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Book Review

Conceptual Foundations of Quantum Physics: An Overview from Modern Perspectives. By Dipankar Home. Plenum Publishing Corporation, New York, New York, 1997, xvii + 386 pp., $(hardcover). ISBN 0-306-45660-5.

My first thought after reading this book is that it is just the sort of book I would like to write myself. Not that I agree with everything that the author says, but rather that he has done for himself what I would love to be able to do for myself. Namely, after having spent a career worrying about many of the fundamental problems that beset quantum theory, he has set down his feelings about what he thinks the best proposed solutions are. This he has done by first discussing each topic, the problems involved, and the various contributions of almost everyone who has contributed to understanding the problem. His presentations are of course colored by his own attitudes towards the problems, but one is struck by his attempt to be fair to all points of view. He does not hesitate to add his own opinions and preferences, but to do that is of course the point of writing the book.

What is most impressive is the full range of references he has taken into account, so that one of the most important uses of the book will be that it can quickly point out to the reader the full range of ideas that have already been explored concerning a topic. It is not suitable for a textbook, but it would make a wonderful supplementary book for any graduate student who wants to gain a deeper understanding of the subject than what the teacher of his first year course has had time to provide. And it goes without saying that it is an invaluable reference for the working physicist.

For example, one of the topics that most concerns him is quantum measurement theory. First he discusses the standard descriptions of the measurement problem, in variations introduced by Bohr and Heisenberg, on the one hand, and by Dirac and Von Neumann, on the other, with special emphasis on the projection postulate. He discusses the fact that a pure state cannot change into a mixed state by virtue of a unitary evolution and he, like many other people, considers this the bte noire of all forms of the standard interpretation. He discusses other methods for producing

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incoherence in the measurement, such as decoherence, which are all subject to the same criticism.

He also discusses the many worlds interpretation, which he dismisses as carrying too much metaphysical baggage. This is a sort of questionable argument, since in a real sense it is the most natural interpretation, following directly from the mathematical formalism. If one believes, as did Dirac and many other first-rate physicists, that in a correct theory the formalism determines its own interpretation, then it is not so easy to dismiss many worlds. For my own part, I think it is a daydream to believe that any formalism determines its own interpretation. As an example, consider a statistical mechanical calculation of an equation of state for a gas, which at some point develops singularities. We immediately ascribe such singularities to phase changes, and use this as a spectacular success of the theory. However, if we didnt know independently that phase changes exist, we would think that the theory had broken down. If one wanted to reverse this logic, to make a, prediction from the theory, what would one predict from a singularity? Nothing in the theory can help you in advance. One has to have the experience of having seen phase changes in order to guess what the theory is telling you. There is a subtle interplay between weird things that happen in our theories and the weird things that we know happen in nature that allow us to successfully interpret theories. In this respect quantum theory is even much further removed from any intuitive interpretations, and in this case it is dangerous to argue either side of this question. (This is not to say that Home's discussion of the subject isn't valuable.)

He also discusses several other models, including spontaneous collapse (Ghirardi–Rimini–Weber–Pearle), the many-Hilbert space scheme (Namiki–Machida–Pascazio), gravitationally induced collapse (Penrose), and several other schemes. But the one scheme that most appeals to him is Bohm's, which is free from the collapse problems of the standard theory, while being equivalent to it in its formalism. The Bohm scheme, which preserves the idea of trajectories for individual particles, is closest to having a classical analog. Also, because it does not have to make loose conjectures to solve the measurement problem, it appeals strongly to Homes aesthetic sensibilities.

One of the chief features of the Bohm scheme is that it (as do many of the other schemes above) singles out position space as special. Bohm pointed out that ultimately our measuring instruments do this, as we have to read their output, and did not see this as a difficulty. But the equivalence of all representations before a measurement is really one of the beautiful features of quantum theory, and corresponds to the choice one has of which experiment to actually do. This is related to the linearity of the theory and the superposition principle, and for the working physicist it is directly connected to ones capacity to dream up all sorts of non-intuitive

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experiments. One sacrifices this in the Bohm representation, which seems to me in this respect to throw out the baby with the bath water.

So what is the best interpretation of quantum theory? I wish I knew! But here, one can read a good discussion of all of them, their good points as well as their bad ones. In this regard, it is a rather special book. But this topic is only one of many major ones discussed in depth in the book. There is a careful treatment of the passage to the classical limit, and the problems of performing experiments with macroscopic bodies. He discusses this problem in the context of many of the above interpretations. He also discusses many other fascinating problems, such as the wave-particle duality, and the Zeno paradox, and he takes a deep look at the question of non-locality. The author has contributed to the original discussion of many of these issues, although again he gives a fair, rounded discussion of most points of view.

Overall, its really a wonderful book. I hope that Plenum Press has had the sense to put it out in a cheap student edition and try to sel it to all students of quantum theory and their teachers. Even in those cases where one doesnt fully agree with the authors conclusions, one will appreciate the careful discussion of many sides of important arguments, and there is much to learn from the book. I have only one complaint (a big one) to make about the book, and that is not the author's fault. It concerns the index. While it looks at first glance like a large, complete index, it is almost exclusively a name index, and very few concepts are listed. The name index is invaluable, given the enormous number of references, but if one trusted the index, one would-never know that such topics as superluminality, which-path experiments, teleportation, causality, empty waves, and ensembles are discussed at length. While the table of contents is a little help, it is very hard to re-find pretty arguments that you know are in there somewhere. Publishers and editors should be shot for allowing an otherwise lovely book like this to come out without a strong subject index. I hope that if there is a new edition, this major defect will be remedied.

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