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Mathematical methods of quantum information theory, Lecture 1

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Abstract: The purpose of this paper is to survey some topics on mathematical foundations of quantum information developed mainly by the present author and co-workers for the last three decades. The topics include an axiomatic construction of quantum measurement theory based on completely positive map-valued measures, a universally valid new formulation of the uncertainty principle for error and disturbance in quantum measurements, the Wigner-Araki-Yanase limit of quantum measurements, the ...

Mathematical foundations of quantum information ...

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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.

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Quantum information and foundations. Our research in quantum information and foundations spans a range of topics from the abstract to the concrete. On the one hand we are working towards a deeper understanding of the puzzling features of quantum theory such as indeterminacy, entanglement and non-locality. On the other, we are exploiting these fundamental ideas for information-processing tasks such as quantum cryptography and quantum computing.

Quantum information and foundations - Mathematics ...

The book *Mathematical Foundations of Quantum Mechanics* (1932) by John von Neumann is an important early work in the development of quantum theory.

Mathematical Foundations of Quantum Mechanics - Wikipedia

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.

Quantum Information Theory - Mathematical Foundation ...

Mathematical foundations of quantum information and computation and its applications to nano- and bio-systems, 2011 (Theoretical and mathematical physics) Series Authors: Ohya Masanori, Volovich I. Language: Anglais

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Quantum set theory (QST) and topos quantum theory (TQT) are two long running projects in the mathematical foundations of quantum mechanics that share a great deal of conceptual and technical affinity.

Foundations of Quantum Mechanics and Quantum Information ...

information security, mathematics, quantum mechanics and quantum computing. We ' ll repeat it many times: quantum physics isn ' t about mathematics, it ' s about the behaviour of nature at its core. But since mathematics is the language of nature, it ' s required to quantify the prediction of quantum mechanics. This present document has been ...

THE MATHEMATICS OF QUANTUM MECHANICS

Staff supervising projects in mathematical physics are: Dr Henning Bostelmann; Rigorous quantum field theory. Dr Roger Colbeck; I am principally offering projects in quantum cryptography (in particular device-independent protocols) or quantum foundations (understanding cause in quantum theory).

PhD Projects - Mathematics, University of York

Mathematical Foundations of Quantum Information and Computation and Its Applications to Nano- and Bio-systems by Masanori Ohya; I. Volovich and Publisher Springer. Save up to 80% by choosing the eTextbook option for ISBN: 9789400701717, 9400701713. The print version of this textbook is ISBN: 9789400701717, 9400701713.

Mathematical Foundations of Quantum Information and ...

In physics and computer science, quantum information is the information of the state of a quantum system. It is the basic entity of study in quantum information theory, and can be manipulated using quantum information processing techniques. Quantum information refers to both the technical definition in terms of Von Neumann entropy and the general computational term. Quantum information, like classical information, can be processed using digital computers, transmitted from one location to another

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

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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.

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

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.

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.

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.

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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.

Quantum mechanics was still in its infancy in 1932 when the young John von Neumann, who would go on to become one of the greatest mathematicians of the twentieth century, published *Mathematical Foundations of Quantum Mechanics*--a revolutionary book that for the first time provided a rigorous mathematical framework for the new science. Robert Beyer's 1955 English translation, which von Neumann reviewed and approved, is cited more frequently today than ever before. But its many treasures and insights were too often obscured by the limitations of the way the text and equations were set on the page. In this new edition of this classic work, mathematical physicist Nicholas Wheeler has completely reset the book in TeX, making the text and equations far easier to read. He has also corrected a handful of typographic errors, revised some sentences for clarity and readability, provided an index for the first time, and added prefatory remarks drawn from the writings of Léon Van Hove and Freeman Dyson. The result brings new life to an essential work in theoretical physics and mathematics.

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.

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

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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.

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

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.

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