FOREWORD

It may turn out that, like certain other phenomena studied by sociologists, bouts of interest in the foundations of quantum mechanics tend to come in 60-year cycles. It is hardly surprising that in the first decade or so of the subject the conceptual puzzles generated by this strange new way of looking at the world should have generated profound interest, not just among professional physicists themselves but also among philosophers and informed laymen; but this intense interest was followed by a fallow period in the forties and fifties when the physics establishment by and large took the view that the only puzzles left were the product either of incompetent application of the formalism or of bad philosophy, and only a few brave individualists like the late David Bohm dared to suggest that maybe there really was something there after all to worry about. As Bell and Nauenberg, surveying the scene in 1966, put it: "The typical physicist feels that [these questions] have long ago been answered, and that he will fully understand how if ever he can spare twenty minutes to think about it." But gradually, through the sixties and seventies, curiosity did revive, and the last ten years or so have seen a level of interest in foundational questions, and an involvement in them by some of the leading figures of contemporary physics, which is probably unparalleled since the earliest days.

What are the origins of this remarkable revival? A cynic might perhaps suggest (no doubt as with other 60-year cycles!) that one major component is that the generation who had "solved" the problems to their own satisfaction in the twenties have by now by and large died off, leaving the field to those who, as these founding fathers might have seen it, have never received the correct intellectual vaccinations in their youth. A rosier view may be that over the last thirty years or so it has gradually become clear that at least some of the questions which had been dismissed by the community of hard-headed practicing physicists as "merely philosophical" could actually generate interesting experiments par excellence on the "quantum nonlocality" associated with Bell's theorem, but also on the quantum behavior of collective (macroscopic) degrees of freedom, on single-atom shelving and much else. Although in all these cases the standard formalism of quantum mechanics, when competently applied, makes unambiguous predictions, and to date these predictions have been confirmed, not everyone in the field would necessarily have staked his or her life in advance of the event that Nature would continue to respect

the quantum prescriptions under these extreme conditions. The last five years or so have seen an even more exciting development: the realization that some of the "weirdest" aspects of quantum theory may actually have useful practical applications, in quantum cryptography and quantum computing. (A development, incidentally, which has its negative aspects; not all of us welcome the thought that nowadays among the audience at conferences on Bell's theorem and such "innocent" subjects there may be people whose prime affiliation is with some military intelligence establishment!)

While the last few years have seen a plethora of books on the conceptual problems of quantum mechanics for a lay audience, and at least a handful intended for the more technically fluent reader, I believe the present book will fill a special niche. On the one hand, Dipankar Home writes on the assumption that his reader is a professional physicist, or at least will be able to follow complex technical discussions, and thus keeps the argument on a rigorous level, without the oversimplifications that inevitably have to be made in books for a lay readership. On the other hand, he does not, unlike some other books in this category, assume a priori that quantum mechanics is the ultimate truth about the world and/or that worries about the conceptual foundations merely reflect an inadequate appreciation of the subtleties involved in applying it. Indeed a major theme of the book is the profound and fundamental difficulties which any version of the "orthodox" interpretation has in explaining the existence, in our everyday experience, of definite outcomes to experiments where the final state predicted by quantum mechanics is a superposition—the classic "quantum measurement paradox," which in his opinion (and mine!) has got no nearer a solution for all the words expended on it over the last sixty years. At the same time, he does not advocate a particular line of solution to this problem to the exclusion of all others; rather, his emphasis is on the different kinds of experimental test that someday may (or may not!) set limits to the validity of the quantum description and/or prove one or other of these "non-standard" approaches correct.

A second special point is the extensive treatment of topics such as non-inequality-based demonstrations of quantum nonlocality, quantum teleportation, and experiments on the "quantum Zeno effect," which have emerged only very recently. (The subject of quantum computation was, however, unfortunately too "late-breaking" to be included). I believe that this book is essential reading for any physicist who is seriously concerned about the foundations of the theory which, for all its curious and counterintuitive aspects, is still (to adapt a famous characterization by a former British Cabinet member of the prime minister of the day) "the best theory of the world we've got."

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