Quantum World Of Ultra Cold Atoms And Light The Book Ii The Physics Of Quantum Optical Devicesquarantine

#quantum physics #ultra-cold atoms #quantum optical devices #light-matter interaction #quantum technologies

Dive deep into the extraordinary 'Quantum World Of Ultra Cold Atoms And Light', exploring the fundamental physics behind these fascinating phenomena. This comprehensive resource, presented as 'The Book II', unveils the intricate mechanics of quantum optical devices, crucial for understanding cutting-edge advancements in quantum technology and research.

The Quantum World of Ultra-Cold Atoms and Light Book II: The Physics of Quantum-Optical Devices

This century has seen the development of technologies for manipulating and controlling matter and light at the level of individual photons and atoms, a realm in which physics is fully quantum-mechanical. The dominant experimental technology is the laser, and the theoretical paradigm is quantum optics. The Quantum World of Ultra-Cold Atoms and Light is a trilogy, which presents the quantum optics way of thinking and its applications to quantum devices. This book — The Physics of Quantum-Optical Devices — provides a comprehensive treatment of theoretical quantum optics. It covers applications to the optical manipulation of the quantum states of atoms, laser cooling, continuous measurement, quantum computers and quantum processors, superconducting systems and quantum networks. The subject is consistently formulated in terms of quantum stochastic techniques, and a systematic and thorough development of these techniques is a central part of the book. There is also a compact overview of the ideas of quantum information theory. The main aim of the book is to present the theoretical techniques necessary for the understanding of quantum optical devices, with special attention to those devices used in quantum information processing and quantum simulation. Although these techniques were developed originally for the optical regime, they are also applicable to electromagnetic radiation from the microwave realm to the ultra-violet, and for atomic systems, Josephson junction systems, quantum dots and nano-mechanical systems. For more information, please visit: http://europe.world-scientific.com/quantum-world-of-ultra-cold-atoms-and-light.html

The Quantum World of Ultra-Cold Atoms and Light Book I: Foundations of Quantum Optics

This century has seen the development of technologies for manipulating and controlling matter and light at the level of individual photons and atoms, a realm in which physics is fully quantum mechanical. The dominant experimental technology is the laser, and the theoretical paradigm is quantum optics. The Quantum World of Ultra-Cold Atoms and Light is a trilogy, which presents the quantum optics way of thinking and its applications to quantum devices. This book — Foundations of Quantum Optics — provides an introductory text on the theoretical techniques of quantum optics, containing the elements of what one needs to teach, learn, and “think” about quantum optics. There is a particular emphasis on the classical and quantum stochastic methods which have come to dominate the field. Book II will cover applications to quantum devices, such as quantum computers and simulators, and will include the more advanced techniques necessary to describe non-classical light fields. Book III will cover the field of ultra-cold atoms, for which the quantum-optical paradigm has proved to be highly applicable for quantitative work. For more information, please visit: http://europe.worldscientif-ic.com/quantum-world-of-ultra-cold-atoms-and-light.html

Quantum World Of Ultra-cold Atoms And Light, The - Book Iii: Ultra-cold Atoms

"This century has seen the development of technologies for manipulating and controlling matter and light at the level of individual photons and atoms, a realm in which physics is fully quantum-mechanical. The dominant experimental technology is the laser, and the theoretical paradigm is quantum optics. The Quantum World of Ultra-Cold Atoms and Light is a trilogy, which presents the quantum optics way of thinking and its applications to quantum devices. This book -- "Ultra-Cold Atoms" -- provides a theoretical treatment of ultra-cold Bosons and Fermions and their interactions with electromagnetic fields in a form consistent with the first two books in the trilogy. The book covers five main areas The physics of cold collisions, binding of atoms into molecules, and Feshbach resonances, Bose-Einstein condensation, at zero temperature, and at finite temperature, Quantum kinetic theory, Ultra-cold Fermions, Atoms in optical lattices. The central concept is the quantum stochastic paradigm, formulated for cold collision physics. For Bosons, this yields a suite of techniques; versions of the stochastic Gross-Pitaevskii equation, using which a wide range of dynamic and thermal properties are formulated. The eBook editions of the "Quantum World Trilogy" feature an extensive system of hyperlinks for ease of cross reference within the books, as well links to the other books in the trilogy. In the section Viewing the eBooks we explain how these links work, and give some advice on appropriate pdf viewer applications. For more information, please visit: http://europe.worldscientific.com/quantum-world-of-ultra-cold-atoms-and-light.html"

The Quantum World of Ultra-cold Atoms and Light

This book explores the physics of atoms frozen to ultralow temperatures and trapped in periodic light structures. It introduces the reader to the spectacular progress achieved on the field of ultracold gases and describes present and future challenges in condensed matter physics, high energy physics, and quantum computation.

The Quantum World of Ultra-cold Atoms and Light: Foundations of quantum optics

This book derives from the content of graduate courses on cold atomic gases, taught at the Renmin University of China and at the University of Science and Technology of China. It provides a brief review on the history and current research frontiers in the field of ultracold atomic gases, as well as basic theoretical description of few- and many-body physics in the system. Starting from the basics such as atomic structure, atom-light interaction, laser cooling and trapping, the book then moves on to focus on the treatment of ultracold Fermi gases, before turning to topics in quantum simulation using cold atoms in optical lattices.The book would be ideal not only for professionals and researchers, but also for familiarizing junior graduate students with the subject and aiding them in their preparation for future study and research in the field.

Ultracold Atoms in Optical Lattices

Quantum information describes the new field which bridges quantum physics and information science. The quantum world allows for completely new architectures and protocols. While originally formulated in continuous quantum variables, the field worked almost exclusively with discrete variables, such as single photons and photon pairs. The renaissance of continuous variables came with European research consortia such as ACQUIRE (Advanced Coherent Quantum Information Research) in the late 1990s, and QUICOV (Quantum Information with Continuous Variables) from 2000–2003. The encouraging research results of QUICOV and the new conference series CVQIP (Continuous Variable Quantum Information Processing) triggered the idea for this book. This book presents the state of the art of quantum information with continuous quantum variables. The individual chapters discuss results achieved in QUICOV and presented at the first five CVQIP conferences from 2002-2006. Many world-leading scientists working on continuous variables outside Europe also contribute to the book. Contents: Bipartite and Multipartite Entanglement of Gaussian States (G Adesso & F Illuminati)Gaussian Quantum Channels (J Eisert & M M Wolf)Entanglement in Systems of Interacting Harmonic Oscillators (K M R Audenaert et al.)Continuous-Variable Quantum Key Distribution (F Grosshans et al.)Gaussian Quantum Cellular Automata (O Krüger & R F Werner)Distillation of Continuous-Variable Entanglement (J Fiurášek et al.)Loophole-Free Test of Quantum Nonlocality with Continuous Variables of Light (R García-Patrón et al.)Homodyne Tomography and the Reconstruction of Quantum States of Light (G M D'Ariano et al.)Schrödinger Cat States for Quantum Information Processing (H Jeong & T C Ralph)Polarization Squeezing and Entanglement (N Korolkova)Type-II Optical Parametric Oscillator: A Versatile Source of Quantum Correlations and Entanglement (J Laurat et al.)Accessing the Phase Quadrature of Intense Non-Classical Light State (O Glöckl et al.)Experimental Polarization Squeezing

and Continuous Variable Entanglement via the Optical Kerr Effect (V Josse et al.)High-Fidelity Quantum Teleportation and a Quantum Teleportation Network (N Takei et al.)Quantum State Sharing with Continuous Variables (T Tyc et al.)Experimental Quantum Cloning with Continuous Variables (U L Andersen et al.)Quantum Imaging Techniques for Improving Information Extraction from Images (C Fabre et al.)Squeezed Light for Gravitational Wave Detectors (R Schnabel)Continuous Variables for Single Photons (L Zhang et al.)Experimental Non-Gaussian Manipulation of Continuous Variables (J Wenger et al.)Continuous-Variable Quantum-State Tomography of Optical Fields and Photons (A I Lvovsky & M G Raymer)Gaussian Description of Continuous Measurements on Continuous Variable Quantum Systems (L B Madsen & K Mølmer)Quantum State Preparation of Spin Ensembles by Continuous Measurement and Feedback (R van Handel et al.)Real-Time Quantum Feedback Control with Cold Alkali Atoms (J M Geremia)Deterministic Quantum Interface Between Light and Atomic Ensembles (K Hammerer et al.)Long Distance Quantum Communication with Atomic Ensembles (C W Chou et al.)Decoherence and Decoherence Suppression in Ensemble-Based Quantum Memories for Photons (M Fleischhauer & C Mewes) Readership: Researchers and students specializing in quantum information systems described by continuous variables; as supporting material for advanced university courses in the field.

Quantum World of Ultra-cold Atoms and Light, the - Book i

Since 1951, the prestigious Les Houches summer school has given rigorous graduate programmes in France. In July 2009, the first Les Houches school outside Europe took place in Singapore. This volume gathers the lectures conducted at the four-week school, focused on two exciting key topics: quantum information science and ultracold atomic physics.

Physics On Ultracold Quantum Gases

Cold and ultracold collisions occupy a strategic position at the intersection of several powerful themes of current research in chemical physics, in atomic, molecular and optical physics, and even in condensed matter. The nature of these collisions has important consequences for optical manipulation of inelastic and reactive processes, precision measurement of molecular and atomic properties, matter-wave coherences and quantum-statistical condensates of dilute, weakly interacting atoms. This crucial position explains the wide interest and explosive growth of the field since its inception in 1987. The author reviews elements of the quantum theory of scattering theory, collisions taking place in the presence of one or more light fields, and collisions in the dark, below the photon recoil limit imposed by the presence of any light field. Finally, it reviews the essential properties of these mesoscopic quantum systems and describes the key importance of the scattering length to condensate stability.

Quantum Information with Continuous Variables of Atoms and Light

Quantum phenomena of many-particle systems are fascinating in their complexity and are consequently not fully understood and largely untapped in terms of practical applications. Ultracold gases provide a unique platform to build up model systems of quantum many-body physics with highly controlled microscopic constituents. In this way, many-body quantum phenomena can be investigated with an unprecedented level of precision, and control and models that cannot be solved with present day computers may be studied using ultracold gases as a quantum simulator.This book addresses the need for a comprehensive description of the most important advanced experimental methods and techniques that have been developed along with the theoretical framework in a clear and applicable format. The focus is on methods that are especially crucial in probing and understanding the many-body nature of the quantum phenomena in ultracold gases and most topics are covered both from a theoretical and experimental viewpoint, with interrelated chapters written by experts from both sides of research.Graduate students and post-doctoral researches working on ultracold gases will benefit from this book, as well as researchers from other fields who wish to gain an overview of the recent fascinating developments in this very dynamically evolving field. Sufficient level of both detailed high level research and a pedagogical approach is maintained throughout the book so as to be of value to those entering the field as well as advanced researchers. Furthermore, both experimentalists and theorists will benefit from the book; close collaboration between the two are continuously driving the field to a very high level and will be strengthened to continue the important progress yet to be made in the field.

Ultracold Gases and Quantum Information

This book provides authoritative tutorials on the most recent achievements in the field of quantum gases at the interface between atomic physics and quantum optics, condensed matter physics, nuclear and high-energy physics, non-linear physics, and quantum information.

Cold and Ultracold Collisions in Quantum Microscopic and Mesoscopic Systems

The Enrico Fermi summer school on Quantum Matter at Ultralow Temperatures held on 7-15 July 2014 at Varenna, Italy, featured important frontiers in the field of ultracold atoms. For the last 25 years, this field has undergone dramatic developments, which were chronicled by several Varenna summer schools, in 1991 on Laser Manipulation of Atoms, in 1998 on Bose-Einstein Condensation in Atomic Gases, and in 2006 on Ultra-cold Fermi Gases. The theme of the 2014 school demonstrates that the field has now branched out into many different directions, where the tools and precision of atomic physics are used to realise new quantum systems, or in other words, to quantum-engineer interesting Hamiltonians. The topics of the school identify major new directions: Quantum gases with long range interactions, either due to strong magnetic dipole forces, due to Rydberg excitations, or, for polar molecules, due to electric dipole interactions; quantum gases in lower dimensions; quantum gases with disorder; atoms in optical lattices, now with single-site optical resolution; systems with non-trivial topological properties, e.g. with spin-orbit coupling or in artificial gauge fields; quantum impurity problems (Bose and Fermi polarons); quantum magnetism. Fermi gases with strong interactions, spinor Bose-Einstein condensates and coupled multi-component Bose gases or Bose-Fermi mixtures continue to be active areas. The current status of several of these areas is systematically summarized in this volume.

Quantum Gas Experiments: Exploring Many-body States

In recent years, there has been much synergy between the exciting areas of quantum information science and ultracold atoms. This volume, as part of the proceedings for the XCI session of Les Houches School of Physics (held for the first time outside Europe in Singapore) brings together experts in both fields. The theme of the school focused on two principal topics: quantum information science and ultracold atomic physics. The topics range from Bose Einstein Condensates to Degenerate Fermi Gases to fundamental concepts in Quantum Information Sciences, including some special topics on Quantum Hall Effects, Quantum Phase Transition, Interactions in Quantum Fluids, Disorder and Interference Phenomenoma, Trapped Ions and Atoms, and Quantum Optical Devices.

Many-Body Physics with Ultracold Gases

This book introduces the preparation, measurement and properties of ultra-cold atoms and molecules at a level accessible to advanced undergraduate students or for researchers approaching the subject from different specialities. Including a review of cooling techniques, the book focuses on the behaviour and applications of both ultra-cold atoms and molecules, and how they are shaping research in atomic physics, quantum optics, condensed matter physics, statistical mechanics, quantum information processing, quantum simulators and finding applications in ultra-high-precision atomic clocks and quantum metrology. Readers of this text should develop an understanding of the techniques used to cool, trap, manipulate and perform measurements on ultra-cold atoms and molecules, as well as how such systems are in being used in a range of exciting areas of modern physics. Key Features Provides an accessible overview for advanced undergraduate students or for researchers approaching the subject from different specialities. Extensive coverage encompassing preparation, properties and applications Includes references to key papers Mathematical appendices

Quantum Matter at Ultralow Temperatures

A survey of the physics of ultracold atoms and molecules, taking into consideration the latest research on ultracold phenomena, such as Bose Einstein condensation and quantum computing. This textbook covers recent experimental results on atom and molecule cooling as well as the theoretical treatment.

Ultracold Gases and Quantum Information

Ultracold atomic systems are ideal candidates for simulating more complex quantum systems due to their high experimental controllability and also for applications in quantum information and quantum computation. A crucial point for comparing experiment with theoretical predictions is the characterization of the many-body state of the atoms. In the present text we study ultracold bosonic gases interacting

dispersively with the electromagnetic field, and analyse the kind of information about the many-body state of the atoms that may be obtained by measuring the scattered photons. In an introductory part the basic theory describing the intreraction of the electromagnetic field with a gas of ultracold atoms and the dynamics of ultracold atoms in optical lattices is reviewed. In the main part we study the response of the ultracold atomic system to a weak probe field and its signatures in the scattered light. We show how to measure the density-density correlation function and the excitation spectrum of the atomic gas, as well as the mean value of the atomic field operator. Each chapter has a separate introduction and summary giving a clear picture of the physical system considered.

Cold Atoms and Molecules Hb

Arising from a workshop, this book surveys the physics of ultracold atoms and molecules taking into consideration the latest research on ultracold phenomena, such as Bose Einstein condensation and quantum computing. Several reputed authors provide an introduction to the field, covering recent experimental results on atom and molecule cooling as well as the theoretical treatment.

Cold Atoms and Molecules

This book will describe recent theoretical advances of cold atom physics in optical lattices, concentrating on strongly correlated systems and possible applications in quantum information processing. Furthermore, the latest experiments aiming towards realizing these theoretical ideas will be discussed. The book will present in detail recently developed quantum optical tools for manipulating atoms in optical lattices and show how they can be used to realize a large range of well controlled many body Hamiltonians. Connections and differences to standard condensed matter physics will be explained. Finally, it will discuss how the ability to dynamically change parameters in these Hamiltonians on time scales much shorter than typical decoherence times can be exploited to realize quantum information processing devices with neutral atoms in optical lattices.

Physics on Ultracold Quantum Gases

This thesis presents a theoretical investigation into the creation and exploitation of quantum correlations and entanglement among ultracold atoms. Specifically, it focuses on these non-classical effects in two contexts: (i) tests of local realism with massive particles, e.g., violations of a Bell inequality and the EPR paradox, and (ii) realization of quantum technology by exploitation of entanglement, for example quantum-enhanced metrology. In particular, the work presented in this thesis emphasizes the possibility of demonstrating and characterizing entanglement in realistic experiments, beyond the simple “toy-models” often discussed in the literature. The importance and relevance of this thesis are reflected in a spate of recent publications regarding experimental demonstrations of the atomic Hong-Ou-Mandel effect, observation of EPR entanglement with massive particles and a demonstration of an atomic SU(1,1) interferometer. With a separate chapter on each of these systems, this thesis is at the forefront of current research in ultracold atomic physics.

Light Propagation in Ultracold Atomic Gases

On June 19th 1999, the European Ministers of Education signed the Bologna Dec laration, with which they agreed that the European university education should be uniformized throughout Europe and based on the two cycle bachelor master’s sys tem. The Institute for Theoretical Physics at Utrecht University quickly responded to this new challenge and created an international master’s programme in Theoret ical Physics which started running in the summer of 2000. At present, the master’s programme is a so called prestige master at Utrecht University, and it aims at train ing motivated students to become sophisticated researchers in theoretical physics. The programme is built on the philosophy that modern theoretical physics is guided by universal principles that can be applied to any sub?eld of physics. As a result, the basis of the master’s programme consists of the obligatory courses Statistical Field Theory and Quantum Field Theory. These focus in particular on the general concepts of quantum ?eld theory, rather than on the wide variety of possible applica tions. These applications are left to optional courses that build upon the ?rm concep tual basis given in the obligatory courses. The subjects of these optional courses in clude, for instance, Strongly Correlated Electrons, Spintronics, Bose Einstein Con densation, The Standard Model, Cosmology, and String Theory.

Interactions in Ultracold Gases

This volume presents the latest advancements and future developments of atomic, molecular and optical (AMO) physics and its vital role in modern sciences and technologies. The chapters are devoted to studies of a wide range of quantum systems, with an emphasis on understanding of quantum coherence and other quantum phenomena originated from light-matter interactions. The book intends to survey the current research landscape and to highlight major scientific trends in AMO physics as well as those interfacing with interdisciplinary sciences. The volume may be particularly useful for young researchers working on establishing their scientific interests and goals. Contents:Collective Phenomena and Long-Range Interactions in Ultracold Atoms and Molecules:Quantum Magnetism with Ultracold Molecules (M L Wall, K R A Hazzard and A M Rey)Optical Manipulation of Light Scattering in Cold Atomic Rubidium (R G Olave, A L Win, K Kemp, S J Roof, S Balik, M D Havey, I M Sokolov and D V Kupriyanov)Seeing Spin Dynamics in Atomic Gases (D M Stamper-Kurn)Atom-like Coherent Solid State Systems:Precision Magnetic Sensing and Imaging Using NV-Diamond (R L Walsworth)Entanglement and Quantum Optics with Quantum Dots (A P Burgers, J R Schaibley and D G Steel)Coherent Nanophotonics and Plasmonics:Enhancement of Single-Photon Sources with Metamaterials (M Y Shalaginov, S Bogdanov, V V Vorobyov, A S Lagutchev, A V Kildishev, A V Akimov, A Boltassevaand V M Shalaev)Linear Optical Properties of Periodic Hybrid Materials at Oblique Incidence: A Numerical Approach (A Blake and M Sukharev)Fundamental Physics:An Introduction to Boson-Sampling (B T Gard, K R Motes, J P Olson, P P Rohde and J P Dowling)New Approach to Quantum Amplification by Superradiant Emission of Radiation (G Shchedrin, Y Rostovtsev, X Zhang and M O Scully)Ultrafast Dynamics in Strong Laser Fields:Circularly Polarized Attosecond Pulses and Molecular Atto-Magnetism (A D Bandrauk and K-J Yuan)Many-Electron Response of Gas-Phase Fullerene Materials to Ultraviolet and Soft X-ray Photons (H S Chakraborty and M Magrakvelidze)Ultra-cold Chemistry:Collisions and Reactions in Ultracold Gases (N Balakrishnan and J Hazra) Readership: For professional researchers as well as young academics in the field of Atomic, Molecular and Optical (AMO) physics. Key Features:The contributors for this volume are all internationally recog-nized experts in their fieldsThis book offers a unique overview of the state of current AMO physics, while outlining future directions. No comparable titles have been identified so far (by editors or by reviewers)All contributions include new unpublished research, and will be of interest for anyone pur-suing the scientific investigations in the presented areasKeywords:Quantum Coherence;Amo;Atomic Physics;Quantum Control;Ultracold Atoms;Ultracold Molecules;Nv-diamonds;Quantum Dots;Quantum Magnetism;Nanophotonics;Plasmonics;Ultrafast Dynamics;Ultracold Chemistry

Cold Atoms in Optical Lattices

This book introduces the preparation, measurement and properties of ultra-cold atoms and molecules at a level accessible to advanced undergraduate students or for researchers approaching the subject from different specialities. Including a review of cooling techniques, the book focuses on the behaviour and applications of both ultra-cold atoms and molecules, and how they are shaping research in atomic physics, quantum optics, condensed matter physics, statistical mechanics, quantum information processing, quantum simulators and finding applications in ultra-high-precision atomic clocks and quantum metrology. Readers of this text should develop an understanding of the techniques used to cool, trap, manipulate and perform measurements on ultra-cold atoms and molecules, as well as how such systems are in being used in a range of exciting areas of modern physics. Key Features Provides an accessible overview for advanced undergraduate students or for researchers approaching the subject from different specialities. Extensive coverage encompassing preparation, properties and applications Includes references to key papers Mathematical appendices

Ultracold Atoms for Foundational Tests of Quantum Mechanics

Proceedings of a NATO ASI held in Erice, Sicily, February 16-18, 1994

Ultracold Quantum Fields

Recent experimental progress has enabled cold atomic gases to be studied at nano-kelvin tempera-tures, creating new states of matter where quantum degeneracy occurs - Bose-Einstein condensates and degenerate Fermi gases. Such quantum states are of macroscopic dimensions. This book presents the phase space theory approach for treating the physics of degenerate quantum gases, an approach already widely used in quantum optics. However, degenerate quantum gases involve massive bosonic and fermionic atoms, not massless photons. The book begins with a review of Fock states for systems of identical atoms, where large numbers of atoms occupy the various single particle states or modes.

First, separate modes are considered, and here the quantum density operator is represented by a phase space distribution function of phase space variables which replace mode annihilation, creation operators, the dynamical equation for the density operator determines a Fokker-Planck equation for the distribution function, and measurable quantities such as quantum correlation functions are given as phase space integrals. Finally, the phase space variables are replaced by time dependent stochastic variables satisfying Langevin stochastic equations obtained from the Fokker-Planck equation, with stochastic averages giving the measurable quantities. Second, a quantum field approach is treated, the density operator being represented by a distribution functional of field functions which replace field annihilation, creation operators, the distribution functional satisfying a functional FPE, etc. A novel feature of this book is that the phase space variables for fermions are Grassmann variables, not c-numbers. However, we show that Grassmann distribution functions and functionals still provide equations for obtaining both analytic and numerical solutions. The book includes the necessary mathematics for Grassmann calculus and functional calculus, and detailed derivations of key results are provided.

Physics with Cold Atoms

This thesis investigates ultracold molecules as a resource for novel quantum many-body physics, in particular by utilizing their rich internal structure and strong, long-range dipole-dipole interactions. In addition, numerical methods based on matrix product states are analyzed in detail, and general algorithms for investigating the static and dynamic properties of essentially arbitrary one-dimensional quantum many-body systems are put forth. Finally, this thesis covers open-source implementations of matrix product state algorithms, as well as educational material designed to aid in the use of understanding such methods.

From Atomic to Mesoscale

This thesis investigates ultracold molecules as a resource for novel quantum many-body physics, in particular by utilizing their rich internal structure and strong, long-range dipole-dipole interactions. In addition, numerical methods based on matrix product states are analyzed in detail, and general algorithms for investigating the static and dynamic properties of essentially arbitrary one-dimensional quantum many-body systems are put forth. Finally, this thesis covers open-source implementations of matrix product state algorithms, as well as educational material designed to aid in the use of understanding such methods.

Cold Atoms and Molecules

The theory of open quantum systems is developed from first principles, and a detailed discussion of real quantum devices is also covered. This unique and self-contained book is accessible to graduate students and researchers working in atomic physics, quantum information, condensed matter physics, and quantum chemistry.

Advances in Quantum Phenomena

Quantum Optics VI documents the most recent theoretical and experimental developments in this field, with particular emphasis on atomic optics and interferometry, which is a new and rapidly developing area of research. New methods for quantum-noise reduction are also covered.

Cavity Quantum Optomechanics with Ultracold Atoms

In this book we discuss how to exploit strong correlations among ultracold atoms in order to create novel, exotic quantum states. In the first two chapters, we devise dynamical out-of-equilibrium preparation schemes which lead to intriguing final states. Most importantly, we propose to create the elusive supersolid state via a quantum quench protocol. Supersolids - quantum hybrids exhibiting both superflow and solidity - have been envisioned long ago, but have not been demonstrated in experiment so far. Our proposal to create a supersolid state is perfectly accessible with current technology and may clear the way to the experimental observation of supersolidity. Furthermore, we propose to use bosons featuring conditional-hopping amplitudes in order to create Abelian anyons in one-dimensional optical lattices. We derive an exact mapping between anyons and bosons via a "fractional" Jordan-Wigner transformation. We suggest to employ a laser-assisted tunneling scheme to establish the many-particle

state of "conditional-hopping bosons," thus realizing a gas of Abelian anyons. The fractional statistics phase can be directly tuned by the lasers.

Phase Space Methods for Degenerate Quantum Gases

This unique book demonstrates the undivided unity and infinite diversity of quantum mechanics using a single phenomenon: quantum bounces of ultra-cold particles. Various examples of such "quantum bounces" are: gravitational quantum states of ultra-cold neutrons (the first observed quantum states of matter in a gravitational field), the neutron whispering gallery (an observed matter-wave analog of the whispering gallery effect well known in acoustics and for electromagnetic waves), and gravitational and whispering gallery states for anti-matter atoms that remain to be observed. These quantum states are an invaluable tool in the search for additional fundamental short-range forces, for exploring the gravitational interaction and quantum effects of gravity, for probing physics beyond the standard model, and for furthering studies into the foundations of quantum mechanics, quantum optics, and surface science.

Quantum Many-Body Physics of Ultracold Molecules in Optical Lattices

A quantum description of light is central to many aspects of the modern quantum technological revolution and key to our understanding and exploitation of photon-matter interactions, interpretation of entanglement, teleportation and quantum metrology. It underpins our comprehension of the quantum nature of information and how we can formulate, manipulate, and process it using physical systems operating on quantum mechanical principles, and a pathway to the building of quantum computing devices. This book gives a broad perspective on quantum light phenomena. It goes beyond traditional quantum optics, to include quantum fluids of light and the complete electromagnetic vacuum. Important topics for students and researchers working in a large range of areas in the modern quantum technological revolution, from single photon processes to ultra-intense laser physics. This includes atom manipulation with photons, quantum computation, ultrafast lasers, Bose-Einstein condensation of photons, superfluid light, laboratory astrophysics, and the exploration of QED vacuum using ultra-intense lasers. It also includes the axion-photon coupling, which is relevant to the search for dark matter. The first part of the book includes basic electromagnetic field quantisation, the characterisation of quantum photon states and elementary photon-atom interactions. Secondly, quantum fluids of light are explored such as recent areas as Bose-Einstein condensation, light vortices and superfluid light. Finally, the last section of the book focuses on a more complete description of quantum vacuum, which includes electron-positron states. The book is intended to make the bridge between these three somewhat distinct aspects of the quantum states of light. The audience for the book includes researchers and advanced students in quantum technology including quantum optics, metrology and computing. Key Features: Up to date review of the field, including quantum fluids of light Extensive coverage of the topic Key and central theme for modern quantum science and technology Written by a respected expert in the field

The Electromagnetic Origin of Quantum Theory and Light

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.

Quantum Many-Body Physics of Ultracold Molecules in Optical Lattices

Three key aspects of quantum gravity are considered in this book: phenomenology, potential experimental aspects and foundational theory. The phenomenology is the treatment of metric quantum fluctuations as torsional curves that deviate from classical expectations. This leads to possible experimental configurations that may detect such fluctuations. Most of these proposed experiments are quantum optical measurements of subtle quantum gravity effects in the interaction of photons and atoms. The

foundational discussions attempt to find an substratum to string theories, which are motivated by the phenomenological treatment. Quantum gravity is not the quantization of general relativity, but is instead the embedding of quantum theory and gravitation into a more fundamental field theoretic framework.

Thermodynamics and Control of Open Quantum Systems

Quantum Optics VI