

GRADUATE STUDIES  
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# **Quantum Computation and Quantum Information**

A Mathematical  
Perspective

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AMERICAN  
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# Quantum Computation And Quantum Information

**Michel Le Bellac**



## **Quantum Computation And Quantum Information:**

**Quantum Computation and Quantum Information** Michael A. Nielsen, Isaac L. Chuang, 2010-12-09 One of the most cited books in physics of all time Quantum Computation and Quantum Information remains the best textbook in this exciting field of science This 10th anniversary edition includes an introduction from the authors setting the work in context This comprehensive textbook describes such remarkable effects as fast quantum algorithms quantum teleportation quantum cryptography and quantum error correction Quantum mechanics and computer science are introduced before moving on to describe what a quantum computer is how it can be used to solve problems faster than classical computers and its real world implementation It concludes with an in depth treatment of quantum information Containing a wealth of figures and exercises this well known textbook is ideal for courses on the subject and will interest beginning graduate students and researchers in physics computer science mathematics and electrical engineering

**Quantum Computation and Quantum Information** Michael A. Nielsen, Isaac L. Chuang, 2010-12-09 One of the most cited books in physics of all time Quantum Computation and Quantum Information remains the best textbook in this exciting field of science This 10th anniversary edition includes an introduction from the authors setting the work in context This comprehensive textbook describes such remarkable effects as fast quantum algorithms quantum teleportation quantum cryptography and quantum error correction Quantum mechanics and computer science are introduced before moving on to describe what a quantum computer is how it can be used to solve problems faster than classical computers and its real world implementation It concludes with an in depth treatment of quantum information Containing a wealth of figures and exercises this well known textbook is ideal for courses on the subject and will interest beginning graduate students and researchers in physics computer science mathematics and electrical engineering

**Quantum Information and Quantum Computing** Mikio Nakahara, Yoshitaka Sasaki, 2012-09-17 The open research center project Interdisciplinary fundamental research toward realization of a quantum computer has been supported by the Ministry of Education Japan for five years This is a collection of the research outcomes by the members engaged in the project To make the presentation self contained it starts with an overview by Mikio Nakahara which serves as a concise introduction to quantum information and quantum computing Subsequent contributions include subjects from physics chemistry mathematics and information science reflecting upon the wide variety of scientists working under this project These contributions introduce NMR quantum computing and related techniques number theory and coding theory quantum error correction photosynthesis non classical correlations and entanglement neutral atom quantum computer among others Each of contributions will serve as a short introduction to these cutting edge research fields

*Quantum Computation and Quantum Information* Michael A. Nielsen, Isaac L. Chuang, 2002 This text is the first comprehensive introduction to the main ideas and techniques of the field of quantum computation and quantum information Michael Nielsen and Isaac Chuang ask the question what are the ultimate physical limits to computation and communication They describe in

detail such remarkable effects as fast quantum algorithms quantum teleportation quantum cryptography and quantum error correction A wealth of accompanying figures and exercises illustrate and develop the material in more depth The authors describe what a quantum computer is how it can be used to solve problems faster than familiar classical computers and the real world implementation of quantum computers The book concludes with an in depth treatment of quantum information explaining how quantum states can be used to perform remarkable feats of communication together with a discussion of how it is possible to protect quantum states against the effects of noise

A Short Introduction to Quantum Information and Quantum Computation Michel Le Bellac, 2006-06-15 Quantum information and computation is a rapidly expanding and cross disciplinary subject This book first published in 2006 gives a self contained introduction to the field for physicists mathematicians and computer scientists who want to know more about this exciting subject After a step by step introduction to the quantum bit qubit and its main properties the author presents the necessary background in quantum mechanics The core of the subject quantum computation is illustrated by a detailed treatment of three quantum algorithms Deutsch Grover and Shor The final chapters are devoted to the physical implementation of quantum computers including the most recent aspects such as superconducting qubits and quantum dots and to a short account of quantum information Written at a level suitable for undergraduates in physical sciences no previous knowledge of quantum mechanics is assumed and only elementary notions of physics are required The book includes many short exercises with solutions available to instructors through solutions cambridge org

*Quantum Computation and Quantum Information Theory* Chiara Macchiavello, G. M. Palma, Anton Zeilinger, 2000 Quantum Entanglement Manipulation Quantum Algorithms Quantum Complexity Quantum Error Correction Quantum Channels Entanglement Purification and Long Distance Quantum Communication Quantum Key Distribution Cavity Quantum Electrodynamics Quantum Computation with Ion Traps Josephson Junctions and Quantum Computation Quantum Computing in Optical Lattices Quantum Computation and Quantum Communication with Electrons NMR Quantum Computing

*Mathematics of Quantum Computation and Quantum Technology* Louis Kauffman, Samuel J. Lomonaco, 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 an

Introduction to Quantum Computation and Information Hoi-Kwong Lo, Tim Spiller, Sandu Popescu, 1998 The book fills a gap between the turgid prose of the burgeoning research literature and the superficial accounts in the popular press Nature 1999 The concepts introduced in this book and the forecast of future directions provided should continue to provide a good primer for the exciting breakthrough anticipated in this field Mathematics Abstracts 2001 Despite its age this book remains an excellent way to learn the basics of quantum information Quantum Information and Computation 2002

Quantum Information Processing and Quantum Error Correction Ivan B. Djordjevic, 2012-05-23 Quantum

Information Processing and Quantum Error Correction is a self contained tutorial based introduction to quantum information quantum computation and quantum error correction Assuming no knowledge of quantum mechanics and written at an intuitive level suitable for the engineer the book gives all the essential principles needed to design and implement quantum electronic and photonic circuits Numerous examples from a wide area of application are given to show how the principles can be implemented in practice This book is ideal for the electronics photonics and computer engineer who requires an easy to understand foundation on the principles of quantum information processing and quantum error correction together with insight into how to develop quantum electronic and photonic circuits Readers of this book will be ready for further study in this area and will be prepared to perform independent research The reader completed the book will be able design the information processing circuits stabilizer codes Calderbank Shor Steane CSS codes subsystem codes topological codes and entanglement assisted quantum error correction codes and propose corresponding physical implementation The reader completed the book will be proficient in quantum fault tolerant design as well Unique Features Unique in covering both quantum information processing and quantum error correction everything in one book that an engineer needs to understand and implement quantum level circuits Gives an intuitive understanding by not assuming knowledge of quantum mechanics thereby avoiding heavy mathematics In depth coverage of the design and implementation of quantum information processing and quantum error correction circuits Provides the right balance among the quantum mechanics quantum error correction quantum computing and quantum communication Dr Djordjevic is an Assistant Professor in the Department of Electrical and Computer Engineering of College of Engineering University of Arizona with a joint appointment in the College of Optical Sciences Prior to this appointment in August 2006 he was with University of Arizona Tucson USA as a Research Assistant Professor University of the West of England Bristol UK University of Bristol Bristol UK Tyco Telecommunications Eatontown USA and National Technical University of Athens Athens Greece His current research interests include optical networks error control coding constrained coding coded modulation turbo equalization OFDM applications and quantum error correction He presently directs the Optical Communications Systems Laboratory OCSL within the ECE Department at the University of Arizona Provides everything an engineer needs in one tutorial based introduction to understand and implement quantum level circuits Avoids the heavy use of mathematics by not assuming the previous knowledge of quantum mechanics Provides in depth coverage of the design and implementation of quantum information processing and quantum error correction circuits

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 necessary 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

**Lectures on Quantum Information** Dagmar Bruss, Gerd Leuchs, 2007 Quantum Information Processing is a young and rapidly growing field of research at the intersection of physics mathematics and computer science Its ultimate goal is to harness quantum physics to conceive and ultimately build quantum computers that would dramatically overtake the capabilities of today's classical computers One example of the power of a quantum computer is its ability to efficiently find the prime factors of a larger integer thus shaking the supposedly secure foundations of standard encryption schemes This comprehensive textbook on the rapidly advancing field introduces readers to the fundamental concepts of information theory and quantum entanglement taking into account the current state of research and development It thus covers all current concepts in quantum computing both theoretical and experimental before moving on to the latest implementations of quantum computing and communication protocols With its series of exercises this is ideal reading for students and lecturers in physics and informatics as well as experimental and theoretical physicists and physicists in industry Dagmar Bru graduated at RWTH University Aachen Germany and received her PhD in theoretical particle physics from the University of Heidelberg in 1994 As a research fellow at the University of Oxford she started to work in quantum information theory Another fellowship at ISI Torino Italy followed While being a research assistant at the University of Hannover she completed her habilitation Since 2004 Professor Bru has been holding a chair at the Institute of Theoretical Physics at the Heinrich Heine University Dsseldorf Germany Gerd Leuchs studied physics and mathematics at the University of Cologne Germany and received his PhD in 1978 After two research visits at the University of Colorado in Boulder USA he headed the German gravitational wave detection group from 1985 to 1989 He became technical director at Nanomach AG in Switzerland Since 1994 Professor Leuchs has been holding the chair for optics at the Friedrich Alexander University of Erlangen Nuremberg Germany His fields of research span the range from modern aspects of classical optics to quantum optics and quantum information Since 2003 he has been Director of the Max Planck Research Group for Optics Information and Photonics at Erlangen

**Quantum Information** Gregg Jaeger, 2006-11-15 This book gives an overview for practitioners and students of quantum physics and information science It provides ready access to essential information on quantum information processing and communication such as definitions protocols and algorithms Quantum information science is rarely found in clear and concise form This book brings together this information from its various sources It allows researchers and students in a range of areas including physics photonics solid state electronics nuclear magnetic resonance and information technology in their applied and theoretical branches to have this vital material directly at hand

**Quantum Computing Explained** David McMahon, 2007-12-14 A self contained treatment of the fundamentals of quantum computing This clear practical book takes quantum computing out of the realm of theoretical physics and teaches the fundamentals of the field to students and professionals who have not had training in quantum computing or quantum information theory

including computer scientists programmers electrical engineers mathematicians physics students and chemists The author cuts through the conventions of typical jargon laden physics books and instead presents the material through his unique how to approach and friendly conversational style Readers will learn how to carry out calculations with explicit details and will gain a fundamental grasp of Quantum mechanics Quantum computation Teleportation Quantum cryptography Entanglement Quantum algorithms Error correction A number of worked examples are included so readers can see how quantum computing is done with their own eyes while answers to similar end of chapter problems are provided for readers to check their own work as they learn to master the information Ideal for professionals and graduate level students alike Quantum Computing Explained delivers the fundamentals of quantum computing readers need to be able to understand current research papers and go on to study more advanced quantum texts

Classical and Quantum Information Dan C. Marinescu, 2011-01-07 A new discipline Quantum Information Science has emerged in the last two decades of the twentieth century at the intersection of Physics Mathematics and Computer Science Quantum Information Processing is an application of Quantum Information Science which covers the transformation storage and transmission of quantum information it represents a revolutionary approach to information processing Classical and Quantum Information covers topics in quantum computing quantum information theory and quantum error correction three important areas of quantum information processing Quantum information theory and quantum error correction build on the scope concepts methodology and techniques developed in the context of their close relatives classical information theory and classical error correcting codes Presents recent results in quantum computing quantum information theory and quantum error correcting codes Covers both classical and quantum information theory and error correcting codes The last chapter of the book covers physical implementation of quantum information processing devices Covers the mathematical formalism and the concepts in Quantum Mechanics critical for understanding the properties and the transformations of quantum information

Classical and Quantum Computation Alexei Yu. Kitaev, Alexander Shen, Mikhail N. Vyalyi, 2002 This book is an introduction to a new rapidly developing theory of quantum computing It begins with the basics of classical theory of computation Turing machines Boolean circuits parallel algorithms probabilistic computation NP complete problems and the idea of complexity of an algorithm The second part of the book provides an exposition of quantum computation theory It starts with the introduction of general quantum formalism pure states density matrices and superoperators universal gate sets and approximation theorems Then the authors study various 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 Rapid development of quantum computing started in 1994 with a stunning suggestion by Peter Shor to use quantum computation for factoring large numbers an extremely difficult and time consuming problem when using a conventional computer Shor's result spawned a

burst of activity in designing new algorithms and in attempting to actually build quantum computers. Currently the progress is much more significant in the former: a sound theoretical basis of quantum computing is under development and many algorithms have been suggested. In this concise text the authors provide solid foundations to the theory in particular a careful analysis of the quantum circuit model and cover selected topics in depth. Included are a complete proof of the Solovay Kitaev theorem with accurate algorithm complexity bounds, approximation of unitary operators by circuits of doubly logarithmic depth. Among other interesting topics are toric codes and their relation to the anyon approach to quantum computing. Prerequisites are very modest and include linear algebra, elements of group theory and probability and the notion of a formal or an intuitive algorithm. This text is suitable for a course in quantum computation for graduate students in mathematics, physics or computer science. More than 100 problems, most of them with complete solutions and an appendix summarizing the necessary results, are a very useful addition to the book. It is available in both hardcover and softcover editions.

*Quantum Computation And Quantum Information Theory, Collected Papers And Notes* Chiara Macchiavello, G. Massimo Palma, Anton Zeilinger, 2001-01-17. Quantum information theory has revolutionised our view on the true nature of information and has led to such intriguing topics as teleportation and quantum computation. The field, by its very nature, strongly interdisciplinary, with deep roots in the foundations both of quantum mechanics and of information theory, and computer science has become a major subject for scientists working in fields as diverse as quantum optics, superconductivity or information theory, all the way to computer engineers. The aim of this book is to provide guidance and introduce the broad literature in all the various aspects of quantum information theory. The topics covered range from the fundamental aspects of the theory, like quantum algorithms and quantum complexity, to the technological aspects of the design of quantum information processing devices. Each section of the book consists of a selection of key papers with particular attention to their tutorial value, chosen and introduced by leading scientists in the specific area. An entirely new introduction to quantum complexity has been specially written for the book.

**Quantum Information and Computation for Chemistry, Volume 154** Sabre Kais, 2014-03-24. Examines the intersection of quantum information and chemical physics. The *Advances in Chemical Physics* series is dedicated to reviewing new and emerging topics as well as the latest developments in traditional areas of study in the field of chemical physics. Each volume features detailed comprehensive analyses coupled with individual points of view that integrate the many disciplines of science that are needed for a full understanding of chemical physics. This volume of the series explores the latest research findings, applications and new research paths from the quantum information science community. It examines topics in quantum computation and quantum information that are related to or intersect with key topics in chemical physics. The reviews address both what chemistry can contribute to quantum information and what quantum information can contribute to the study of chemical systems, surveying both theoretical and experimental quantum information research within the field of chemical physics. With contributions from an international team of leading experts.



Volume 154 offers seventeen detailed reviews including Introduction to quantum information and computation for chemistry Quantum computing approach to non relativistic and relativistic molecular energy calculations Quantum algorithms for continuous problems and their applications Photonic toolbox for quantum simulation Vibrational energy and information transfer through molecular chains Tensor networks for entanglement evolution Reviews published in Advances in Chemical Physics are typically longer than those published in journals providing the space needed for readers to fully grasp the topic the fundamentals as well as the latest discoveries applications and emerging avenues of research Extensive cross referencing enables readers to explore the primary research studies underlying each topic     Explorations in Quantum Computing Colin P. Williams, 2010-12-07 By the year 2020 the basic memory components of a computer will be the size of individual atoms At such scales the current theory of computation will become invalid Quantum computing is reinventing the foundations of computer science and information theory in a way that is consistent with quantum physics the most accurate model of reality currently known Remarkably this theory predicts that quantum computers can perform certain tasks breathtakingly faster than classical computers and better yet can accomplish mind boggling feats such as teleporting information breaking supposedly unbreakable codes generating true random numbers and communicating with messages that betray the presence of eavesdropping This widely anticipated second edition of Explorations in Quantum Computing explains these burgeoning developments in simple terms and describes the key technological hurdles that must be overcome to make quantum computers a reality This easy to read time tested and comprehensive textbook provides a fresh perspective on the capabilities of quantum computers and supplies readers with the tools necessary to make their own foray into this exciting field Topics and features concludes each chapter with exercises and a summary of the material covered provides an introduction to the basic mathematical formalism of quantum computing and the quantum effects that can be harnessed for non classical computation discusses the concepts of quantum gates entangling power quantum circuits quantum Fourier wavelet and cosine transforms and quantum universality computability and complexity examines the potential applications of quantum computers in areas such as search code breaking solving NP Complete problems quantum simulation quantum chemistry and mathematics investigates the uses of quantum information including quantum teleportation superdense coding quantum data compression quantum cloning quantum negation and quantum cryptography reviews the advancements made towards practical quantum computers covering developments in quantum error correction and avoidance and alternative models of quantum computation This text reference is ideal for anyone wishing to learn more about this incredible perhaps ultimate computer revolution Dr Colin P Williams is Program Manager for Advanced Computing Paradigms at the NASA Jet Propulsion Laboratory California Institute of Technology and CEO of Xtreme Energetics Inc an advanced solar energy company Dr Williams has taught quantum computing and quantum information theory as an acting Associate Professor of Computer Science at Stanford University He has spent over a decade inspiring and leading high technology teams and

building business relationships with and Silicon Valley companies Today his interests include terrestrial and Space based power generation quantum computing cognitive computing computational material design visualization artificial intelligence evolutionary computing and remote olfaction He was formerly a Research Scientist at Xerox PARC and a Research Assistant to Prof Stephen W Hawking Cambridge University      Diversities In Quantum Computation And Quantum Information Mikio Nakahara,Yidun Wan,Yoshitaka Sasaki,2012-09-17 This book is a collection of lecture notes and contributions in Summer School on Diversities in Quantum Computation Information held on 1 5 August 2010 at U Community Hotel Higashi Osaka Japan Lecturers are world class authorities in respective areas in quantum information and quantum computing including physics mathematics chemistry and information science They lectured on cutting edge research frontiers where they are currently working including quantum error correction relativistic quantum information quantum computing of link polynomials quantum algorithms etc Each lecture note is written in a self contained manner so that it may be used as a textbook for one semester graduate course or advanced undergraduate course Contributions report current research subjects also in a self contained manner We believe that these articles are accessible to the readers form various disciplines a

**Elements of Quantum Computation and Quantum Communication** Anirban Pathak,2019-08-30 This book originated from a course on quantum computing designed for an audience of varied experience backgrounds and qualifications Not assuming that the readers have advanced knowledge of information theory or quantum mechanics or linear algebra this introductory text book provides a lucid introduction to the rapidly developing field of quantum computing and quantum communication rigorously proving all mathematical sentences

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