Quantum Computing A Gentle Introduction Scientific And Engineering Computation

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<u>Physics from Finance</u> Springer Nature

A mind-blowing glimpse into the near future, where quantum computing will have world-transforming effects. The quantum computer is no longer the stuff of science fiction. Pioneering physicists are on the brink of unlocking a new quantum universe which provides a better representation of reality than our everyday experiences and common sense ever could. The birth of quantum computers - which, like Schrödinger's famous "dead and alive" cat, rely on entities like electrons, photons, or atoms existing in two states at the same time - is set to turn the computing world on its head. In his fascinating study of this cutting-edge technology, John Gribbin updates his previous views on the nature of quantum reality, arguing for a universe of many parallel worlds where "everything is real." Looking back at Alan Turing's work on the Enigma machine and the first electronic computer, Gribbin explains how quantum theory developed to make quantum computers work in practice as well as in principle. He takes us beyond the arena of theoretical physics to explore their practical applications - from machines which learn through "intuition" and trial and error to unhackable laptops and smartphones. And he investigates the potential for this extraordinary science to create a world where communication occurs faster than light and teleportation is possible. This is an exciting insider's look at the new frontier of computer science and its revolutionary implications.

Quantum Computing Springer Nature

A thorough exposition of quantum computing and the underlying concepts of quantum physics, with explanations of the relevant mathematics and numerous examples.

<u>Quantum Computing in Action</u> Cambridge University Press

What is "topological" about topological quantum states? How many types of topological quantum phases are there? What is a zero-energy Majorana mode, how can it be realized in a solid state system, and how can it be used as a platform for topological quantum computation? What is quantum computation and what makes it different from classical computation? Addressing these and other related questions, Introduction to Topological Quantum Matter & Quantum Computation provides an introduction to and a synthesis of a fascinating and rapidly expanding research field emerging at the crossroads of condensed matter physics, mathematics, and computer science. Providing the big picture, this book is ideal for graduate students and researchers entering this field as it allows for the fruitful transfer of paradigms and ideas amongst different areas, and includes many specific examples to help the reader understand abstract and sometimes challenging concepts. It explores the topological quantum world beyond the well-known topological insulators and superconductors and emphasizes the deep connections with quantum computation. It addresses key principles behind the classification of topological quantum phases and relevant mathematical concepts and discusses models of interacting and noninteracting topological systems, such as the torric code and the p-wave superconductor. The book also covers the basic properties of anyons, and aspects concerning the realization of topological states in solid state structures and cold atom systems. Quantum computation is also presented using a broad perspective, which includes fundamental aspects of quantum mechanics, such as Bell's theorem, basic concepts in the theory of computation, such as computational models and computational complexity, examples of quantum algorithms, and elements of classical and quantum information theory.

<u>Explorations in Quantum Computing</u> MIT Press

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

<u>Introduction to Quantum Information Science</u> Apress

Write algorithms and program in the new field of quantum computing. This book covers major topics such as the physical components of a quantum computer: qubits, entanglement, logic gates, circuits, and how they differ from a traditional computer. Also, Practical Quantum Computing for Developers discusses quantum computing in the cloud using IBM Q Experience including: the composer, quantum scores, experiments, circuits, simulators, real quantum devices, and more. You'll be able to run experiments in the cloud on a real quantum device. Furthermore, this book shows you how to do quantum programming using the QISKit (Quantum Information Software Kit), Python SDK, and other APIs such as QASM (Quantum Assembly). You'll learn to write code using these languages and execute it against simulators (local or remote) or a real quantum computer provided by IBM's Q Experience. Finally, you'll learn the current quantum algorithms for entanglement, random number generation, linear search, integer factorization, and others. You'll peak inside the inner workings of the Bell states for entanglement, Grover's algorithm for linear search, Shor's algorithm for integer factorization, and other algorithms in the fields of optimization, and more. Along the way you'll also cover game theory with the Magic Square, an example of quantum pseudo-telepathy where parties sharing entangled states can be observed to have some kind of communication between them. In this game Alice and Bob play against a referee. Quantum mechanics allows Alice and Bob to always win! By the end of this book, you will understand how this emerging technology provides massive parallelism and significant computational speedups over classical computers, and will be prepared to program quantum computers which are expected to replace traditional computers in the data center. What You Will Learn Use the Q Experience Composer, the first-of-its-kind web console to create visual programs/experiments and submit them to a quantum simulator or real device on the cloud Run programs remotely using the Q Experience REST API Write algorithms that provide superior performance over their classical counterparts Build a Node.js REST client for authenticating, listing remote devices, querying information about quantum processors, and listing or running experiments remotely in the cloud Create a quantum number generator: The quintessential coin flip with a quantum twist Discover quantum teleportation: This algorithm demonstrates how the exact state of a qubit (quantum information) can be transmitted from one location to another, with the help of classical communication and quantum entanglement between the sender and receiver Peek into single qubit operations with the classic game of Battleships with a quantum twist Handle the counterfeit coin problem: a classic puzzle that consists of finding a counterfeit coin in a beam balance among eight coins in only two turns Who This Book Is For Developers and programmers interested in this new field of computing.

Quantum Mechanics for Scientists and Engineers Cambridge University Press

This textbook presents the elementary aspects of quantum computing in a mathematical form. It is intended as core or supplementary reading for physicists, mathematicians, and computer scientists taking a first course on quantum computing. It starts by introducing the basic mathematics required for quantum mechanics, and then goes on to present, in detail, the notions of quantum mechanics, entanglement, quantum gates, and quantum algorithms, of which Shor's factorisation and Grover's search algorithm are discussed extensively. In addition, the algorithms for the Abelian Hidden Subgroup and Discrete Logarithm problems are presented and the latter is used to show how the Bitcoin digital signature may be compromised. It also addresses the problem of error correction as well as giving a detailed exposition of adiabatic quantum computing. The book contains around 140 exercises for the student, covering all of the topics treated, together with an appendix of solutions.

Oxford University Press on Demand

This book targets computer scientists and engineers who are familiar with concepts in classical computer systems but are curious to learn the general architecture of quantum computing systems. It gives a concise presentation of this new paradigm of computing from a computer systems' point of view without assuming any background in quantum mechanics. As such, it is divided into two parts. The first part of the book provides a gentle overview on the fundamental principles of the quantum theory and their implications for computing. The second part is devoted to state-of-the-art research in designing practical quantum programs, building a scalable software systems stack, and controlling quantum hardware components. Most chapters end with a summary and an outlook for future directions. This book celebrates the remarkable progress that scientists across disciplines have made in the past decades and reveals what roles computer scientists and engineers can play to enable practical-scale quantum computing.

Nanotechnology Cambridge University Press

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.

Quantum Computer Systems: Research for Noisy Intermediate Scale Quantum Computers OUP Oxford

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.

Google's PageRank and Beyond CRC Press

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 Computation and Quantum Information CRC Press

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 Computer Science Morgan & Claypool Publishers

The Physics of Information Technology explores the familiar devices that we use to collect, transform, transmit, and interact with electronic information. Many such devices operate surprisingly close to very many fundamental physical limits. Understanding how such devices work, and how they can (and cannot) be improved, requires deep insight into the character of physical law as well as engineering practice. The book starts with an introduction to units, forces, and the probabilistic foundations of noise and signalling, then progresses through the electromagnetics of wired and wireless communications, and the quantum mechanics of electronic, optical, and magnetic materials, to discussions of mechanisms for computation, storage, sensing, and display. This self-contained volume will help both physical scientists and computer scientists see beyond the conventional division between hardware and software to understand the implications of physical theory for information manipulation.

Dancing with Qubits Cambridge University Press

Understanding modern physics doesn't have to be confusing and hard What if there was an intuitive way to understand how nature fundamentally works? What if there was a book that allowed you to see the whole picture and not just tiny parts of it? Thoughts like this are the reason that Physics from Finance now exists. What will you learn from this book? Get to know all fundamental interactions —Grasp how we can describe electromagnetic interactions, weak interactions, strong interactions and gravity using the same key ideas.Learn how to describe modern physics mathematically — Understand the meaning and origin of the Einstein equation, Maxwell's equations, and the Schrödinger equation.Develop an intuitive understanding of key concepts — Read how we can understand abstract ideas like Gauge Symmetry, Internal Spaces, Gauge Fields, Connections and Curvature using a simple toy model of the financial market.Get an understanding you can be proud of — Learn why fiber bundles and group theory provide a unified framework for all modern theories of physics. Physics from Finance is the most reader-friendly book on the geometry of modern physics ever written. Here's why. First of all, it's is nothing like a formal university lecture. Instead, it's like a casual conservation with a more experienced student. This also means that nothing is assumed to be "obvious" or "easy to see".Each chapter, each section, and each page focusses solely on the goal to help you understand. Nothing is introduced without a thorough motivation and it is always clear where each formula comes from.The book contains no fluff since unnecessary content quickly leads to confusion. Instead, it ruthlessly focusses on the fundamentals and makes sure you'll understand them in detail. The primary focus on the readers' needs is also visible in dozens of small features that you won't find in any other textbook In total, the book contains more than 100 illustrations that help you understand the most important concepts visually.Whenever a concept is used which was already introduced previously, there is a short sidenote that reminds you where it was first introduced and often recites the main points. In addition, helpful diagrams make sure you won't get lost.

Second Edition Cambridge University Press

New and classical results in computational complexity, including interactive proofs, PCP, derandomization, and quantum computation. Ideal for graduate students.

Quantum Algorithms via Linear Algebra MIT Press

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.

Quantum Information Theory Quantum ComputingA Gentle Introduction

Quantum computers can (in theory) solve certain problems far faster than a classical computer running any known classical algorithm. While existing technologies for building quantum computers are in their infancy, it is not too early to consider their scalability and reliability in the context of the design of large-scale quantum computers. To architect such systems, one must understand what it takes to design and model a balanced, fault-tolerant quantum computer architecture. The goal of this lecture is to provide architectural abstractions for the design of a quantum computer and to explore the systems-level challenges in achieving scalable, fault-tolerant quantum computation. In this lecture, we provide an engineering-oriented introduction to quantum computation with an overview of the theory behind key quantum algorithms. Next, we look at architectural case studies based upon experimental data and future projections for quantum computation implemented using trapped ions. While we focus here on architectures targeted for realization using trapped ions, the techniques for quantum computer architecture design, quantum fault-tolerance, and compilation described in this lecture are applicable to many other physical technologies that may be viable candidates for building a large-scale quantum computing system. We also discuss general issues involved with programming a quantum computer as well as a discussion of work on quantum architectures based on quantum teleportation. Finally, we consider some of the open issues remaining in the design of quantum computers. Table of Contents: Introduction / Basic Elements for Quantum Computation / Key Quantum Algorithms / Building Reliable and Scalable Quantum Architectures / Simulation of Quantum Computation / Architectural Elements / Case Study: The Quantum Logic Array Architecture / Programming the Quantum Architecture / Using the QLA for Quantum Simulation: The Transverse Ising Model / Teleportation-Based Quantum Architectures / Concluding Remarks

Introduction to Quantum Computing with Qiskit John Wiley & Sons

In the 1990's it was realized that quantum physics has some spectacular applications in computer science. This book is a concise introduction to quantum computation, developing the basic elements of this new branch of computational theory without assuming any background in physics. It begins with an introduction to the quantum theory from a computer-science perspective. It illustrates the quantum-computational approach with several elementary examples of quantum speed-up, before moving to the major applications: Shor's factoring algorithm, Grover's search algorithm, and quantum error correction. The book is intended primarily for computer scientists who know nothing about quantum theory, but will also be of interest to physicists who want to learn the theory of quantum computation, and philosophers of science interested in quantum foundational issues. It evolved during six years of teaching the subject to undergraduates and graduate students in computer science, mathematics, engineering, and physics, at Cornell University.

Quantum Computing Morgan & Claypool Publishers

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 Information and Consciousness Simon and Schuster

Explore the principles and practicalities of quantum computing Key Features Discover how quantum computing works and delve into the math behind it with this quantum computing textbook Learn how it may become the most important new computer technology of the century Explore the inner workings of quantum computing technology to quickly process complex cloud data and solve problems Book Description Quantum computing is making us change the way we think about computers. Quantum bits, a.k.a. qubits, can make it possible to solve problems that would otherwise be intractable with current computing technology. Dancing with Qubits is a quantum computing textbook that starts with an overview of why quantum computing is so different from classical computing and describes several industry use cases where it can have a major impact. From there it moves on to a fuller description of classical computing and the mathematical underpinnings necessary to understand such concepts as superposition, entanglement, and interference. Next up is circuits and algorithms, both basic and more sophisticated. It then nicely moves on to provide a survey of the physics and engineering ideas behind how quantum computing hardware is built. Finally, the book looks to the future and gives you guidance on understanding how further developments will affect you. Really understanding quantum computing requires a lot of math, and this book doesn't shy away from the necessary math concepts you'll need. Each topic is introduced and explained thoroughly, in clear English with helpful examples. What you will learn See how quantum computing works, delve into the math behind it, what makes it different, and why it is so powerful with this quantum computing textbook Discover the complex, mind-bending mechanics that underpin quantum systems Understand the necessary concepts behind classical and quantum computing Refresh and extend your grasp of essential mathematics, computing, and quantum theory Explore the main applications of quantum computing to the fields of scientific computing, AI, and elsewhere Examine a

detailed overview of qubits, quantum circuits, and quantum algorithm Who this book is for Dancing with Qubits is a quantum computing textbook for those who want to deeply explore the inner workings of quantum computing. This entails some sophisticated mathematical exposition and is therefore best suited for those with a healthy interest in mathematics, physics, engineering, and computer science.

A Modern Approach Cambridge University Press

In Nanotechnology: A Gentle Introduction to the Next Big Idea, nanotech pioneer Mark Ratner and tech entrepreneur Daniel Ratner show how nanotech works, what's new, what's next, and why nanotech may be the next $1 trillion industry. They survey every area of R&D: nanobots, quantum and DNA computing, nanosensors, biostructures, neuro-electronic interfaces, molecular motors, and much more. Simple, brief, and nearly math-free, this is the perfect briefing on nanotech technology and business for every non-technical reader.