating the historical development and his deep sensitivity to the personal, Dresden has given us an outstanding account of Kramers's life.

Dresden's fascination and admiration for his subject, his love of the subject matter and his deep respect for the circles in which Kramers moved illuminate a world that disappeared with Adolf Hitler and World War II. I know of no better account of the German-speaking theoretical physics community during the 1920s than that found in Dresden's book. Similarly, the "atmospherics" of Copenhagen, Göttingen and Munich and the interactions among Niels Bohr, Werner Heisenberg, Wolfgang Pauli and Kramers are beautifully conveyed. The portrait of Bohr that Dresden paints is incisive, but I would have liked to get a clearer assessment, based on Kramers's interactions with Bohr, of Bohr's mathematical powers.

Throughout the book Dresden explicates the physics clearly and coherently in terms of the conceptual apparatus of the day. But he has also tried to shed light on why Kramers failed to fulfill his great gifts and promise.

Dresden's original manuscript was in excess of 2000 typewritten pages and included technical discussions of almost all of Kramers's scientific works. The publishers felt that a book of that length "would be too long to read and too expensive to produce." (They may have been right about the second point; they were surely wrong about the first!) The cutting of the manuscript has resulted in a certain imbalance.

In the edited version Dresden gives the greatest attention to Kramers's contributions to the "old" quantum theory, which culminated with the Kramers–Heisenberg dispersion formulae, and to his investigations relating to the "structure independent" description of the interaction of electrons with radiation, from which emerged the procedure now known as mass renormalization. In both these enterprises Kramers failed to carry through, and he did not participate in a major way in the subsequent developments. The subtitle of the book, *Between Tradition and Revolution,* conveys some of Kramers's struggles during those fateful years when quantum mechanics was created. It is true that on several other occasions Kramers came "tantalizingly close to epoch-making discoveries" and that in those instances he likewise failed to carry the advances he had initiated to their "often revolutionary conclusions." Nevertheless, I believe a slightly different portrait would have emerged if extended discussions of some of Kramers's other important contributions had been retained in the text, for example, the Kramers–Kronig relations, his works in statistical mechanics [see Dresden's article on page 26] and his textbook on quantum mechanics.

What is so admirable about Dresden's presentation is that he has been able to convey what good physics is about. And good physics need not be right—as becomes clear from Dresden's accounts of the Bohr–Kramers–Slater paper. Particularly valuable is Dresden's presentation of the research by Kramers and his students that led to a divergence-free formulation of the interaction between a nonrelativistic electron and the elec-

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tromagnetic field. In June 1947 Kramers presented some of these results at the Shelter Island conference, and his contributions played an important role in unraveling the meaning of the Lamb shift. Dresden feels that Kramers was shortchanged by not receiving sufficient credit. Perhaps. But he represented a style of doing physics that was inimical to the American theorists who had gathered at Shelter Island to prove to the world that the United States was as impressive in "pure" physics as it had been during the war in applied and engineering physics.

The immediate challenge was to get the numbers out to explain the magnitude of the Lamb shift and the new values of the hyperfine splitting in hydrogen H and D isotopes that I. I. Rabi, John E. Nafe and Edward B. Nelson had measured. Hans Bethe did that for the Lamb shift. Robert Oppenheimer, Julian Schwinger and Victor Weisskopf all suggested during the conference that the Lamb shift must be an electromagnetic–radiative effect. Bethe gave a lecture on the infrared problem and discussed the Bloch–Nordsieck and the Pauli–Fierz papers. In the latter paper, a fully *quantum mechanical* treatment of the interaction between a nonrelativistic charged particle and the electromagnetic field is given and an explicit mass renormalization is carried out to remove the electromagnetic self-energy. In his lecture Kramers dealt with the *classical* theory only. Bethe's famous train-ride paper, in which he calculated the nonrelativistic Lamb shift, is much closer in spirit and style to the Pauli–Fierz paper than to Kramers's work and lecture. I suspect that without Kramers in attendance at the Shelter Island conference, developments would have proceeded much as they did in fact.

Dresden quotes a lecture in which Kramers attempted to sketch a "miniature" scientific biography of Peter Debye: "You want to know about the scientist because your human . . . intuition tells you that there is an exaltation to be experienced which in turn can produce an exaltation into yourself, because even with all the uncertainty about the man and his field—there is so much in both of you—that is near to you, that it reflects something of your being and aspirations." Dresden has done that for Kramers. Rarely have we been given so rich, so penetrating and so valuable an account of the mind, the style and the life of a first-rate scientist and of his science. Dresden has indeed given us an insight into our very own being and aspirations.

Incompleteness, Nonlocality and Realism: A Prolegomenon to the Philosophy of Quantum Mechanics

Michael Redhead
Clarendon P. (Oxford U. P.), New York, 1987. 191 pp. $45.00 hc ISBN 0-19-824937-3

The 1980s have seen a revival of interest in the problem of interpretation in quantum mechanics. Largely motivated by the results of the precision experiments by Alain Aspect and his collaborators in 1982, the revival was further stimulated by the 1985 centennial of Niels Bohr's birth, which was also the semicentennial of the famous Einstein–Podolsky–Rosen paper that questioned the completeness of quantum mechanics. The voluminous and very helpful collection of original articles on the interpretation problem compiled by John A. Wheeler and Wojciech Zurek in *Quantum Theory and Measurement* (Princeton U. P., Princeton, N. J., 1983) aided greatly in providing the necessary background. As a consequence there has come about a considerable clarification of the available conceptual options and much deeper insight into the issues of locality and separability. But questions remain.

No one entering this research field today would have an easy time working through the extensive recent literature. This glut alone is sufficient reason to welcome Michael Redhead's book. It provides a thorough introduction and an excellent digest of much of the most important recent literature. It is also the first book on the subject in about 15 years and is quite different in style from its predecessors by Frederik Belinfante (*Survey of Hidden-Variable Theories*, Pergamon, Oxford, 1973), Bernard d'Espagnat (*Conceptual Foundations of Quantum Mechanics*, second edition, Benjamin, Reading, Mass., 1976), Max Jammer (*The Philosophy of Quantum Mechanics*, Wiley, New York, 1974) and Erhard Scheibe (*The Logical Analysis of Quantum Mechanics*, Pergamon, Oxford, 1973). With its crossing of the disciplines of physics, mathematics and philosophy of science, writing the book successfully required considerable expertise.

Redhead is extremely well qualified for the task. A British theoretical physicist who did research in quantum mechanics and quantum electrodynamics, he has since turned to the philosophy of science. He was an active and successful participant in the debate following Aspect's experiments and has contributed a number of key papers. He is now the head of the department of history and philosophy of science at Cambridge University. Not surprisingly given this background, he has written a rather technical book. In the preface Redhead states that his book was written for both physicists and philosophers. But I suspect that most philosophers will have some difficulties with its mathematics, even if they can get through its physics, and many physicists will have problems understanding the philosophical issues. A mathematical appendix, which briefly reviews set theory, vector spaces and lattice theory, will help the insufficiently prepared reader. The author wisely steers clear of overly sophisticated mathematics by restricting himself almost throughout to finite-dimensional vector spaces and by providing just a short review of Gleason's theorem. An extensive bibliography will permit readers to pursue specific questions on their own.

While the last chapter, dealing with quantum logic, stands somewhat separate from the rest of the book, the bulk is divided into two parts of nearly equal length. The first is a review of those aspects of quantum mechanics and of its three most important interpretations that are necessary for understanding what follows. The second, more difficult part starts with a careful, very clear review of the Einstein–Podolsky–Rosen paper and then plunges into the heart of the matter: the vexing nonlocality problem. This problem is studied in detail in the contexts of both the Bell inequality theorem and the old Kochen–Specker paradox. This second part requires considerable sophistication in all three overlapping fields (physics, mathematics and philosophy) for a full appreciation. For instance the author distinguishes among no fewer than seven different definitions of locality, carefully analyzes all of these for their mathematical and philosophical consequences, and then compares them with one another.

Throughout the book's discussions, the author keeps three different interpretations of quantum mechanics in the reader's mind. These are the hidden-variables view, the complementarity view and the potentiality view. Most physicists usually dismiss the first of these out of hand in an unscientific manner. Here, the serious arguments for a dismissal are carefully marshaled. The second view is of course the Copenhagen interpretation, championed primarily