Mathematical Foundations Of Quantum Information And Computation And Its Applications To Nano And Bio Systems Theoretical And Mathematical Physics

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Quantum Information and Foundations - Giacomo Mauro D'Ariano 2020-03-23
Quantum information has dramatically changed information science and technology, looking at the quantum nature of the information carrier as a resource for building new information protocols, designing radically new communication and computation algorithms, and ultra-sensitive measurements in metrology, with a wealth of applications. From a fundamental perspective, this new discipline has led us to regard quantum theory itself as a special theory of information, and has opened routes for exploring solutions to the tension with general relativity, based, for example, on the holographic principle, on non-causal variations of the theory, or else on the powerful algorithm of the quantum cellular automaton, which has revealed new routes for exploring quantum fields theory, both as a new microscopic mechanism on the fundamental side, and as a tool for efficient physical quantum simulations for practical purposes. In this golden age of foundations, an astonishing number of new ideas, frameworks, and results, spawned by the quantum information theory experience, have revolutionized the way we think about the subject, with a new research community emerging worldwide, including scientists from computer science and mathematics.

Quantum Bio-Informatics II -

Introduction to Quantum Information Science - Masahito Hayashi 2014-08-22
This book presents the basics of quantum information, e.g., foundation of quantum theory, quantum algorithms, quantum entanglement, quantum entropies, quantum coding, quantum error correction and quantum cryptography. The required knowledge is only elementary calculus and linear algebra. This way the book can be understood by undergraduate students. In order to study quantum information, one usually has to study the foundation of quantum theory. This

book describes it from more an operational viewpoint which is suitable for quantum information while traditional textbooks of quantum theory lack this viewpoint. The current book bases on Shor's algorithm, Grover's algorithm, Deutsch-Jozsa's algorithm as basic algorithms. To treat several topics in quantum information, this book covers several kinds of information quantities in quantum systems including von Neumann entropy. The limits of several kinds of quantum information processing are given. As important quantum protocols, this book contains quantum teleportation, quantum dense coding, quantum data compression. In particular conversion theory of entanglement via local operation and classical communication are treated too. This theory provides the quantification of entanglement, which coincides with von Neumann entropy. The next part treats the quantum hypothesis testing. The decision problem of two candidates of the unknown state are given. The asymptotic performance of this problem is characterized by information quantities. Using this result, the optimal performance of classical information transmission via noisy quantum channel is derived. Quantum information transmission via noisy quantum channel by quantum error correction are discussed too. Based on this topic, the secure quantum communication is explained. In particular, the quantification of quantum security which has not been treated in existing book is explained. This book treats quantum cryptography from a more practical viewpoint.

Quantum Foundations, Probability and Information - Andrei Khrennikov 2018-06-13

Composed of contributions from leading experts in quantum foundations, this volume presents viewpoints on a number of complex problems through informational, probabilistic, and mathematical perspectives and features novel mathematical models of quantum and subquantum phenomena. Rich with multi-disciplinary mathematical content, this book

includes applications of partial differential equations in quantum field theory, differential geometry, oscillatory processes and vibrations, and Feynman integrals for quickly growing potential functions. Due to rapid growth in the field in recent years, this volume aims to promote interdisciplinary collaboration in the areas of quantum probability, information, communication and foundation, and mathematical physics. Many papers discuss complex yet novel problems that depart from the mainstream of quantum physical studies. Others devote explanation to fundamental problems of the conventional quantum theory, including its mathematical formalism. Overall, authors cover a diverse set of topics, including quantum and classical field theory and oscillatory processing, quantum mechanics from a Darwinian evolutionary perspective, and biological applications of quantum theory. Together in one volume, these essays will be useful to experts in the corresponding areas of quantum theory. Theoreticians, experimenters, mathematicians, and even philosophers in quantum physics and quantum probability and information theory can consider this book a valuable resource.

Classical and Quantum Computation - Alexei Yu. Kitaev 2002

This book presents a concise introduction to an emerging and increasingly important topic, the theory of quantum computing. The development of quantum computing exploded in 1994 with the discovery of its use in factoring large numbers--an extremely difficult and time-consuming problem when using a conventional computer. In less than 300 pages, the authors set forth a solid foundation to the theory, including results that have not appeared elsewhere and improvements on existing works. The book starts with the basics of classical theory of computation, including NP-complete problems and the idea of complexity of an algorithm. Then the authors introduce general principles of quantum computing and pass to the

study of main quantum computation algorithms: Grover's algorithm, Shor's factoring algorithm, and the Abelian hidden subgroup problem. In concluding sections, several related topics are discussed (parallel quantum computation, a quantum analog of NP-completeness, and quantum error-correcting codes). This is a suitable textbook for a graduate course in quantum computing. Prerequisites are very modest and include linear algebra, elements of group theory and probability, and the notion of an algorithm (on a formal or an intuitive level). The book is complete with problems, solutions, and an appendix summarizing the necessary results from number theory.

Mathematical Foundations of Quantum Information and Computation and Its Applications to Nano- and Bio-systems - Masanori Ohya 2013-02-25

This monograph provides a mathematical foundation to the theory of quantum information and computation, with applications to various open systems including nano and bio systems. It includes introductory material on algorithm, functional analysis, probability theory, information theory, quantum mechanics and quantum field theory. Apart from standard material on quantum information like quantum algorithm and teleportation, the authors discuss findings on the theory of entropy in C*-dynamical systems, space-time dependence of quantum entangled states, entangling operators, adaptive dynamics, relativistic quantum information, and a new paradigm for quantum computation beyond the usual quantum Turing machine. Also, some important applications of information theory to genetics and life sciences, as well as recent experimental and theoretical discoveries in quantum photosynthesis are described.

Mathematical Foundations of Quantum Information and Computation and Its Applications to Nano- and Bio-systems - Masanori Ohya 2011-01-15

This monograph provides a mathematical foundation to the theory of quantum information and computation, with applications to various open systems including nano and bio systems. It includes introductory material on algorithm, functional analysis, probability theory, information theory, quantum mechanics and quantum field theory. Apart from standard material on quantum information like quantum algorithm and teleportation, the authors discuss findings on the theory of entropy in C*-dynamical systems, space-time dependence of quantum entangled states, entangling operators, adaptive dynamics, relativistic quantum information, and a new paradigm for quantum computation beyond the usual quantum Turing machine. Also, some important applications of information theory to genetics and life sciences, as well as recent experimental and theoretical discoveries in quantum photosynthesis are described.

White Noise Analysis And Quantum Information - Ohya Masanori 2017-08-29

This volume is to pique the interest of many researchers in the fields of infinite dimensional analysis and quantum probability. These fields have undergone increasingly significant developments and have found many new applications, in particular, to classical probability and to different branches of physics. These fields are rather wide and are of a strongly interdisciplinary nature. For such a purpose, we strove to bridge among these interdisciplinary fields in our Workshop on IDAQP and their Applications that was held at the Institute for Mathematical Sciences, National University of Singapore from 3–7 March 2014. Readers will find that this volume contains all the exciting contributions by well-known researchers in search of new directions in these fields. Contents: Extensions of Quantum Theory Canonically Associated to Classical Probability Measures (Luigi Accardi)Hida Distribution Construction of Indefinite Metric

(ϕp)d (d ≥ 4) Quantum Field Theory (Sergio Albeverio and Minoru W Yoshida)A Mathematical Realization of von Neumann's Measurement Scheme (Masanari Asano, Masanori Ohya and Yuta Yamamori)On Random White Noise Processes with Memory for Time Series Analysis (Christopher C Bernido and M Victoria Carpio-Bernido)Self-Repelling (Fractional) Brownian Motion: Results and Open Questions (Jinky Bornales and Ludwig Streit)Normal Approximation for White Noise Functionals by Stein's Method and Hida Calculus (Louis H Y Chen, Yuh-Jia Lee and Hsin-Hung Shih)Sensitive Homology Searching Based on MTRAP Alignment (Toshihide Hara and Masanori Ohya)Some of the Future Directions of White Noise Theory (Takeyuki Hida)Local Statistics for Random Selfadjoint Operators (Peter D Hislop and Maddaly Krishna)Multiple Markov Properties of Gaussian Processes and Their Control (Win Win Htay)Quantum Stochastic Differential Equations Associated with Square of Annihilation and Creation Processes (Un Cig Ji and Kalyan B Sinha)Itô Formula for Generalized Real and Complex White Noise Functionals (Yuh-Jia Lee)Quasi Quantum Quadratic Operators of □2(ℂ) (Farrukh Mukhamedov)New Noise Depending on the Space Parameter and the Concept of Multiplicity (Si Si)A Hysteresis Effect on Optical Illusion and Non-Kolmogorovian Probability Theory (Masanari Asano, Andrei Khrennikov, Masanori Ohya and Yoshiharu Tanaka)Note on Entropy-Type Complexity of Communication Processes (Noboru Watanabe) Readership: Mathematicians, physicists, biologists, and information scientists as well as advanced undergraduates, and graduate students studying in these fields. All researchers interested in the study of Quantum Information and White Noise Theory. Keywords: White Noise Analysis;Quantum Information;Quantum Probability;Bioinformatics;Genes;Adaptive Dynamics;Entanglement;Quantum Entropy;Non-

Kolmogorovian Probability;Infinite Dimensional AnalysisReview: Key Features: Mainly focused on quantum information theory and white noise analysis in line with the fields of infinite dimensional analysis and quantum probabilityWhite noise analysis is in a leading position of the analysis on modern stochastic analysis, and this volume contains contributions to the development of these new exciting directions

Quantum Computing - Eleanor G. Rieffel 2014-08-29

A thorough exposition of quantum computing and the underlying concepts of quantum physics, with explanations of the relevant mathematics and numerous examples. The combination of two of the twentieth century's most influential and revolutionary scientific theories, information theory and quantum mechanics, gave rise to a radically new view of computing and information. Quantum information processing explores the implications of using quantum mechanics instead of classical mechanics to model information and its processing. Quantum computing is not about changing the physical substrate on which computation is done from classical to quantum but about changing the notion of computation itself, at the most basic level. The fundamental unit of computation is no longer the bit but the quantum bit or qubit. This comprehensive introduction to the field offers a thorough exposition of quantum computing and the underlying concepts of quantum physics, explaining all the relevant mathematics and offering numerous examples. With its careful development of concepts and thorough explanations, the book makes quantum computing accessible to students and professionals in mathematics, computer science, and engineering. A reader with no prior knowledge of quantum physics (but with sufficient knowledge of linear algebra) will be able to gain a fluent understanding by working through the book.

Principles of Quantum Computation and Information - Giuliano Benenti 2004-04-16
' Quantum computation and information is a new, rapidly developing interdisciplinary field. Therefore, it is not easy to understand its fundamental concepts and central results without facing numerous technical details. This book provides the reader a useful and not-too-heavy guide. It offers a simple and self-contained introduction; no previous knowledge of quantum mechanics or classical computation is required. Volume I may be used as a textbook for a one-semester introductory course in quantum information and computation, both for upper-level undergraduate students and for graduate students. It contains a large number of solved exercises, which are an essential complement to the text, as they will help the student to become familiar with the subject. The book may also be useful as general education for readers who want to know the fundamental principles of quantum information and computation and who have the basic background acquired from their undergraduate course in physics, mathematics, or computer science. Contents:Introduction to Classical ComputationIntroduction to Quantum MechanicsQuantum ComputationQuantum Communication Readership: Upper-level undergraduates and graduate students in physics, mathematics and computer science. Keywords:Quantum Computation;Quantum Information;Quantum Algorithms;Quantum Communication;Quantum Cryptography;Complex Systems;Dynamical Systems;Quantum Chaos;Nanoscience;Quantum OpticsReviews:“The book by Benenti, Casati and Strini is an excellent introduction to the fascinating field of quantum computation and information. The reader is gently introduced to this field starting from the basics in computation and quantum mechanics to the more advanced topics of quantum computation of dynamical systems. The book is written in a very clear way, accessible both to undergraduate and graduate

students in physics, computer science and engineering.”Rosario Fazio Scuola Normale Superiore Pisa, Italy “The first volume of the present textbook aims at filling the gap between elementary introductory books and more advanced reference manuals. The choice of topics and the emphasis on concepts rather than mathematical technicalities makes it good choice for an introductory course of Quantum Information Theory for physicists or computer scientists with little background in this area. Of particular interest is the description of the links between quantum computation and quantum chaos, a research area in which the authors are leading experts, a topic rarely treated in introductory textbooks. The present volume is a welcomed addition to the existing choice of textbooks in quantum information theory and quantum computation.”Professor G Massimo Palma University of Milan, Italy “This book gives a clear and exhaustive introduction to quantum computation and quantum communication. Together with the second volume it covers all the main topics in the field of quantum information theory. It is suited for a wide audience, ranging from computer scientists to physicists and engineers. It is an effective self-contained textbook for an introductory course in quantum information theory and a precious tool for researchers who wish to approach the field.”Professor Chiara Macchiavello University of Pavia, Italy “The first volume of the two-volume edition is an introduction to the main concepts of quantum computation and information. The book offers a simple, clear and systematic treatment of qubits, quantum gates, various quantum algorithms and quantum communication. The chapters on classical information theory and quantum mechanics make the book easy to read. The book is recommended to undergraduate as well as graduate students in physics, mathematics and computer science. The large number of exercises is supplemented by solutions. The reader is

encouraged for active work."Professor Ioannis Antoniou Aristotle University of Thessaloniki, Greece "Besides giving an excellent introduction to the field it provides a unique perspective on the blending and cross-fertilization between the methods of quantum information and quantum chaos, both areas in which the authors are leading experts."Marcos Saraceno Comision Nac. de Energia Atomica, Argentina "The authors have done a very good job, succeeding to present the main topics of this domain with remarkable concision and clarity."Bertrand Georgeot CNRS/Universite Paul Sabatier, France "This book is, on the whole, well-written and readable. The material is presented concisely, and illustrated with simple examples and exercises ... the material in the current book is much more compact and easily learned than the phonebook-sized compendium of Nielsen and Chuang. It could serve well as the text for an introductory course ... It also contains numerous exercises, which mostly seem well thought out and appropriate to the material presented."Mathematical Reviews "Reading this book one remarks from the very beginning that it is outstanding and well formulated with both mathematical and verbal respects ... This book is didactically well organized and written in a clear language. It can be best recommended to people to whom it is addressed by the authors."Zentralblatt MATH '

Fundamentals of Quantum Computing - Venkateswaran Kasirajan 2021-06-21

This introductory book on quantum computing includes an emphasis on the development of algorithms. Appropriate for both university students as well as software developers interested in programming a quantum computer, this practical approach to modern quantum computing takes the reader through the required background and up to the latest developments. Beginning with introductory chapters on the required math and quantum mechanics, Fundamentals of Quantum

Computing proceeds to describe four leading qubit modalities and explains the core principles of quantum computing in detail. Providing a step-by-step derivation of math and source code, some of the well-known quantum algorithms are explained in simple ways so the reader can try them either on IBM Q or Microsoft QDK. The book also includes a chapter on adiabatic quantum computing and modern concepts such as topological quantum computing and surface codes. Features: o Foundational chapters that build the necessary background on math and quantum mechanics. o Examples and illustrations throughout provide a practical approach to quantum programming with end-of-chapter exercises. o Detailed treatment on four leading qubit modalities -- trapped-ion, superconducting transmons, topological qubits, and quantum dots -- teaches how qubits work so that readers can understand how quantum computers work under the hood and devise efficient algorithms and error correction codes. Also introduces protected qubits - 0-π qubits, fluxon parity protected qubits, and charge-parity protected qubits. o Principles of quantum computing, such as quantum superposition principle, quantum entanglement, quantum teleportation, no-cloning theorem, quantum parallelism, and quantum interference are explained in detail. A dedicated chapter on quantum algorithm explores both oracle-based, and Quantum Fourier Transform-based algorithms in detail with step-by-step math and working code that runs on IBM QisKit and Microsoft QDK. Topics on EPR Paradox, Quantum Key Distribution protocols, Density Matrix formalism, and Stabilizer formalism are intriguing. While focusing on the universal gate model of quantum computing, this book also introduces adiabatic quantum computing and quantum annealing. This book includes a section on fault-tolerant quantum computing to make the discussions complete. The topics on Quantum Error Correction, Surface codes such

as Toric code and Planar code, and protected qubits help explain how fault tolerance can be built at the system level.

Mathematical Foundations of Quantum Mechanics - John von Neumann 1955

This text shows that insights in quantum physics can be obtained by exploring the mathematical structure of quantum mechanics. It presents the theory of Hermitean operators and Hilbert spaces, providing the framework for transformation theory, and using th

Quantum Information Theory - Mark M. Wilde 2017-02-06

Developing many of the major, exciting, pre- and post-millennium developments from the ground up, this book is an ideal entry point for graduate students into quantum information theory. Significant attention is given to quantum mechanics for quantum information theory, and careful studies of the important protocols of teleportation, superdense coding, and entanglement distribution are presented. In this new edition, readers can expect to find over 100 pages of new material, including detailed discussions of Bell's theorem, the CHSH game, Tsirelson's theorem, the axiomatic approach to quantum channels, the definition of the diamond norm and its interpretation, and a proof of the Choi–Kraus theorem. Discussion of the importance of the quantum dynamic capacity formula has been completely revised, and many new exercises and references have been added. This new edition will be welcomed by the upcoming generation of quantum information theorists and the already established community of classical information theorists.

Quantum Information, Computation and Communication - Jonathan A. Jones 2012-07-19

Quantum physics allows entirely new forms of computation and cryptography, which could perform tasks currently impossible on classical devices, leading to an explosion of new algorithms, communications protocols and suggestions for physical implementations of all

these ideas. As a result, quantum information has made the transition from an exotic research topic to part of mainstream undergraduate courses in physics. Based on years of teaching experience, this textbook builds from simple fundamental concepts to cover the essentials of the field. Aimed at physics undergraduate students with a basic background in quantum mechanics, it guides readers through theory and experiment, introducing all the central concepts without getting caught up in details. Worked examples and exercises make this useful as a self-study text for those who want a brief introduction before starting on more advanced books. Solutions are available online at www.cambridge.org/9781107014466.

Quantum Computing Since Democritus - Scott Aaronson 2013-03-14

Takes students and researchers on a tour through some of the deepest ideas of maths, computer science and physics.

Quantum Information - Masahito Hayashi 2006-04-20

This graduate-level textbook provides a unified viewpoint of quantum information theory that merges key topics from both the information-theoretic and quantum- mechanical viewpoints. The text provides a unified viewpoint of quantum information theory and lucid explanations of those basic results, so that the reader fundamentally grasps advances and challenges. This unified approach makes accessible such advanced topics in quantum communication as quantum teleportation, superdense coding, quantum state transmission (quantum error-correction), and quantum encryption.

Quantum Information Theory - Masahito Hayashi 2018-06-29

This graduate textbook provides a unified view of quantum information theory. Clearly explaining the necessary mathematical basis, it merges key topics from both information-theoretic and quantum- mechanical viewpoints and provides lucid explanations of the basic

results. Thanks to this unified approach, it makes accessible such advanced topics in quantum communication as quantum teleportation, superdense coding, quantum state transmission (quantum error-correction) and quantum encryption. Since the publication of the preceding book Quantum Information: An Introduction, there have been tremendous strides in the field of quantum information. In particular, the following topics – all of which are addressed here – made seen major advances: quantum state discrimination, quantum channel capacity, bipartite and multipartite entanglement, security analysis on quantum communication, reverse Shannon theorem and uncertainty relation. With regard to the analysis of quantum security, the present book employs an improved method for the evaluation of leaked information and identifies a remarkable relation between quantum security and quantum coherence. Taken together, these two improvements allow a better analysis of quantum state transmission. In addition, various types of the newly discovered uncertainty relation are explained. Presenting a wealth of new developments, the book introduces readers to the latest advances and challenges in quantum information. To aid in understanding, each chapter is accompanied by a set of exercises and solutions.

What is Quantum Information? - Olimpia Lombardi 2017-04-24

Combining physics and philosophy, this is a uniquely interdisciplinary examination of quantum information science. Suitable as both a discussion of the conceptual and philosophical problems of this field and a comprehensive stand-alone introduction, this book will benefit both experienced and new researchers in quantum information and the philosophy of physics.

Mathematics of Quantum Computation - Ranee K Brylinski 2019-08-30

Among the most exciting developments in

science today is the design and construction of the quantum computer. Its realization will be the result of multidisciplinary efforts, but ultimately, it is mathematics that lies at the heart of theoretical quantum computer science. Mathematics of Quantum Computation brings together leading computer scientists, mathematicians, and physicists to provide the first interdisciplinary but mathematically focused exploration of the field's foundations and state of the art. Each section of the book addresses an area of major research, and does so with introductory material that brings newcomers quickly up to speed. Chapters that are more advanced include recent developments not yet published in the open literature. Information technology will inevitably enter into the realm of quantum mechanics, and, more than all the atomic, molecular, optical, and nanotechnology advances, it is the device-independent mathematics that is the foundation of quantum computer and information science. Mathematics of Quantum Computation offers the first up-to-date coverage that has the technical depth and breadth needed by those interested in the challenges being confronted at the frontiers of research.

Quantum Information Theory and the Foundations of Quantum Mechanics - Christopher G. Timpson 2013-04-25

Quantum Information Theory and the Foundations of Quantum Mechanics is a conceptual analysis of one the most prominent and exciting new areas of physics, providing the first full-length philosophical treatment of quantum information theory and the questions it raises for our understanding of the quantum world. Beginning from a careful, revisionary, analysis of the concepts of information in the everyday and classical information-theory settings, Christopher G. Timpson argues for an ontologically deflationary account of the nature of quantum information. Against what many have supposed, quantum information can be

clearly defined (it is not a primitive or vague notion) but it is not part of the material contents of the world. Timpson's account sheds light on the nature of nonlocality and information flow in the presence of entanglement and, in particular, dissolves puzzles surrounding the remarkable process of quantum teleportation. In addition it permits a clear view of what the ontological and methodological lessons provided by quantum information theory are; lessons which bear on the gripping question of what role a concept like information has to play in fundamental physics. Topics discussed include the slogan 'Information is Physical', the prospects for an informational immaterialism (the view that information rather than matter might fundamentally constitute the world), and the status of the Church-Turing hypothesis in light of quantum computation. With a clear grasp of the concept of information in hand, Timpson turns his attention to the pressing question of whether advances in quantum information theory pave the way for the resolution of the traditional conceptual problems of quantum mechanics: the deep problems which loom over measurement, nonlocality and the general nature of quantum ontology. He marks out a number of common pitfalls to be avoided before analysing in detail some concrete proposals, including the radical quantum Bayesian programme of Caves, Fuchs, and Schack. One central moral which is drawn is that, for all the interest that the quantum information-inspired approaches hold, no cheap resolutions to the traditional problems of quantum mechanics are to be had.

An Introduction to the Mathematical Structure of Quantum Mechanics - F Strocchi 2008-10-30

The second printing contains a critical discussion of Dirac derivation of canonical quantization, which is instead deduced from general geometric structures. This book arises out of the need for Quantum Mechanics (QM) to be part of the common education of mathematics

students. The mathematical structure of QM is formulated in terms of the C*-algebra of observables, which is argued on the basis of the operational definition of measurements and the duality between states and observables, for a general physical system. The Dirac–von Neumann axioms are then derived. The description of states and observables as Hilbert space vectors and operators follows from the GNS and Gelfand–Naimark Theorems. The experimental existence of complementary observables for atomic systems is shown to imply the noncommutativity of the observable algebra, the distinctive feature of QM; for finite degrees of freedom, the Weyl algebra codifies the experimental complementarity of position and momentum (Heisenberg commutation relations) and Schrödinger QM follows from the von Neumann uniqueness theorem. The existence problem of the dynamics is related to the self-adjointness of the Hamiltonian and solved by the Kato–Rellich conditions on the potential, which also guarantee quantum stability for classically unbounded-below Hamiltonians. Examples are discussed which include the explanation of the discreteness of the atomic spectra. Because of the increasing interest in the relation between QM and stochastic processes, a final chapter is devoted to the functional integral approach (Feynman–Kac formula), to the formulation in terms of ground state correlations (the quantum mechanical analog of the Wightman functions) and their analytic continuation to imaginary time (Euclidean QM). The quantum particle on a circle is discussed in detail, as an example of the interplay between topology and functional integral, leading to the emergence of superselection rules and θ sectors. Errata(s) Errata

Mathematics of Quantum Computation and Quantum Technology - Louis Kauffman 2007-09-19

Research and development in the pioneering

field of quantum computing involve just about every facet of science and engineering, including the significant areas of mathematics and physics. Based on the firm understanding that mathematics and physics are equal partners in the continuing study of quantum science, Mathematics of Quantum Computation and Quantum Technology explores the rapid mathematical advancements made in this field in recent years. Novel Viewpoints on Numerous Aspects of Quantum Computing and Technology Edited by a well-respected team of experts, this volume compiles contributions from specialists across various disciplines. It contains four main parts, beginning with topics in quantum computing that include quantum algorithms and hidden subgroups, quantum search, algorithmic complexity, and quantum simulation. The next section covers quantum technology, such as mathematical tools, quantum wave functions, superconducting quantum computing interference devices (SQUIDs), and optical quantum computing. The section on quantum information deals with error correction, cryptography, entanglement, and communication. The final part explores topological quantum computation, knot theory, category algebra, and logic. The Tools You Need to Tackle the Next Generation of Quantum Technology This book facilitates both the construction of a common quantum language and the development of interdisciplinary quantum techniques, which will aid efforts in the pursuit of the ultimate goal-a "real" scalable quantum computer.

Quantum Information and Computing -

Fundamentals of Quantum Information - Dieter Heiss 2008-01-11

Quantum information science is a rapidly developing field that not only promises a revolution in computer sciences but also touches deeply the very foundations of quantum physics. This book consists of a set of lectures by leading

experts in the field that bridges the gap between standard textbook material and the research literature, thus providing the ne- cessary background for postgraduate students and non-specialist researchers wishing to familiarize themselves with the subject thoroughly and at a high level. This volume is ideally suited as a course book for postgraduate students, and lecturers will find in it a large choice of material for bringing their courses up to date.

Topological Quantum Computation - Zhenghan Wang 2010

Topological quantum computation is a computational paradigm based on topological phases of matter, which are governed by topological quantum field theories. In this approach, information is stored in the lowest energy states of many-anyon systems and processed by braiding non-abelian anyons. The computational answer is accessed by bringing anyons together and observing the result. Besides its theoretical esthetic appeal, the practical merit of the topological approach lies in its error-minimizing hypothetical hardware: topological phases of matter are fault-avoiding or deaf to most local noises, and unitary gates are implemented with exponential accuracy. Experimental realizations are pursued in systems such as fractional quantum Hall liquids and topological insulators. This book expands on the author's CBMS lectures on knots and topological quantum computing and is intended as a primer for mathematically inclined graduate students. With an emphasis on introducing basic notions and current research, this book gives the first coherent account of the field, covering a wide range of topics: Temperley-Lieb-Jones theory, the quantum circuit model, ribbon fusion category theory, topological quantum field theory, anyon theory, additive approximation of the Jones polynomial, anyonic quantum computing models, and mathematical models of topological phases of matter.

Quantum Systems, Channels, Information -

Alexander S. Holevo 2013-01-01
The subject of this book is theory of quantum system presented from information science perspective. The central role is played by the concept of quantum channel and its entropic and information characteristics. Quantum information theory gives a key to understanding elusive phenomena of quantum world and provides a background for development of experimental techniques that enable measuring and manipulation of individual quantum systems. This is important for the new efficient applications such as quantum computing, communication and cryptography. Research in the field of quantum informatics, including quantum information theory, is in progress in leading scientific centers throughout the world. This book gives an accessible, albeit mathematically rigorous and self-contained introduction to quantum information theory, starting from primary structures and leading to fundamental results and to exiting open problems.

Quantum Information Processing with Finite Resources - Marco Tomamichel 2015-10-14
This book provides the reader with the mathematical framework required to fully explore the potential of small quantum information processing devices. As decoherence will continue to limit their size, it is essential to master the conceptual tools which make such investigations possible. A strong emphasis is given to information measures that are essential for the study of devices of finite size, including Rényi entropies and smooth entropies. The presentation is self-contained and includes rigorous and concise proofs of the most important properties of these measures. The first chapters will introduce the formalism of quantum mechanics, with particular emphasis on norms and metrics for quantum states. This is necessary to explore quantum generalizations of Rényi divergence and conditional entropy, information measures that lie at the core of

information theory. The smooth entropy framework is discussed next and provides a natural means to lift many arguments from information theory to the quantum setting. Finally selected applications of the theory to statistics and cryptography are discussed. The book is aimed at graduate students in Physics and Information Theory. Mathematical fluency is necessary, but no prior knowledge of quantum theory is required.

Quantum Computation and Quantum Information - Michael A. Nielsen 2000-10-23

First-ever comprehensive introduction to the major new subject of quantum computing and quantum information.

Quantum Bio-informatics Vi: From Quantum Information To Bio-informatics - Proceedings Of Quantum Bio-informatics 2014 - Luigi Accardi 2020-05-19

This volume seeks to return to the starting point of bio-informatics and quantum information, where these fields are constantly engaged in explosive advancements, and to seriously attempt mutual interaction between the two fields, with a view to enumerating and solving the many encountered fundamental problems. For such a purpose, we look for interdisciplinary bridges in mathematics, physics, information and life sciences, in particular, the research for a new paradigm for information science and life science on the basis of quantum theory.

Lectures on Quantum Mechanics for Mathematics Students - L. D. Faddeev 2009

Describes the relation between classical and quantum mechanics. This book contains a discussion of problems related to group representation theory and to scattering theory. It intends to give a mathematically oriented student the opportunity to grasp the main points of quantum theory in a mathematical framework.

Quantum Theory: Informational Foundations and Foils - Giulio Chiribella 2019-03-29

This book provides the first unified overview of the burgeoning research area at the interface

between Quantum Foundations and Quantum Information. Topics include: operational alternatives to quantum theory, information-theoretic reconstructions of the quantum formalism, mathematical frameworks for operational theories, and device-independent features of the set of quantum correlations. Powered by the injection of fresh ideas from the field of Quantum Information and Computation, the foundations of Quantum Mechanics are in the midst of a renaissance. The last two decades have seen an explosion of new results and research directions, attracting broad interest in the scientific community. The variety and number of different approaches, however, makes it challenging for a newcomer to obtain a big picture of the field and of its high-level goals. Here, fourteen original contributions from leading experts in the field cover some of the most promising research directions that have emerged in the new wave of quantum foundations. The book is directed at researchers in physics, computer science, and mathematics and would be appropriate as the basis of a graduate course in Quantum Foundations.

International Symposium on Mathematics, Quantum Theory, and Cryptography - Tsuyoshi Takagi 2020-10-22

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.

Classical and Quantum Computing - Yorick Hardy 2001-11-01

This is a self-contained, systematic and comprehensive introduction to all the subjects and techniques important in scientific computing. The style and presentation are readily accessible to undergraduates and graduates. A large number of examples, accompanied by complete C++ and Java code wherever possible, cover every topic.

The Theory of Quantum Information - John Watrous 2018-04-26

Formal development of the mathematical theory of quantum information with clear proofs and exercises. For graduate students and researchers.

Mathematical Foundations of Quantum Theory - A.R. Marlow 2012-12-02

Mathematical Foundations of Quantum Theory is a collection of papers presented at the 1977 conference on the Mathematical Foundations of Quantum Theory, held in New Orleans. The contributors present their topics from a wide variety of backgrounds and specialization, but all shared a common interest in answering quantum issues. Organized into 20 chapters, this book's opening chapters establish a sound mathematical basis for quantum theory and a mode of observation in the double slit experiment. This book then describes the Lorentz particle system and other mathematical structures with which fundamental quantum theory must deal, and then some unsolved

problems in the quantum logic approach to the foundations of quantum mechanics are considered. Considerable chapters cover topics on manuals and logics for quantum mechanics. This book also examines the problems in quantum logic, and then presents examples of their interpretation and relevance to nonclassical logic and statistics. The accommodation of conventional Fermi-Dirac and Bose-Einstein statistics in quantum mechanics or quantum field theory is illustrated. The final chapters of the book present a system of axioms for nonrelativistic quantum mechanics, with particular emphasis on the role of density operators as states. Specific connections of this theory with other formulations of quantum theory are also considered. These chapters also deal with the determination of the state of an elementary quantum mechanical system by the associated position and momentum distribution. This book is of value to physicists, mathematicians, and researchers who are interested in quantum theory.

An Introduction to Quantum Computing - Phillip Kaye 2007

The authors provide an introduction to quantum computing. Aimed at advanced undergraduate and beginning graduate students in these disciplines, this text is illustrated with diagrams and exercises.

A Group Theoretic Approach to Quantum Information - Masahito Hayashi 2016-10-31

This book is the first one addressing quantum information from the viewpoint of group symmetry. Quantum systems have a group symmetrical structure. This structure enables to handle systematically quantum information processing. However, there is no other textbook focusing on group symmetry for quantum information although there exist many textbooks for group representation. After the mathematical preparation of quantum information, this book discusses quantum entanglement and its quantification by using group symmetry. Group

symmetry drastically simplifies the calculation of several entanglement measures although their calculations are usually very difficult to handle. This book treats optimal information processes including quantum state estimation, quantum state cloning, estimation of group action and quantum channel etc. Usually it is very difficult to derive the optimal quantum information processes without asymptotic setting of these topics. However, group symmetry allows to derive these optimal solutions without assuming the asymptotic setting. Next, this book addresses the quantum error correcting code with the symmetric structure of Weyl-Heisenberg groups. This structure leads to understand the quantum error correcting code systematically. Finally, this book focuses on the quantum universal information protocols by using the group SU(d). This topic can be regarded as a quantum version of the Csiszar-Korner's universal coding theory with the type method. The required mathematical knowledge about group representation is summarized in the companion book, Group Representation for Quantum Theory.

Elements of Quantum Computing - Seiki Akama 2014-07-14

A quantum computer is a computer based on a computational model which uses quantum mechanics, which is a subfield of physics to study phenomena at the micro level. There has been a growing interest on quantum computing in the 1990's and some quantum computers at the experimental level were recently implemented. Quantum computers enable super-speed computation and can solve some important problems whose solutions were regarded impossible or intractable with traditional computers. This book provides a quick introduction to quantum computing for readers who have no backgrounds of both theory of computation and quantum mechanics. “Elements of Quantum Computing” presents the history, theories and engineering applications of

quantum computing. The book is suitable to computer scientists, physicists and software engineers.

MATHEMATICAL CONCEPTS OF QUANTUM MECHANICS - STEPHEN J. GUSTAFSON 2020

The book gives a streamlined introduction to quantum mechanics while describing the basic mathematical structures underpinning this discipline. Starting with an overview of key physical experiments illustrating the origin of the physical foundations, the book proceeds with a description of the basic notions of quantum mechanics and their mathematical content. It then makes its way to topics of current interest, specifically those in which mathematics plays an important role. The more advanced topics presented include: many-body systems, modern perturbation theory, path integrals, the theory of resonances, adiabatic theory, geometrical phases, Aharonov-Bohm effect, density functional theory, open systems, the theory of radiation (non-relativistic quantum electrodynamics), and the renormalization group. With different selections of chapters, the book can serve as a text for an introductory, intermediate, or advanced course in quantum mechanics. Some of the sections could be used for introductions to geometrical methods in Quantum Mechanics, to quantum information theory and to quantum electrodynamics and quantum field theory.

Mathematical Foundations of Computer Science 2003 - Branislav Rovan 2003-12-03

This book constitutes the refereed proceedings of the 28th International Symposium on Mathematical Foundations of Computer Science, MFCS 2003, held in Bratislava, Slovakia in August 2003. The 55 revised full papers presented together with 7 invited papers were carefully reviewed and selected from 137 submissions. All current aspects in theoretical computer science are addressed, ranging from discrete mathematics, combinatorial optimization, graph theory, networking,

algorithms, and complexity to programming theory, formal methods, and mathematical logic.