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A Mathematical Approach to Research Problems of Science and Technology Springer Nature
Publisher Description

Quantum Information and Quantum Optics with Superconducting Circuits Springer
This book is a thoroughly modern and highly pedagogical graduate-level introduction to quantum optics, a subject which has witnessed stunning developments in recent years and has come to occupy a central role in the 'second quantum revolution'. The reader is invited to explore the fundamental role that quantum optics plays in the control and manipulation of quantum systems, leading to ultracold atoms, circuit QED, quantum information science, quantum optomechanics, and quantum metrology. The building blocks of the subject are presented in a sequential fashion, starting from the simplest physical situations before moving to increasingly complicated ones. This pedagogically appealing approach leads to quantum entanglement and measurement theory being introduced early on and before more specialized topics such as cavity QED or laser cooling. The final chapter illustrates the power of scientific cross-fertilization by surveying cutting-edge applications of quantum optics and optomechanics in gravitational wave detection, tests of fundamental physics, searches for dark matter, geophysical monitoring, and ultraprecise clocks. Complete with worked examples and exercises, this book provides the reader with enough background knowledge and understanding to follow the current journal literature and begin producing their own original research.

Quantum Coherence Correlation and Decoherence in Semiconductor Nanostructures MDPI
Prototypical quantum optics models, such as the Jaynes-Cummings, Rabi, Tavis-Cummings, and Dicke models, are commonly analyzed with diverse techniques, including analytical exact solutions, mean-field theory, exact diagonalization, and so on. Analysis of these systems strongly depends on their symmetries, ranging, e.g., from a U(1) group in the Jaynes-Cummings model to a Z2 symmetry in the full-fledged quantum Rabi model. In recent years, novel regimes of light-matter interactions, namely, the ultrastrong and deep-strong coupling regimes, have been attracting an increasing amount of interest. The quantum Rabi and Dicke models in these exotic regimes present new features, such as collapses and revivals of the population, bounces of photon-number wave packets, as well as the breakdown of the rotating-wave approximation. Symmetries also play an important role in these regimes and will additionally change depending on whether the few- or many-qubit systems considered have associated inhomogeneous or equal couplings to the bosonic mode. Moreover, there is a growing interest in proposing and carrying out quantum simulations of these models in quantum platforms such as trapped ions, superconducting circuits, and quantum photonics. In this Special Issue Reprint, we have gathered a series of articles related to symmetry in quantum optics models, including the quantum Rabi model and its symmetries, Floquet topological quantum states in optically driven semiconductors, the spin-boson model as a simulator of non-Markovian multiphoton Jaynes-Cummings models, parity-assisted generation of nonclassical states of light in circuit quantum electrodynamics, and quasiprobability distribution functions from fractional Fourier transforms.

Our Changing Views of Photons OUP Oxford
The contributions in this volume were presented at a NATO Advanced Study Institute held in Erice, Italy, 4-19 July 2013. Many aspects of important research into nanophotonics, plasmonics, semiconductor materials and devices, instrumentation for bio sensing to name just a few, are covered in depth in this volume. The growing connection between optics and electronics, due to the increasing important role plaid by semiconductor materials and devices, find their expression in the term photonics, which also reflects the importance of the photon aspect of light in the description of the performance of several optical systems. Nano-structures have unique capabilities that allow the enhanced performance of processes of interest in optical and photonic devices. In particular these structures permit the nanoscale manipulation of photons, electrons and atoms; they represent a very hot topic of research and are relevant to many devices and applications. The various subjects bridge over the disciplines of physics, biology and chemistry, making this volume of interest to people working in these fields. The emphasis is on the principles behind each technique and on examining the full potential of each technique.

Quantum simulation experiments with superconducting circuits Springer Nature

Quantum OpticsSpringer Nature

Using Mathematica for Quantum Mechanics Cambridge University Press
Quantum information theory is a branch of science at the frontier of physics, mathematics, and information science, and offers a variety of solutions that are impossible using classical theory. This book provides a detailed introduction to the key concepts used in processing quantum information and reveals that quantum mechanics is a generalisation of classical probability theory. The second edition contains new sections and entirely new chapters: the hot topic of multipartite entanglement; in-depth discussion of the discrete structures in finite dimensional Hilbert space, including unitary operator bases, mutually unbiased bases, symmetric informationally complete generalized measurements, discrete Wigner function, and unitary designs; the Gleason and Kochen – Specker theorems; the proof of the Lieb conjecture; the measure concentration phenomenon; and the Hastings' non-additivity theorem. This richly-illustrated book will be useful to a broad audience of graduates and researchers interested in quantum information theory. Exercises follow each chapter, with hints and answers supplied.

A Theoretical Study of Quantum Molecular Reaction Dynamics and of the Effects of Intense Laser Radiation on a Diatomic Molecule Clarendon Press
Advances in technology often rely on a world of photons as the basic units of light. Increasingly one reads of photons as essential to enterprises in Photonics and Quantum Technology, with career and investment opportunities. Notions of photons have evolved from the energy-packet crowds of Planck and Einstein, the later field modes of Dirac, the seeming conflict of wave and particle photons, to the ubiquitous laser photons of today. Readers who take interest in contemporary technology will benefit from learning what photons are now considered to be, and how our views of photons have changed — in learning about the various operational definitions that have been used for photons and their association with a variety of quantum-state manipulations that include Quantum Information, astronomical sources and crowds of photons, the boxed fields of Cavity Quantum Electrodynamics and single photons on demand, the photons of Feynman and Glauber, and the photon constituents of the Standard Model of Particle Physics. The narrative points to contemporary photons as causers of change to atoms, as carriers of messages, and as subject to controllable creation and alteration — a considerable diversity of photons, not just one kind. Our Changing Views of Photons: A Tutorial Memoir presents those general topics as a memoir of the author's involvement with physics and the photons of theoretical Quantum Optics, written conversationally for readers with no assumed prior exposure to science. It offers lay readers a glimpse of scientific discovery — of how ideas become practical, as a small scientific community reconsiders its assumptions and offers the theoretical ideas that are then developed, revised, and adopted into technology for daily use. For readers who want a more detailed understanding of the theory, three substantial appendices provide tutorials that, assuming no prior familiarity, proceed from a very elementary start to basics of discrete states and abstract vector spaces; Lie groups; notions of quantum theory and the Schr ö dinger equation for quantum-state manipulation; Maxwell's equations for electromagnetism, with wave modes that become photons, possibly exhibiting quantum entanglement; and the coupling of atoms and fields to create quasiparticles. The appendices can be seen as a companion to traditional textbooks on Quantum Optics.

Towards a Scalable Quantum Computing Platform in the Ultrastrong Coupling Regime Springer
This open access book presents selected papers from International Symposium on Mathematics, Quantum Theory, and Cryptography (MQC), which was held on September 25-27, 2019 in Fukuoka, Japan. The international symposium MQC addresses the mathematics and quantum theory underlying secure modeling of the post quantum cryptography including e.g. mathematical study of the light-matter interaction models as well as quantum computing. The security of the most widely used RSA cryptosystem is based on the difficulty of factoring large integers. However, in 1994 Shor proposed a quantum polynomial time algorithm for factoring integers, and the RSA cryptosystem is no longer secure in the quantum computing model. This vulnerability has prompted research into post-quantum cryptography using alternative mathematical problems that are secure in the era of quantum computers. In this regard, the National Institute of Standards and Technology (NIST) began to standardize post-quantum cryptography in 2016. This book is suitable for postgraduate students in mathematics and computer science, as well as for experts in industry working on post-quantum cryptography.

Schr ö dinger Operators, Spectral Analysis and Number Theory Routledge
With both industrial and teaching experience, the author explains the effects of time dependence in systems with two energy levels. The book starts with time-independent interactions and goes on to treat interactions with time-dependent electric and magnetic fields. Complete derivations are presented for each case, so the reader understands how the solutions are found. Both closed-form and numerical solutions are treated, and the calculations are compared with experimental data from the literature. Numerous plots are provided to show how the solutions depend on the parameters of the interactions. The book builds upon an undergraduate course in quantum mechanics and is useful for readers interested in magnetic resonance and quantum optics. In addition, this book is ideal for self-study by students or researchers starting on two-level systems. The detailed derivations and plots should ease readers into the study of two-level systems in a wide variety of settings.

Mathematical Modelling for Next-Generation Cryptography Oxford University Press
This thesis devotes three introductory chapters to outlining basic recipes for constructing the quantum Hamiltonian of an arbitrary superconducting circuit, starting from classical circuit design. Since a superconducting circuit is one of the most promising platforms for realizing a practical quantum computer, anyone who is starting out in the field will benefit greatly from this introduction. The second focus of the introduction is the ultrastrong light-matter interaction (USC), where the latest developments are described. This is followed by three main research works comprising quantum memory in USC; scaling up the 1D circuit to a 2D lattice configuration; creation of Noisy Intermediate-Scale Quantum era quantum error correction codes and polariton-mediated qubit-qubit interaction. The research work detailed in this thesis will make a major contribution to the development of quantum random access memory, a prerequisite for various quantum machine learning algorithms and applications.

Heun's Differential Equations World Scientific Publishing
Comprehensive introduction to the theory of superconducting circuits and their application in quantum computing and simulation.

Special Functions Springer
The subject of this book is the theory of special functions, not considered as a list of functions exhibiting a certain range of properties, but based on the unified study of singularities of second-order ordinary differential equations in the complex domain. The number and characteristics of the singularities serve as a basis for classification of each individual special function. Links between linear special functions (as solutions of linear second-order equations), and non-linear special functions (as solutions of Painlev é equations) are presented as a basic and new result. Many applications to different areas of physics are shown and discussed. The book is written from a practical point of view and will address all those scientists whose work involves applications of mathematical methods. Lecturers, graduate students and researchers will find this a useful text and reference work.

Introduction to the Standard Model and Beyond Oxford University Press
This work presents the mathematical methods widely used by workers in the field of quantum optics. It deals with the physical assumptions which lead to the models and approximations employed, but the main purpose of the text is to give a firm grounding in those techniques needed to derive analytical solutions to problems.

Quantum Optics Cambridge University Press
Concepts of Quantum Optics is a coherent and sequential coverage of some real insight into quantum physics. This book is divided into six chapters, and begins with an overview of the principles and concepts of radiation and quanta, with an emphasis on the significance of the Maxwell's electromagnetic theory of light. The next chapter describes first the properties of the radiation field in a bounded cavity, showing how each cavity field mode has the characteristics of a simple harmonic oscillator and how each can be quantized using known results for the quantum harmonic oscillator. This chapter also deals with the quantum fluctuations of the radiation field and the interpretation of a photon as an occupation of a normal mode of the system. These topics are followed by discussions of the radiation absorption and emission and the principles of coherent state and coherence functions. The

final chapter considers the concept of semi-classical theory and its connection to quantum electrodynamics. This book is of value to undergraduate and postgraduate students who are starting research in laser physics or quantum optics.

Analysis as a Tool in Mathematical Physics World Scientific Publishing Company

Written by major contributors to the field who are well known within the community, this is the first comprehensive summary of the many results generated by this approach to quantum optics to date. As such, the book analyses selected topics of quantum optics, focusing on atom-field interactions from a group-theoretical perspective, while discussing the principal quantum optics models using algebraic language. The overall result is a clear demonstration of the advantages of applying algebraic methods to quantum optics problems, illustrated by a number of end-of-chapter problems. An invaluable source for atomic physicists, graduates and students in physics.

Exploring the Quantum Springer Nature

This book provides a comprehensive collection of problems together with their detailed solutions for Bose, Spin, Fermi systems and also interacting systems. Supplementary problems are also provided. Exercises for representations of Lie groups and Lie algebras are also covered as well as computer algebra implementations. It is the only book which summarizes these topics from the quantum theory aspect in the form of exercises and solutions. The book is also self-contained. Both physicists and mathematicians will benefit from all the different techniques explained and worked out in detail.

Springer Nature

Exactly solvable models, that is, models with explicitly and completely diagonalizable Hamiltonians are too few in number and insufficiently diverse to meet the requirements of modern quantum physics. Quasi-exactly solvable (QES) models (whose Hamiltonians admit an explicit diagonalization only for some limited segments of the spectrum) provide a practical way forward. Although QES models are a recent discovery, the results are already numerous. Collecting the results of QES models in a unified and accessible form, Quasi-Exactly Solvable Models in Quantum Mechanics provides an invaluable resource for physicists using quantum mechanics and applied mathematicians dealing with linear differential equations. By generalizing from one-dimensional QES models, the expert author constructs the general theory of QES problems in quantum mechanics. He describes the connections between QES models and completely integrable theories of magnetic chains, determines the spectra of QES Schr ö dinger equations using the Bethe-Iansatz solution of the Gaudin model, discusses hidden symmetry properties of QES Hamiltonians, and explains various Lie algebraic and analytic approaches to the problem of quasi-exact solubility in quantum mechanics. Because the applications of QES models are very wide, such as, for investigating non-perturbative phenomena or as a good approximation to exactly non-solvable problems, researchers in quantum mechanics-related fields cannot afford to be unaware of the possibilities of QES models.

Linear Ordinary Differential Equations Oxford University Press

This book provides a comprehensive discussion of the Jahn-Teller Effect (JTE), focusing on the boson-fermion interaction. While current research is concerned with measuring and calculating ever more sophisticated and complex manifestations of the JT effect, the present volume takes away the epicycles of the theory and focuses on the symmetry dilemma at its core. When fermions and bosons meet, they get entangled and form a new dynamic reality. According to the rules of Molecular Symmetry, this reality is limited to a small set of patterns, with degeneracy cardinalities: 2, 3, 4, 5, and 6. The novelty of the book is that it adopts a unique mathematical technique, known as the Bargmann-Fock representation, and treats all degeneracies in detail. So far, this method was only applied to the simplest doublet case therefore its extension to the entire range of cases offers a new unified perspective. This volume will help the reader acquire a clear understanding of the JT effect, discover its universal mechanism and it will be a great tool for researchers and graduates working on this topic.

Energy Research Abstracts KIT Scientific Publishing

In this book, the equilibrium and nonequilibrium properties of continuous phase transitions are studied in various systems, with a special emphasis on understanding how well-established universal traits at equilibrium may be extended into the dynamic realm, going beyond the paradigmatic Kibble – Zurek mechanism of defect formation. This book reports on the existence of a quantum phase transition in a system comprising just a single spin and a bosonic mode (the quantum Rabi model). Though critical phenomena are inherent to many-body physics, the author demonstrates that this small and ostensibly simple system allows us to explore the rich phenomenology of phase transitions, both in- and out-of-equilibrium. Moreover, the universal traits of this quantum phase transition may be realized in a single trapped-ion experiment, thus avoiding the need to scale up the number of constituents. In this system, the phase transition takes place in a suitable limit of system parameters rather than in the conventional thermodynamic limit – a novel notion that the author and his collaborators have dubbed the finite-component system phase transition. As such, the results gathered in this book will open promising new avenues in our understanding and exploration of quantum critical phenomena.

Equilibrium and Nonequilibrium Aspects of Phase Transitions in Quantum Physics SIAM

This book revisits many of the problems encountered in introductory quantum mechanics, focusing on computer implementations for finding and visualizing analytical and numerical solutions. It subsequently uses these implementations as building blocks to solve more complex problems, such as coherent laser-driven dynamics in the Rubidium hyperfine structure or the Rashba interaction of an electron moving in 2D. The simulations are highlighted using the programming language Mathematica. No prior knowledge of Mathematica is needed; alternatives, such as Matlab, Python, or Maple, can also be used.