

MR2351852 (2008g:81004) 81-03 (01A60 81P05)**Home, Dipankar (6-CALC-I); Whitaker, Andrew (4-QUEEN)****★Einstein's struggles with quantum theory.**

A reappraisal.

With a foreword by Roger Penrose.

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This fascinating book presents and defends Einstein's work on quantum theory. Though his earlier work on the photoelectric effect is universally well-regarded, his later work is often thought to involve a failure "to come to terms with the conceptual revolution that Niels Bohr had shown was required in order to solve the paradoxes and problems apparent from the early days of quantum theory" (p. xxvii). Far from depicting him as being a failure in this respect, Home and Whitaker paint a picture of Einstein as a pioneer in the field of 'quantum foundations'—indeed he comes across very strongly as the *first* quantum foundationist. I think they succeed in their mission, and they do so in a manner which never degenerates into tasteless hagiography. Einstein's questioning of quantum theory was not the product of a senile mind, but rather the product of an *open* mind. Home and Whitaker show how this open-minded line of questioning, involving a focus on conceptual problems, led (after Einstein's death, and with J. S. Bell's probing work) to novel research avenues effectively cut off by the once reigning Copenhagen orthodoxy.

The book consist of fourteen chapters, spread over four parts, joined by brief 'Interludes'. Though the chapters are well cross-referenced, in terms of content they read like separate essays. The first two-thirds of the book (comprising Parts A and B) deal with Einstein's views on their own terms. The final third of the book (Parts C and D) connect his views up to the contemporary debates in quantum foundations, including alternatives to the Copenhagen interpretation.

Part A deals with Einstein's early contributions to quantum theory, up to 1927. Chapter 1 contains a discussion of Einstein's philosophical views and the influence of Mach on his thinking (and his departure from such thinking). Chapter 2 focuses on Einstein's contributions to the construction of quantum theory. Chapter 3 provides an excellent presentation of the structure of quantum mechanics, and unpacks some of its foundational problems (e.g. the measurement problem). Chapter 4 then develops the standard interpretation of Bohr and Heisenberg, involving the principle of complementarity, and the notion of a collapse of the wave-function.

Part B follows the story of Einstein's involvement with quantum theory from 1925 until his death, in 1955. Chapter 5 looks at development of the various formulations of quantum mechanics, and the origins of Einstein's distaste for the Bohr-Heisenberg approach (and his preference for the Schrödinger approach)—here too we find a discussion of an early (unpublished) paper of Einstein's on hidden variables, in which he appears to discover entanglement (the grounds for his own rejection of the paper). This chapter also contains a very clear discussion of the Solvay controversy, in which Einstein tried to develop counterexamples to Copenhagen-interpreted quantum mechanics. Chapter 6 continues this theme, looking at the EPR paper, giving a spirited defense, and connecting it up to the modern debate via Bell. Chapter 7 looks at Einstein's correspondence

with Max Born over the status of the classical limit of quantum mechanics. As Home and Whitaker show, the advocates of the Copenhagen interpretation swept the problem under a rug of assumptions. Einstein's arguments here are clear precursors of decoherence. Chapter 8 ties the previous discussion together in a very well argued discussion of Einstein's general philosophical views. Of particular interest is Einstein's (very sensible) pragmatic approach to all manner of conceptual issues (especially realism, determinism and locality). The authors do an excellent job unpacking Einstein's brand of realism (following Arthur Fine, as they admit).

Parts C and D show how Einstein's struggles live on in contemporary research. In Chapter 9 Bell's work is discussed, along with some of the massive industry of conceptual work that followed in its aftermath. Chapter 10 looks at the profusion of alternative interpretations that grew as a reaction to positivism of the Copenhagen interpretation. Chapter 11 looks at the role of Einstein's arguments in quantum information and computation. Chapter 12 discusses the quantum-classical transition and the topic of decoherence that Einstein stumbled upon in his correspondence with Born. Chapter 13 looks at some experimental tests of foundational issues. Chapter 14 offers an assessment of Einstein's contribution to quantum mechanics and speculates on Einstein's reaction to the present state.

Let me sum up by saying that I recommend this book in the very highest of terms: Home and Whitaker have produced a wonderful book that will appeal to physicists, historians, and philosophers alike. They never lose sight of the connections to modern debates in quantum foundations, and many of the discussions of the historical origins have the potential to reinvigorate contemporary research topics. Indeed, this book constitutes an excellent argument for quantum foundations research. Furthermore, although nominally about Einstein's views, given its range, simplicity, and clarity I think it would make an excellent 'first encounter' with quantum theory.

Reviewed by *Dean Rickles*

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