INTRODUCTION TO QUANTUM THEORY

Since its emergence in the early twentieth century, quantum theory has become the fundamental physical paradigm, and is essential to our understanding of the world.

Providing a deeper understanding of the microscopic world through quantum theory, this supplementary text covers a wider range of topics than conventional textbooks. Emphasis is given to modern achievements such as entanglement, quantum teleportation, and Bose–Einstein condensation. Macroscopic quantum effects of practical relevance, for example, superconductivity and the quantum Hall effect, are also described. Looking to the future, the author discusses the exciting prospects for quantum computing.

Physical, rather than formal, explanations are given, and mathematical formalism is kept to a minimum so that readers can understand the concepts. Theoretical discussions are combined with a description of the corresponding experimental results. This book is ideal for undergraduate and graduate students in quantum theory and quantum optics.

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INTRODUCTION TO QUANTUM THEORY

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Preface

This is an unconventional introduction to quantum mechanics. Emphasis is laid on the physical aspects rather than the formal apparatus. (As a side-effect, the book will be easier to read than usual textbooks in which mathematics is predominant.) To elucidate the novel features displayed by the quantum world, comparison is made with classical physics whenever possible, thus emphasizing the anti-intuitive (in German: ‘unanschaulich’) character of the new physics.

It is my goal to discuss thoroughly the basic quantum mechanical concepts, such as quantum states and their preparation, quantum mechanical uncertainty, quantum correlations and quantum measurement. In addition, selected experiments are reported that show up the potential of quantum theory and, by the way, tell us of the ingenuity of the researchers. Many of those experiments are taken from quantum optics which, in fact, is a wonderful playing ground for quantum physicists. In particular, exciting theoretical concepts, such as the famous gedanken experiment of Einstein, Podolsky and Rosen, and quantum teleportation, could be realized experimentally. Those achievements, of course, find their due place in this book.

Attention is also given to the mysterious interrelationship between spin and statistics, which makes the behaviour of Fermi and Bose gases so different. A special paragraph is devoted to the experimental verification of Bose–Einstein condensation, one of the highlights of experimental research in the last two decades.

Furthermore, fundamental interaction processes, notably scattering, are treated, as well as macroscopic quantum effects, such as superconductivity and the Josephson and quantum Hall effects. Finally, the intriguing concept of quantum computers is briefly discussed.

With this book, I hope to contribute to a deeper understanding of quantum mechanics and its ‘mysteries’. So it might supplement, certainly not substitute,
existing textbooks on quantum theory and quantum optics. It addresses mainly students and scientific workers. However, they should already be familiar with the quantum mechanical formalism.

What fascinates me on quantum physics is, first of all, ideas. I hope, I can convey some of my enthusiasm to the reader.