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The ghost in the atom

A discussion of the mysteries of quantum physics

The ghost in the atom

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Cover illustration – a burst of light fills a test chamber: fusion of deuterium and tritium.
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CONTENTS

FOREWORD

Niels Bohr once remarked that anybody who is not shocked by quantum theory has not understood it. Certainly a powerful sense of shock and bewilderment reverberated among his contemporaries in the 1920s when the full implications of the theory began to emerge. Not only did quantum theory fly in the face of classical nineteenth-century physics but it also radically transformed scientists' outlook on our relationship with the material world. For, according to Bohr's interpretation of the theory, the existence of the world 'out there' is not something that enjoys an independence of its own, but is inextricably tied up with our perceptions of it.

Not surprisingly, some physicists found such an idea hard to swallow. Ironically, having played a significant part in the early development of quantum theory, Albert Einstein became its foremost critic. Until his death in 1955, he was convinced that an essential ingredient was missing from the formulation of quantum theory; without this ingredient he argued, our description of matter on the atomic scale would inevitably remain intrinsically uncertain and therefore incomplete. In the course of a long friendship with Bohr, Einstein repeatedly tried to demonstrate the incompleteness of quantum theory. He produced a number of highly ingenious arguments, some of which caused considerable concern among scientists. But each time Bohr quickly managed to find an elegant and persuasive refutation. Gradually, the feeling grew that Einstein's quest to exorcise the ghost in the atom had been in vain.

But today the quantum controversy is far from over. In recent

years a series of experimental tests has been carried out, culminating in those of Alain Aspect and his colleagues in France – tests which promised to cast new light on the Bohr–Einstein debate.

The resurgence of interest in the interpretation of quantum theory prompted me (J.B.) to consider making a radio documentary on the subject. I discussed the idea with Professor Paul Davies, who agreed to present a programme for BBC Radio 3. We interviewed several leading physicists who have taken a particular interest in the conceptual foundations of quantum mechanics, to find out what they made of Aspect's results and other recent developments in quantum theory.

Owing to the naturally quite limited time available within a documentary format only brief segments of the interviews could be used in the final programme. Nevertheless, the Radio 3 broadcast of the 'The Ghost in the Atom' provoked a great deal of interest and subsequently we felt that it would be well worth while publishing the interviews in a fuller and more permanent form.

With the exception of Chapter 1, the contents of this book are based upon the transcripts of the original radio interviews. In editing them, we have been obliged to make some amendments to render the dialogues more suitable for the printed page, but we have endeavoured to do this without sacrificing too much of their conversational character. This book is intended for the general reader, and we have therefore written Chapter 1 as an introduction to the ideas discussed within the interviews. If you are already familiar with many of these, you may wish to jump directly to Chapter 2 and refer to the index or glossary for explanations of any technical terms or arguments.

A final thought and a note of caution; when we commissioned the interviews, several of our contributors (who shall remain nameless!) expressed the view that there is now no real doubt over how quantum theory should be interpreted. At the very least, we hope this book will show that there is little justification for such complacency.

We are greatly indebted to all our contributors and especially Sir Rudolf Peierls for his critical reading of Chapter 1. We would also like to thank Mandy Eustace for performing the difficult task of transcribing the contents of the original audio tapes.

January 1986

J. Brown
P. C. W. Davies