PARTICLES AND PARADOXES

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The Limits of Quantum Logic

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To
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Contents

	Preface	*page* ix
1.	Meta-physics	1
	PART I	
2.	Quantum mechanics for natural philosophers (I)	19
3.	Wave–particle duality	36
4.	The Copenhagen interpretation (I)	47
5.	The Copenhagen interpretation (II): Einstein versus Bohr	62
	PART II	
6.	Quantum mechanics for natural philosophers (II)	87
7.	Projection postulates	102
8.	Nonlocality and hidden variables	116
9.	A user-friendly quantum logic	126
10.	Quantum logic: what it can and can't do	142
	Conclusion	166
	Notes	168
	References	175
	Index	179

Preface

Niels Bohr solved the problem of interpreting quantum mechanics once and for all. That, until recently, was the orthodoxy in physics, especially among writers of textbooks on quantum mechanics, who mostly wanted to get off the philosophy as quickly as possible and on with the physics. Niels Bohr, incidentally, would not have agreed with them.

Now the fashion is for physicists to say that quantum mechanics is so peculiar that no one understands it, least of all themselves. Perhaps the change was wrought by Bell's theorem in the 1960s; perhaps it really was just a matter of fashion.

Of course, in saying that quantum mechanics is incomprehensible, one is not saying that it is false, only that the human mind is not tuned in to the way the world is. The philosophy of quantum mechanics deals with the question: What is the way the world is, *if* quantum mechanics is true? It would be nice if, in answering that question, one were also to make quantum mechanics comprehensible, something philosophers tend to feel they can pull off.

Philosophers often have another motive, one which is inspired by their intellectual cussedness. Quantum mechanics is most easily interpreted *antirealistically*, that is, as a theory which, though it works, does not describe the way the world is. Therefore, philosophers go out of their way to interpret it *realistically*. Realism in the philosophy of quantum mechanics means the idea that quantum systems are really like classical particles. Everything points against it. Interestingly, the opposite situation occurs with classical physics, which is naturally interpreted realistically, meaning here 'directly corresponds to the world'. So positivist philosophers try to interpret it as a theory about (say) sense data.

'The philosophy of quantum mechanics' is of course an embarrassingly pretentious expression. Perhaps it makes one blush because philosophers are expected to be wise. The philosophy of quantum mechanics, on the other hand, is a bundle of problems.

The central problem in the bundle is this: Quantum mechanics accounts perfectly well for the results of measurements made on quantum systems but it is quite unclear what, if anything, the theory entails about quantum systems upon which no measurement has just been made. Quantum theory gives us a highly workable algorithm for making predictions about the results of measurements, but philosophers and physicists are in total disagreement about what, again if anything, quantum theory tells us about the way the quantum world is.

So does the philosophy of quantum mechanics matter?

It matters because we do physics in order to understand what is true of the world as well as to gain some small (though possibly for us, fatal) mastery over it. So physics and philosophy are not wholly separate and distinct activities. The philosophy of quantum mechanics shows us just how entangled they really are. There is a lesson here even for the unphilosophical physicist. The late J. M. Jauch, certainly a physicist rather than a philosopher, wrote:

> The pragmatic tendency of modern research has often obscured the difference between knowing the usage of a language and understanding the meaning of its concepts. There are many students everywhere who pass their examinations in quantum mechanics with top grades without really understanding what it all means.[1]

Talk of what quantum mechanics asserts about the world, of what is true or false of the world, suggests that we investigate the logic of the language in which we describe quantum systems. So we explore quantum logic – that typically awkward and peculiar system which drops out so nicely from the formalism of quantum mechanics. In fact, we eventually put quantum logic at the centre of our focus. We use it as a way of looking at recent developments in the philosophy of quantum mechanics. Quantum logic is in any case of great intrinsic interest. There is no better illustration, even within the philosophy of quantum mechanics, of the interconnection of physics and philosophy than the network of problems generated by quantum logic. Questions like: 'Is quantum logic really logic?', 'Is quantum logic a rival to classical logic?', 'Can we speak of a logic of the world?', 'If we can, is this logic to be decided empirically?', 'Can quantum logic be used to resolve the paradoxes of quantum mechanics?', all fall within an area of philosophy which overlaps with the philosophy of logic, with traditional metaphysics, and with physics proper. They are exciting questions, just as exciting to the philosopher of physics as the possibility of non-Euclidean geometries in the theory of space and time.

The idea that this is a classically illogical world is about as deeply

metaphysical an idea as one can find. Philosophers naturally gravitate towards the topic of quantum logic, and its employment in attempts to preserve quantum-mechanical realism. Quantum logic and Bell's theorem are the new things in contemporary philosophy of quantum mechanics. For what it's worth, let me say that I think that quantum logic is a logic, and that quantum logical realism fails.

No text as short as this one could begin to handle all the problems of the subject. But I should at least like to give the student enough background knowledge to enable him or her to explore the contemporary literature. In fact, the book has the appropriately incompatible aims of being both an introductory textbook on the philosophy of quantum mechanics and also an essay on quantum logic.

If this book has a single thesis, it is: the lasting results of the philosophy of quantum mechanics are largely negative; quantum systems are not like classical particles; this is not a world of separate things whose behaviour depends only on the way the world nearby is; there is no reason to believe that something like a new classical mechanics can underpin quantum mechanics even when this mechanics is suitably warped by a nonclassical logic. If we are finally left with a mystery, as I think we are, we can still learn from the philosophy of quantum mechanics just how odd the physical world must be.

The book is based on a course of lectures entitled 'Particles and Paradoxes: An Introduction to the Philosophy of Quantum Mechanics' given during the Hilary Term of 1984 at the sub-Faculty of Philosophy at Oxford University, and repeated at the Department of Philosophy of Bristol University in the following year. John Lucas and Rom Harré at Oxford, and David Hirschmann, Adam Morton, and Ian Thompson at Bristol kept me on my toes. My thanks also go to Peter Alexander, Mike Berry, and John Mayberry who read and commented on parts of the text. The many mistakes that have survived their scrutiny are of course my sole responsibility.

Peter Gibbins
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