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***The Physics Of
Quantum Information
By Dirk Bouwmeester***

One of the most cited books in
physics of all time, Quantum
Computation and Quantum

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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

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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'

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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

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researchers in physics, computer science, mathematics, and electrical engineering.

Quantum information is an area of science, which brings together physics, information theory, computer science & mathematics. This book, which is based on two

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successful lecture courses, is intended to introduce readers to the ideas behind new developments including quantum cryptography, teleportation & quantum computing. This graduate textbook provides a unified view of quantum information theory. Clearly explaining the

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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

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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

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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

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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

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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

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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. This book collects independent contributions on current

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developments in quantum information theory, a very interdisciplinary field at the intersection of physics, computer science and mathematics. Making intense use of the most advanced concepts from each discipline, the authors give in each contribution

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pedagogical introductions to the main concepts underlying their present research and present a personal perspective on some of the most exciting open problems. Keeping this diverse audience in mind, special efforts have been made to ensure that the basic

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concepts underlying quantum information are covered in an understandable way for mathematical readers, who can find there new open challenges for their research. At the same time, the volume can also be of use to physicists wishing to learn

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advanced mathematical tools,
especially of differential and
algebraic geometric nature.

Principles and Methods of Quantum
Information Technologies

NMR Quantum Information
Processing

The Theory of Quantum Information

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Quantum Information
Introduction to Quantum
Computing

In addition to treating quantum communication, entanglement and algorithms, this book also addresses a number of miscellaneous topics, such as Maxwell's demon, Landauer's erasure,

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*the Bekenstein bound and Caratheodory's
treatment of the Second law of
thermodynamics.*

*Lecture Notes for Physics 229:Quantum
Information and ComputationBy John
Preskill*

*This book is an introduction to the two
closely related subjects of quantum optics*

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and quantum information. The book gives a simple, self-contained introduction to both subjects, while illustrating the physical principles of quantum information processing using quantum optical systems. To make the book accessible to those with backgrounds other than physics, the authors also include a

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brief review of quantum mechanics. Furthermore, some aspects of quantum information, for example those pertaining to recent experiments on cavity QED and quantum dots, are described here for the first time in book form. This book gives an overview for practitioners and students of quantum

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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

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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 Computation and Quantum

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information.*

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quantum information
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*physics. Traditionally,
information processing
such as computation
occurred in a framework
governed by laws of
classical physics.
However, information can*

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*also be stored and
processed using the states
of matter described by non-
classical quantum theory.
Understanding this quantum
information, a
fundamentally different*

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*type of information, has
been a major project of
physicists and
information theorists in
recent years, and recent
experimental research
has started to yield*

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*promising results. Quantum
Approach to Informatics
fills the need for a
concise introduction to
this burgeoning new field,
offering an
intuitive approach for*

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readers in both the physics and information science communities, as well as in related fields. Only a basic background in quantum theory is required, and the text

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*keeps the focus on bringing
this theory to bear on
contemporary informatics.
Instead of proofs and other
highly formal structures,
detailed examples present
the material, making this*

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*a uniquely
accessible introduction to
quantum informatics.*

*Topics covered include: **
*An introduction to quantum
information and the qubit*
** Concepts and methods of*

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*interested readers with
some scientific background,
with an essential overview
of the field.*

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mathematical framework*

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*required to fully explore
the potential of small
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*conceptual tools which
make such investigations
possible. A strong
emphasis is given to
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study of devices of finite*

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size, including Rényi entropies and smooth entropies. The presentation is self-contained and includes rigorous and concise proofs of the most

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*important properties of
these measures. The first
chapters will introduce
the formalism of quantum
mechanics, with particular
emphasis on norms and
metrics for quantum*

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*states. This is necessary
to explore quantum
generalizations of Rényi
divergence and conditional
entropy, information
measures that lie at the
core of information*

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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

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applications of the theory to statistics and cryptography are discussed. The book is aimed at graduate students in Physics and Information Theory. Mathematical

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*fluency is necessary, but
no prior knowledge of
quantum theory is
required.*

*"First published by
Cappella Archive in 2008."
Quantum Information Theory*

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*and Quantum Statistics
Quantum Cryptography,
Quantum Teleportation,
Quantum Computation
From Quantum Entanglement
to Topological Phases of
Many-Body Systems*

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*An Introduction to the
Thermodynamics of Quantum
Information
Elements of Quantum
Computing*
***Introduction to the Theory
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Processing provides the material for a one-semester graduate level course on quantum information theory and quantum computing for students who have had a one-year

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***graduate course in
quantum mechanics. Many
standard subjects are
treated, such as density
matrices, entanglement,
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cryptography, and quantum***

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codes. Also included are discussions of quantum machines and quantum walks. In addition, the book provides detailed treatments of several underlying fundamental

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principles of quantum theory, such as quantum measurements, the no-cloning and no-signaling theorems, and their consequences. Problems of various levels of difficulty

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***supplement the text, with
the most challenging
problems bringing the
reader to the forefront of
active research. This book
provides a compact
introduction to the***

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***fascinating and rapidly
evolving interdisciplinary
field of quantum
information theory, and it
prepares the reader for
doing active research in
this area.***

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This concise and readable book addresses primarily readers with a background in classical statistical physics and introduces quantum mechanical notions as required.

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Conceived as a primer to bridge the gap between statistical physics and quantum information, it emphasizes concepts and thorough discussions of the fundamental notions and

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***prepares the reader for
deeper studies, not least
through a selection of well
chosen exercises.***

***This volume presents
papers on the topics
covered at the National***

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***Academy of Engineering's
2018 US Frontiers of
Engineering Symposium.
Every year the symposium
brings together 100
outstanding young leaders
in engineering to share***

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their cutting-edge research and innovations in selected areas. The 2018 symposium was held September 5-7 and hosted by MIT Lincoln Laboratory in Lexington, Massachusetts. The intent

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of this book is to convey the excitement of this unique meeting and to highlight innovative developments in engineering research and technical work.

This book provides an

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***introduction to the basic
ideas and concepts of
quantum computation and
information for both
undergraduate and
graduate students. The
book starts with the***

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***quantum bits and the
entangled states which turn
out to bring revolutionary
ideas in information theory.
This book is self-contained
and unified in its
description of the cross-***

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disciplinary nature of this field. The book aims to provide intuitive and transparent ideas of the subjects, and is not strictly mathematical. Quantum mechanics and

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***mathematical tools
(especially, number theory)
are explained with many
examples and illustrations.
The students can obtain
practical problem-solving
ability by solving the***

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exercises at the end of each chapter. Detailed solutions to all problems are provided at the end of the book.

Fundamentals of Quantum Information

Quantum Computing for

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***the Quantum Curious
Quantum Information
Meets Quantum Matter
Quantum Information
Processing with Finite
Resources
An Introduction to the***

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***Formalism of Quantum
Information with
Continuous Variables***

This book approaches condensed matter physics from the perspective of quantum information science, focusing on systems with strong

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interaction and unconventional order for which the usual condensed matter methods like the Landau paradigm or the free fermion framework break down. Concepts and tools in quantum information science such as

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entanglement, quantum circuits, and the tensor network representation prove to be highly useful in studying such systems. The goal of this book is to introduce these techniques and show how they lead to a new systematic way

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of characterizing and classifying quantum phases in condensed matter systems. The first part of the book introduces some basic concepts in quantum information theory which are then used to study the central topic explained in Part II:

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local Hamiltonians and their ground states. Part III focuses on one of the major new phenomena in strongly interacting systems, the topological order, and shows how it can essentially be defined and characterized in terms of

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entanglement. Part IV shows that the key entanglement structure of topological states can be captured using the tensor network representation, which provides a powerful tool in the classification of quantum phases. Finally, Part V

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discusses the exciting prospect at the intersection of quantum information and condensed matter physics - the unification of information and matter. Intended for graduate students and researchers in condensed matter physics,

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quantum information science and related fields, the book is self-contained and no prior knowledge of these topics is assumed.

This new edition of a well-received textbook provides a concise introduction to both the theoretical

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and experimental aspects of quantum information at the graduate level. While the previous edition focused on theory, the book now incorporates discussions of experimental platforms. Several chapters on experimental

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implementations of quantum information protocols have been added: implementations using neutral atoms, trapped ions, optics, and solidstate systems are each presented in its own chapter. Previous chapters on

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entanglement, quantum measurements, quantum dynamics, quantum cryptography, and quantum algorithms have been thoroughly updated, and new additions include chapters on the stabilizer formalism and the

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Gottesman-Knill theorem as well as aspects of classical and quantum information theory. To facilitate learning, each chapter starts with a clear motivation to the topic and closes with exercises and a recommended reading list.

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Quantum Information Processing: Theory and Implementation will be essential to graduate students studying quantum information as well as and researchers in other areas of physics who wish to gain knowledge in the field.

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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

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cryptology. 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

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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

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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.

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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

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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

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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

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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

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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.

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Quantum information is an emerging field which has attracted a lot of attention in the last couple of decades. It is a broad subject which extends from the most applied questions (e.g. how to build quantum computers or secure

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cryptographic systems) to the most theoretical problems concerning the formalism and interpretation of quantum mechanics, its complexity, and its potential to go beyond classical physics. This book is an introduction to quantum information

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with special emphasis on continuous-variable systems (such as light) which can be described as collections of harmonic oscillators. It covers a selection of basic concepts, focusing on their physical meaning and mathematical

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treatment. It starts from the very first principles of quantum mechanics, and builds up the concepts and techniques following a logical progression. This is an excellent reference for students with a full semester of standard

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quantum mechanics and
researchers in closely related fields.

A Short Introduction to Quantum
Information and Quantum
Computation

Lecture Notes for Physics
229:Quantum Information and

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An Introductory Survey of Theory,
Technology and Experiments

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Mathematical Foundation

Formal development of the

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

A quantum computer is a computer based on a computational model which

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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

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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

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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"

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presents the history, theories and engineering applications of quantum computing. The book is suitable to computer scientists, physicists and software engineers.

This open access book makes

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quantum computing more accessible than ever before. A fast-growing field at the intersection of physics and computer science, quantum computing promises to have revolutionary capabilities far surpassing "classical"

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computation. Getting a grip on the science behind the hype can be tough: at its heart lies quantum mechanics, whose enigmatic concepts can be imposing for the novice. This classroom-tested textbook uses simple

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language, minimal math, and plenty of examples to explain the three key principles behind quantum computers: superposition, quantum measurement, and entanglement. It then goes on to explain how this

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quantum world opens up a whole new paradigm of computing. The book bridges the gap between popular science articles and advanced textbooks by making key ideas accessible with just high school physics as

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a prerequisite. Each unit is broken down into sections labelled by difficulty level, allowing the course to be tailored to the student's experience of math and abstract reasoning. Problem sets and simulation-

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based labs of various levels reinforce the concepts described in the text and give the reader hands-on experience running quantum programs. This book can thus be used at the high school level after the AP or IB

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exams, in an extracurricular club, or as an independent project resource to give students a taste of what quantum computing is really about. At the college level, it can be used as a supplementary text to

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the science behind
computing's future.

A self-contained
introduction to the basic
theoretical concepts,
experimental techniques and
recent advances in the
fields of quantum

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communication, quantum information and quantum computation. The introductory and self-contained character of the contributions should make this book particularly attractive to students and

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active researchers in physics and computer science who want to become acquainted with the underlying basic ideas and recent advances in the rapidly evolving field of quantum information

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The Physics of Quantum
Mechanics

Mathematical Foundations

Quantum Information for
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*This multi-authored
textbook addresses
graduate students with a
background in physics,
mathematics or computer
science. No research
experience is necessary.*

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Consequently, rather than comprehensively reviewing the vast body of knowledge and literature gathered in the past twenty years, this book concentrates

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*on a number of carefully
selected aspects of
quantum information
theory and technology.
Given the highly
interdisciplinary nature
of the subject, the*

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*multi-authored approach
brings together
different points of view
from various renowned
experts, providing a
coherent picture of the
subject matter. The book*

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*consists of ten chapters
and includes examples,
problems, and exercises.
The first five present
the mathematical tools
required for a full
comprehension of various*

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*aspects of quantum
mechanics, classical
information, and coding
theory. Chapter 6 deals
with the manipulation
and transmission of
information in the*

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*quantum realm. Chapters
7 and 8 discuss
experimental
implementations of
quantum information
ideas using photons and
atoms. Finally, chapters*

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9 and 10 address ground-breaking applications in cryptography and computation.

Leading experts from "The Physics of Quantum Information" network,

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*initiated by the
European Commission,
bring together the most
recent results from this
emerging area of quantum
technology. Written in a
consistent style as a*

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research monograph, the book introduces quantum cryptography, quantum teleportation, and quantum computation, considering both theory and newest experiments.

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*Both scientists working
in the field and
advanced students will
find a rich source of
information on this
exciting new area.*

Quantum Computation and
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*Quantum Information
(QIP) deals with the
identification and use
of quantum resources for
information processing.
This includes three main
branches of*

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*investigation: quantum
algorithm design,
quantum simulation and
quantum communication,
including quantum
cryptography. Along the
past few years, QIP has*

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*become one of the most
active area of research
in both, theoretical and
experimental physics,
attracting students and
researchers fascinated,
not only by the*

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*potential practical
applications of quantum
computers, but also by
the possibility of
studying fundamental
physics at the deepest
level of quantum*

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*phenomena. NMR Quantum
Computation and Quantum
Information Processing
describes the
fundamentals of NMR QIP,
and the main
developments which can*

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lead to a large-scale quantum processor. The text starts with a general chapter on the interesting topic of the physics of computation. The very first ideas

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which sparked the development of QIP came from basic considerations of the physical processes underlying computational actions. In Chapter 2 it

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*is made an introduction
to NMR, including the
hardware and other
experimental aspects of
the technique. In
Chapter 3 we revise the
fundamentals of Quantum*

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*Computation and Quantum
Information. The chapter
is very much based on
the extraordinary book
of Michael A. Nielsen
and Isaac L. Chuang,
with an upgrade*

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*containing some of the
latest developments,
such as QIP in phase
space, and telecloning.
Chapter 4 describes how
NMR generates quantum
logic gates from*

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*radiofrequency pulses,
upon which quantum
protocols are built. It
also describes the
important technique of
Quantum State Tomography
for both, quadrupole and*

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*spin 1/2 nuclei. Chapter
5 describes some of the
main experiments of
quantum algorithm
implementation by NMR,
quantum simulation and
QIP in phase space. The*

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important issue of entanglement in NMR QIP experiments is discussed in Chapter 6. This has been a particularly exciting topic in the literature. The chapter

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contains a discussion on the theoretical aspects of NMR entanglement, as well as some of the main experiments where this phenomenon is reported. Finally, Chapter 7 is an

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*attempt to address the
future of NMR QIP, based
in very recent
developments in
nanofabrication and
single-spin detection
experiments. Each*

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*chapter is followed by a
number of problems and
solutions. * Presents a
large number of problems
with solutions, ideal
for students * Brings
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*quantum thermodynamics,
with particular focus on
its relation to quantum
information and its
implications for quantum
computers and next
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*technologies. The text,
aimed at graduate level
physics students with a
working knowledge of
quantum mechanics and
statistical physics,
provides a brief*

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*overview of the
development of classical
thermodynamics and its
quantum formulation in
Chapter 1. Chapter 2
then explores typical
thermodynamic settings,*

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*such as cycles and work
extraction protocols,
when the working
material is genuinely
quantum. Finally,
Chapter 3 explores the
thermodynamics of*

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*quantum information
processing and
introduces the reader to
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comprehensive stand-alone introduction, this book will benefit both experienced and new researchers in quantum information and the philosophy of physics.

The transverse field Ising and

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XY models (the simplest quantum spin models) provide the organising principle for the rich variety of interconnected subjects which are covered in this book. From a generic introduction to in-depth

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discussions of the subtleties of the transverse field Ising and related models, it includes the essentials of quantum dynamics and quantum information. A wide range of relevant topics has also been provided: quantum

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phase transitions, various
measures of quantum
information, the effects of
disorder and frustration,
quenching dynamics and the
Kibble-Zurek scaling relation, the
Kitaev model, topological phases

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of quantum systems, and bosonisation. In addition, it also discusses the experimental studies of transverse field models (including the first experimental realisation of quantum annealing) and the

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recent realisation of the transverse field Ising model using tunable Josephson junctions. Further, it points to the obstacles still remaining to develop a successful quantum computer.

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An Overview

The Physics of Quantum
Information

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Quantum Information Theory
and the Foundations of Quantum
Mechanics

Quantum Information,
Computation and Cryptography
10th Anniversary Edition

Quantum physics allows

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**entirely new forms of
computation and
cryptography, which
could perform tasks
currently impossible on
classical devices,
leading to an explosion**

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**of new algorithms,
communications protocols
and suggestions for
physical implementations
of all these ideas. As a
result, quantum
information has made the**

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**transition from an
exotic research topic to
part of mainstream
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physics. Based on years
of teaching experience,
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research and development-
related results of the
“FIRST” Quantum
Information Processing
Project, which was**

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**conducted from 2010 to
2014 with the support of
the Council for Science,
Technology and
Innovation of the
Cabinet Office of the
Government of Japan. The**

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**project supported 33
research groups and
explored five areas:
quantum communication,
quantum metrology and
sensing, coherent
computing, quantum**

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**simulation, and quantum
computing. The book is
divided into seven main
sections. Parts I
through V, which consist
of twenty chapters,
focus on the system and**

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**architectural aspects of
quantum information
technologies, while
Parts VI and VII, which
consist of eight
chapters, discuss the
superconducting quantum**

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**circuit, semiconductor
spin and molecular spin
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will be introduced to
new quantum computing
schemes such as quantum
annealing machines and**

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**coherent Ising machines,
which have now arisen as
alternatives to standard
quantum computers and
are designed to
successfully address NP-
hard/NP-complete**

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**combinatorial
optimization problems,
which are ubiquitous and
relevant in our modern
life. The book offers a
balanced mix of theory-
based and**

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**experimentation-based
chapters written by
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provided on Quantum
simulation, which
focuses on the**

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**implementation of
various many-body
Hamiltonians in a well-
controlled physical
system, Quantum key
distribution, Quantum
repeaters and quantum**

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**teleportation, which are
indispensable
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building quantum
networks with various
advanced applications
and require far more**

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protocols of
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diamond norm and its
interpretation, and a**

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the importance of the
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formula has been
completely revised, and
many new exercises and**

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**references have been
added. This new edition
will be welcomed by the
upcoming generation of
quantum information
theorists and the
already established**

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introduces quantum
information and
computation for**

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Optics and Quantum**

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Information

Quantum Information

Processing

Frontiers of Engineering

What is Quantum

Information?

Quantum Information

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**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
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information theory and the
questions it raises for our
understanding of the
quantum world. Beginning
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analysis of the concepts of**

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**information in the everyday
and classical information-
theory settings, Christopher
G. Timpson argues for an
ontologically deflationary
account of the nature of
quantum information.**

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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

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**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**

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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

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**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**

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**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**

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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

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**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**

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**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**

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**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**

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**traditional problems of
quantum mechanics are to
be had.**