

Preface

The original German edition of this book was published in 2009. Because of the positive response I have got from students and colleagues I translated the book into English and furthermore added some new problems, the last chapter “synopsis” and an additional Appendix about the reduced density matrix.

What was the reason to write this book? There are a large number of excellent textbooks on quantum mechanics on the market. Nearly all of these books have in common, that quantum mechanics is presented as one of the most important and successful theories to solve physical problems. This is totally in the sense of most physicists, who applied, until the 1970s of the 20th century, in a first quantum revolution quantum mechanics with overwhelming success not only to atom and particle physics but also to nearly all other science branches as chemistry, solid state physics, biology or astrophysics. Because of the success in answering essential questions in these fields fundamental open problems concerning the theory itself were approached only in rare cases. This situation has changed since the last decade of the 20th century. Since then there are new sophisticated experimental tools in quantum optics, atom and ion physics and in nanoelectronics, which can touch inherent quantum physical questions and allow interesting tests of the theory itself. Such questions, as for example, origin and consequences of superposition and entanglement, are of predominant importance for fields as quantum teleportation, quantum computing and quantum information in general.

From this “second quantum revolution” as this continuing further development of quantum physical thinking is called by Alain Aspect, one of the pioneers in this field, one expects a deeper understanding of quantum physics itself but also applications in engineering. There is already the term “quantum engineering” which describes scientific activities to apply particle wave duality or entanglement for practical purposes, for example, nano-machines, quantum computers etc.

This background in mind I have written the present book. Particular quantum phenomena are more at the center of interest rather than the mathematical formalism. I prefer a more pictorial and sometimes intuitive description of the phenomena, and recent experimental findings from research on nanoelectronic systems are often presented to support the theory. Also connections to other science branches such as

elementary particle, quantum electronics or nuclear magnetic resonance in biology and medicine are made.

Concerning the formalism I generally restrict myself to first approximation steps, which are relevant for experimental physicists and engineers in applying the theory or to estimate the order of magnitude of experimental results or data. On the other hand, the Dirac bra-ket notation is introduced in analogy to three-dimensional vectors and it is used for simplicity reasons in many cases. Similarly commutator algebra is introduced as essentially adding or subtraction of symbols (operators). The mathematical background necessary to read the book is quite simple. Only the knowledge of simple functions, simple differential equations and basics of matrix algebra is required.

Rather than axiomatically introducing important quantities and equations I have preferred to make the invention of basic equations or the mathematical tools for field quantization plausible by physically reasonable conclusions and extrapolations.

The book was written on the basis of manuscripts of lectures about quantum physics and nanoelectronics, which I have given to physics and electrical engineering students at the Aachen University of Technology (RWTH). Essential extensions are, of course, due to my own research in quantum electronics. In particular, supervising PhD students in this field and the many discussions with them had great influence on the way of presentation. I want to thank all of them for the interesting discussions which also helped me to a deeper insight into the fascinating field of quantum physics.

Furthermore, I want to thank my former coworkers, meanwhile all in academic teaching and research positions, Arno Förster, Michel Marso, Michael Indlekofer and Thomas Schäpers for many exciting disputes, which contributed to further elucidation of difficult questions.

During the translation of the original German edition into English Margrit Klöcker sometimes improved and corrected my English grammar; also thanks to her.

I owe very special thanks to my late wife Roswitha. She supported me all the time during which I wrote the original German manuscript and she invented the subtitle “Schrödinger’s Cat and the Dwarfs”. This subtitle accurately expresses the main focus of the book, namely a more thorough diving into the physical and philosophical content of quantum mechanics (paradigm: Schrödinger’s cat), and this in the context of the nanoworld (world of the dwarfs). Roswitha found the right words for this aspect of the book that I lacked.

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