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0521675677 - A Philosopher's Understanding of Quantum Mechanics: Possibilities and Impossibilities of a Model Interpretation

Pieter E. Vermaas

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This book is about how to understand quantum mechanics by means of a modal interpretation. Modal interpretations provide a general framework within which quantum mechanics can be considered as a theory that describes reality in terms of physical systems possessing definite properties. The text surveys results obtained using modal interpretations, and is intended as both an accessible survey that can be read from cover to cover, and a systematic reference book.

Quantum mechanics is standardly understood to be a theory about probabilities with which measurements have outcomes. Modal interpretations are relatively new attempts, first proposed in the 1970s and 1980s, to present quantum mechanics as a theory which, like other physical theories, describes an observer-independent reality. In the 1990s much work has been carried out to develop fully these interpretations. In this book, Pieter Vermaas summarises the results of this work. A basic acquaintance with quantum mechanics is assumed.

This book will be of great value to undergraduates, graduate students and researchers in philosophy of science and physics departments with an interest in learning about modal interpretations of quantum mechanics.

PIETER VERMAAS studied philosophy and theoretical physics in his home town at the University of Amsterdam. He obtained his PhD with research on modal interpretations of quantum mechanics at Utrecht University with Dennis Dieks. He published several papers on especially the modal interpretation in the version proposed by Simon Kochen, Dennis Dieks and Richard Healey, in physics and philosophy journals ranging from *Physical Review Letters* to *Minnesota Studies of Philosophy of Science*. Together with Dennis Dieks he proposed a generalised modal interpretation. This generalisation has since formed the basis of much further research on modal interpretations. He has worked at the University of Cambridge with a British Council Fellowship. Currently he is a Research Fellow at the Delft University of Technology, where he is involved in developing the new field of philosophy of technology.

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Preface

When I decided to enter research on modal interpretations of quantum mechanics, I barely knew what it was about. I had attended a talk on the subject and read bits about them, but the ideas behind these interpretations didn't stick in my mind. Modal interpretations were at that time (1993) not widely known, and their approach to quantum mechanics was not common knowledge in the philosophy of physics. So my decision was a step in the dark. But what I did know was that I was beginning research on one of the most irritating and challenging problems of contemporary physics. Namely, the problem that quantum theories, unlike all other fundamental theories in physics, cannot be understood as descriptions of an outside world consisting of systems with definite physical properties.

Your decision to read this book may be a step in the dark as well, because modal interpretations are presently, especially among physicists, still rather unknown. The reason for this may lie in their somewhat isolated and slow development. The first modal interpretation was formulated in 1972 by Van Fraassen. Then, in the 1980s, Kochen, Dieks and Healey put forward similar proposals which, later on, were united under Van Fraassen's heading as modal interpretations. But these proposals were not immediately developed to fully elaborated accounts of quantum mechanics. Moreover, modal interpretations were proposed and discussed in journals and at conferences which were mainly directed towards philosophers of physics, rather than towards general physicists. Modal interpretations are in that sense true philosophers' understandings of quantum mechanics. But, as a possible down-side of that, the discussion of the possibilities and the impossibilities of the modal account remained slightly formal and therefore maybe not that appealing to the general physicist.

In the 1990s, however, the development of modal interpretations gained momentum and took a turn which made them much more accessible and

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interesting to a wider audience. A group of researchers started to work on modal interpretations and took up the challenge to systematically answer physical and theoretical questions about the way these interpretations describe our world. This has led to a burst of results about, for instance, the algebraic structure of the properties ascribed by modal interpretations, the correlations and the dynamics of those properties, the way in which modal interpretations describe measurements, and how one can philosophically and physically motivate modal interpretations.

These efforts have meant that nowadays many of the more important issues for modal interpretations have been resolved or have been proved to be unresolvable. Modal interpretations have thus matured into what can be taken as a well-developed and general framework to convert quantum mechanics into a description of a world of physical systems with definite properties. This general framework is of interest to anyone who aims at understanding quantum mechanics. Presently, one can therefore witness a second burst of activity, namely a burst of publications which present modal interpretations to the wider communities of physicists and philosophers and to those interested in philosophy and physics. This book introduces the reader to modal interpretations and guides him or her through many of their results. It may also be used as a reference book which can be consulted without the need to read it from cover to cover. The text is accessible to those who have a basic understanding of the quantum mechanical formalism. For experts I have added proofs of the various results in separate subsections.

This book is the result of five years of research at the *Institute for History and Foundations of Mathematics and the Natural Sciences* of Utrecht University. This research has started as a PhD project, supervised by Dennis Dieks and financially supported by the Foundation for Fundamental Research on Matter (FOM) and by the Foundation for Research in the Field of Philosophy and Theology (SFT) which is subsidised by the Netherlands Organisation for Scientific Research (NWO).

I thank Dennis Dieks for his invitation to work on modal interpretations. I feel indebted for the way in which he, one of the modal pioneers, supported my work and enabled me to develop my own views on the subject. I am also grateful to Tim Budden, Fred Muller and Jos Uffink, for their helpful discussions and advice, and for their friendship during my time at Utrecht University.

In addition to Dennis Dieks, I acknowledge the fruitfulness and importance for my work of discussions and joint projects with Guido Bacciagaluppi and Rob Clifton as well as with Michael Dickson, Matthew Donald and Meir Hemmo. I also thank the British Council for providing a fellowship to

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visit Cambridge University, and I thank Jeremy Butterfield for his friendly support.

Finally a word of dedication: It has become a tradition to dedicate academic books to those who are important to the author. However, to be honest, I have not written this book to honour my family, my friends or the one I love. Instead I have written it for those who wish to read it and, possibly, in dedication to the academic adventure to get to the heart of the matter. (And adding the names of the ones I am close to on one of the first pages of this book seems to me an academic variation of tattooing them on one of my arms, which, incidently, I haven't done either.) However, to meet tradition halfway, I heartily thank my parents, send sincere apologies to my friends for being absent during the period that I have worked on this book, and express my deep affection to Florentien Vaillant.

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