Quantum error-correcting codes from the quantum construction X

Peng Hu[1] · Xiusheng Liu[2]

Abstract

In this paper, we first modify a result of constructing quantum error-correcting (QEC) codes via Hermitian dual to via Euclidean dual over finite fields. Then, we give five methods of constructing QEC codes. In addition, we construct QEC codes to have better parameters than the ones available in the literature.

Keywords Quantum construction X · QEC WMDS codes · Generalized Reed–Solomon (GRS) codes

Mathematics Subject Classification 94B15 · 94B65

1 Introduction

Quantum error-correcting (QEC) codes have an important effect on quantum computing and quantum communications. The construction of QEC codes has been an active field of quantum information theory since the publication of [2, 3, 7, 11, 35–38] in recent years. It is well known that an interesting research field of QEC codes is to construct quantum codes with good parameters. Calderbank et al. [7] constructed QEC codes from classical linear codes, called CSS construction. Consequently, QEC codes started to develop rapidly [14, 22, 23, 29, 33]. In order to construct new QEC codes, Lisonek and Singh [27] provided a method of constructing QEC codes over $\mathbb{F}_4$ by relaxing the self-orthogonality requirement, which is called quantum construction

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Quantum Computation Quantum Error Correcting Codes And Informati

Tony Hey

Quantum Computation Quantum Error Correcting Codes And Informati:

Lectures on Quantum Computation, Quantum Error Correcting Codes and Information Theory K. R. Parthasarathy,2006 These notes are based on a course of about twenty lectures on quantum computation quantum error correcting codes and information theory The topics include a comparative description of the basic features of classical probability theory on finite sample spaces and quantum probability theory on finite dimensional complex Hilbert spaces quantum gates and cicuits simple examples of circuits arising from quantum teleportation communication through EPR pairs and arithmetical computations on a quantum computer more sophisticated examples of such circuits in the context of Fourier transform and phase estimation a detailed account of the order finding algorithm as well as the celebrated Shor s algorithm for factorising a positive integer into its prime factors There is a leisurely discussion of quantum error correcting codes with the Knill Laflamme criterion for error correction and a number of examples of such codes whose construction is based on the Weyl commutation relations for finite abelian groups The reader may find here a brief introduction to the basic ideas of classical information theory as developed by Shannon properties of von Neumann s quantum entropy and relative entropy as well as a proof of Schumacher s noiseless quantum coding theorem The Holevo bound for transmission of classical information through encoding by quantum states followed by measurements is derived The only background assumed of the reader is linear algebra on finite dimensional complex vector spaces and elementary classical probability theory on finite sample spaces These notes are aimed at mathematicians and computer scientists who are curious to know the mystery behind a quantum computer and the possibility of communicating information using the principles of elementary quantum theory   Quantum Error Correction Daniel A. Lidar,Todd A. Brun,2013-09-12 Quantum computation and information is one of the most exciting developments in science and technology of the last twenty years To achieve large scale quantum computers and communication networks it is essential not only to overcome noise in stored quantum information but also in general faulty quantum operations Scalable quantum computers require a far reaching theory of fault tolerant quantum computation This comprehensive text written by leading experts in the field focuses on quantum error correction and thoroughly covers the theory as well as experimental and practical issues The book is not limited to a single approach but reviews many different methods to control quantum errors including topological codes dynamical decoupling and decoherence free subspaces Basic subjects as well as advanced theory and a survey of topics from cutting edge research make this book invaluable both as a pedagogical introduction at the graduate level and as a reference for experts in quantum information science   **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   *Quantum Error Correction and Fault Tolerant Quantum Computing* Frank Gaitan,2018-10-03 It was once widely believed that quantum computation would never become a reality However the discovery of quantum error correction and the proof of the accuracy threshold theorem nearly ten years ago gave rise to extensive development and research aimed at creating a working scalable quantum computer Over a decade has passed since this monumental accomplishment yet no book length pedagogical presentation of this important theory exists Quantum Error Correction and Fault Tolerant Quantum Computing offers the first full length exposition on the realization of a theory once thought impossible It provides in depth coverage on the most important class of codes discovered to date quantum stabilizer codes It brings together the central themes of quantum error correction and fault tolerant

procedures to prove the accuracy threshold theorem for a particular noise error model The author also includes a derivation of well known bounds on the parameters of quantum error correcting code Packed with over 40 real world problems 35 field exercises and 17 worked out examples this book is the essential resource for any researcher interested in entering the quantum field as well as for those who want to understand how the unexpected realization of quantum computing is possible

Quantum Computation and Information Samuel J. Lomonaco,Howard E. Brandt,2002 This book is a collection of papers given by invited speakers at the first AMS Special Session on Quantum Computation and Information held at the January 2000 Annual Meeting of the AMS in Washington DC The papers in this volume give readers a broad introduction to the many mathematical research challenges posed by the new and emerging field of quantum computation and quantum information Of particular interest is a long paper by Lomonaco and Kauffman discussing mathematical and computational aspects of the so called hidden subgroup algorithm This book is intended to help readers recognize that as a result of this new field of quantum information science mathematical research opportunities abound in such diverse mathematical fields as algebraic coding theory algebraic geometry algebraic topology communication theory control theory cryptography differential geometry differential topology dynamical systems game theory group theory information theory number theory operator theory robotics theory of computation mathematical logic mathematical physics and more It is hoped that this book will act as a catalyst to encourage members of the mathematical community to take advantage of the many mathematical research opportunities arising from the grand challenge of Quantum Information Science This book is the companion volume to Quantum Computation A Grand Mathematical Challenge for the Twenty First Century and the Millennium PSAPM 58 Volume 58 in the Proceedings of Symposia in Applied Mathematics series   Quantum Information Processing, Quantum Computing, and Quantum Error Correction Ivan B. Djordjevic,2021-02-20 The Second Edition of Quantum Information Processing Quantum Computing and Quantum Error Correction An Engineering Approach presents a self contained introduction to all aspects of the area teaching the essentials such as state vectors operators density operators measurements and dynamics of a quantum system In additional to the fundamental principles of quantum computation basic quantum gates basic quantum algorithms and quantum information processing this edition has been brought fully up to date outlining the latest research trends These include Key topics include Quantum error correction codes QECCs including stabilizer codes Calderbank Shor Steane CSS codes quantum low density parity check LDPC codes entanglement assisted QECCs topological codes and surface codes Quantum information theory and quantum key distribution QKD Fault tolerant information processing and fault tolerant quantum error correction together with a chapter on quantum machine learning Both quantum circuits and measurement based quantum computational models are described The next part of the book is spent investigating physical realizations of quantum computers encoders and decoders including photonic quantum realization cavity quantum electrodynamics and ion traps In depth analysis of the design and realization of a quantum

information processing and quantum error correction circuits This fully up to date new edition will be of use to engineers computer scientists optical engineers physicists and mathematicians A self contained introduction to quantum information processing and quantum error correction Integrates quantum information processing quantum computing and quantum error correction Describes the latest trends in the quantum information processing quantum error correction and quantum computing Presents the basic concepts of quantum mechanics In depth presentation of the design and realization of a quantum information processing and quantum error correction circuit **FUNDAMENTALS OF QUANTUM COMPUTING: THEORY AND PRACTICE** MRS.BASKARI.S,K.KOWSALYADEVI,ANANTHA RAO GOTTIMUKKALA,PREMA S. KADAM,2025-08-08 Quantum computing is a new discipline of computer science and engineering that uses quantum physics unique properties to solve problems beyond the capabilities of even the most powerful classical computers Quantum computing encompasses several disciplines such as quantum hardware and quantum algorithms While still in progress quantum technology will soon be able to solve complicated problems that classical supercomputers cannot solve or not quickly enough **Quantum Computing** Rob Botwright,2024 Explore the Future with the Quantum Computing Computer Science Physics and Mathematics Book Bundle Are you ready to unlock the secrets of quantum computing and delve into the multidisciplinary world of computer science physics and mathematics Look no further Our exclusive bundle consisting of four captivating books is your ticket to the quantum frontier Book 1 Quantum Computing Demystified A Beginner s Guide Are you new to quantum computing This beginner s guide will unravel the complex concepts and lay the foundation for your quantum journey Dive into qubits superposition and quantum algorithms and embark on a transformative exploration of quantum computing s limitless possibilities Book 2 Mastering Quantum Computing A Comprehensive Guide for Intermediate Learners Ready to take the next step This comprehensive guide is tailored for intermediate learners providing in depth insights into advanced topics quantum programming and algorithm design Elevate your skills and become a quantum computing virtuoso Book 3 Advanced Quantum Computing Exploring the Frontiers of Computer Science Physics and Mathematics Step into the cutting edge world of quantum computing s frontiers Delve into quantum error correction cryptography and simulations and discover the complex challenges and captivating possibilities that await at the forefront of this transformative technology Book 4 Quantum Computing A Multidisciplinary Approach for Experts Quantum computing transcends disciplines and this book proves it Explore its multifaceted applications in computer science physics mathematics and beyond Recognize its potential to reshape industries and address global challenges This book is a must read for experts and visionaries Why Choose This Bundle Comprehensive Learning Our bundle offers a 360 degree view of quantum computing catering to beginners and experts alike Multidisciplinary Insights Explore the intersections of computer science physics mathematics and quantum computing for innovative perspectives Future Ready Quantum computing is at the forefront of technology Equip yourself with the skills and knowledge that will shape the future In Depth Exploration Dive deep into quantum

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coming from mathematics physics and computer science this volume aims to provide a taste of different sub disciplines for novices and a wealth of new perspectives for veteran researchers Regardless of your point of entry into topological quantum computing or your experience level this volume has something for you **Quantum Computing** Richard Skiba,2025-03-09 Quantum computing is revolutionizing the way we approach computation unlocking unprecedented capabilities that challenge the limits of classical computers This book is a guide for anyone seeking to understand the complexities of this emerging field Whether you are a student researcher or technology enthusiast this book provides a comprehensive exploration of the core concepts algorithms hardware and real world applications of quantum computing The book begins with a solid introduction to quantum mechanics the foundational science that makes quantum computing possible Readers will gain an understanding of key principles such as superposition entanglement and quantum interference phenomena that enable quantum computers to process vast amounts of data in parallel The discussion then shifts to qubits the fundamental building blocks of quantum computation explaining their physical implementations using superconducting circuits trapped ions photonic systems and other technologies As the book progresses it delves into the architecture of quantum computing covering quantum logic gates circuit design and universal gate sets that define how quantum computers perform calculations It explores groundbreaking quantum algorithms such as Shor s algorithm for factoring large numbers and Grover s algorithm for quantum search demonstrating how quantum computing achieves exponential speedup over classical methods A key challenge in quantum computing is error correction and noise mitigation This book provides an in depth analysis of quantum error correction techniques fault tolerant computing and strategies for overcoming decoherence and environmental noise making it accessible even to readers without a deep background in physics The discussion extends beyond theory to practical implementations examining quantum hardware developed by leading technology companies such as IBM Google Microsoft IonQ and Rigetti It also explores the role of quantum computing in cybersecurity highlighting quantum cryptography post quantum encryption and quantum key distribution protocols that ensure secure communications The latter sections of the book showcase real world applications of quantum computing in fields such as artificial intelligence drug discovery climate modelling financial modelling and supply chain optimization It also covers cloud based quantum computing services like IBM Quantum Experience Google Quantum AI and Amazon Braket providing insights into how organizations can leverage quantum computing without owning expensive quantum hardware With an eye toward the future Quantum Computing Fundamental Principles of Quantum Computing Systems examines the ongoing challenges and expected advancements in the field offering predictions on the evolution of quantum computing over the next two decades This book is an indispensable resource for understanding one of the most exciting technological frontiers of our time **Encyclopaedia of Mathematics, Supplement III** Michiel Hazewinkel,2007-11-23 This is the third supplementary volume to Kluwer s highly acclaimed twelve volume Encyclopaedia of Mathematics This additional volume contains nearly 500 new entries written by experts and covers

developments and topics not included in the previous volumes These entries are arranged alphabetically throughout and a detailed index is included This supplementary volume enhances the existing twelve volumes and together these thirteen volumes represent the most authoritative comprehensive and up to date Encyclopaedia of Mathematics available

Quantum Computing for Computer Scientists Noson S. Yanofsky,Mirco A. Mannucci,2008-08-11 The multidisciplinary field of quantum computing strives to exploit some of the uncanny aspects of quantum mechanics to expand our computational horizons Quantum Computing for Computer Scientists takes readers on a tour of this fascinating area of cutting edge research Written in an accessible yet rigorous fashion this book employs ideas and techniques familiar to every student of computer science The reader is not expected to have any advanced mathematics or physics background After presenting the necessary prerequisites the material is organized to look at different aspects of quantum computing from the specific standpoint of computer science There are chapters on computer architecture algorithms programming languages theoretical computer science cryptography information theory and hardware The text has step by step examples more than two hundred exercises with solutions and programming drills that bring the ideas of quantum computing alive for today s computer science students and researchers *Quantum Communication, Computing, and Measurement 3* Paolo Tombesi,Osamu Hirota,2007-05-08 This volume contains contributions based on the lectures delivered and posters presented at the Fifth International Conference on Quantum Communication Measurement and Computing QCM i Quantum Information and Communication ii Quantum Measurement coherence and Tomography iii Quantum Computing iv Cryptography v Entanglement and Teleportation We were lucky in that almost all major perimental groups in the world working in this area were represented as were the major theoreticians There was very active audience participation A n ber of graduate students and post docs were able to present their contributions in four after dinner poster sessions **Quantum Information Theory** Masahito Hayashi,2016-11-03 This graduate textbook provides a unified view of quantum information theory Clearly explaining the necessary mathematical basis it merges key topics from both information theoretic and quantum mechanical viewpoints and provides lucid explanations of the basic results Thanks to this unified approach it makes accessible such advanced topics in quantum communication as quantum teleportation superdense coding quantum state transmission quantum error correction and quantum encryption Since the publication of the preceding book Quantum Information An Introduction there have been tremendous strides in the field of quantum information In particular the following topics all of which are addressed here made seen major advances quantum state discrimination quantum channel capacity bipartite and multipartite entanglement security analysis on quantum communication reverse Shannon theorem and uncertainty relation With regard to the analysis of quantum security the present book employs an improved method for the evaluation of leaked information and identifies a remarkable relation between quantum security and quantum coherence Taken together these two improvements allow a better analysis of quantum state transmission In addition various types of the newly discovered

uncertainty relation are explained Presenting a wealth of new developments the book introduces readers to the latest advances and challenges in quantum information To aid in understanding each chapter is accompanied by a set of exercises and solutions   **Mastering Quantum Computing** Cybellium, Embark on a Journey into the Quantum Frontier with Mastering Quantum Computing In the realm of cutting edge technology quantum computing stands as a revolutionary frontier that promises to transform the world of computation and problem solving Quantum computers harness the power of quantum mechanics to tackle complex calculations that are beyond the reach of classical computers Mastering Quantum Computing is your comprehensive guide to unlocking the potential of quantum computation providing you with the knowledge skills and strategies to navigate this exciting and rapidly evolving field Your Path to Quantum Computing Excellence Quantum computing is more than just the future it s the present Whether you re new to quantum computing or an experienced physicist or computer scientist this book will empower you to master the art and science of quantum computation What You Will Discover Quantum Fundamentals Gain a deep understanding of the principles of quantum mechanics and quantum computing including quantum bits qubits and quantum gates Quantum Algorithms Explore groundbreaking quantum algorithms and their applications from Shor s algorithm for integer factorization to Grover s algorithm for unstructured search Quantum Hardware Dive into the world of quantum hardware platforms including superconducting qubits trapped ions and topological qubits Quantum Software Development Learn to program quantum computers using quantum programming languages like Qiskit Cirq and Quipper Quantum Cryptography Discover the principles of quantum cryptography which promises unbreakable security through the laws of quantum physics Quantum Future Explore the potential impact of quantum computing on various industries from cryptography and materials science to artificial intelligence and drug discovery Why Mastering Quantum Computing Is Essential Comprehensive Coverage This book provides comprehensive coverage of quantum computing topics ensuring you have a well rounded understanding of quantum principles and applications Expert Guidance Benefit from insights and advice from experienced quantum physicists computer scientists and industry experts who share their knowledge and best practices Career Advancement Quantum computing is at the forefront of technological innovation and this book will help you unlock your full potential in this dynamic field Stay at the Cutting Edge In a world where quantum computing is poised to revolutionize multiple industries mastering quantum computing is vital for staying at the forefront of scientific discovery and technological innovation Your Gateway to Quantum Computing Mastery Mastering Quantum Computing is your passport to excellence in the world of quantum computation Whether you aspire to be a quantum physicist quantum software developer or quantum engineer this guide will equip you with the skills and knowledge to achieve your goals Mastering Quantum Computing is the ultimate resource for individuals seeking to excel in the world of quantum computation and technology Whether you are new to quantum computing or looking to enhance your skills this book will provide you with the knowledge and strategies to become a

proficient quantum computing expert Don t wait begin your journey to quantum computing mastery today 2023 Cybellium Ltd All rights reserved www cybellium com **Feynman Lectures on Computation** Tony Hey,2023-05-18 The last lecture course that Nobel Prize winner Richard P Feynman gave to students at Caltech from 1983 to 1986 was not on physics but on computer science The first edition of the Feynman Lectures on Computation published in 1996 provided an overview of standard and not so standard topics in computer science given in Feynman s inimitable style Although now over 20 years old most of the material is still relevant and interesting and Feynman s unique philosophy of learning and discovery shines through For this new edition Tony Hey has updated the lectures with an invited chapter from Professor John Preskill on Quantum Computing 40 Years Later This contribution captures the progress made toward building a quantum computer since Feynman s original suggestions in 1981 The last 25 years have also seen the Moore s law roadmap for the IT industry coming to an end To reflect this transition John Shalf Senior Scientist at Lawrence Berkeley National Laboratory has contributed a chapter on The Future of Computing beyond Moore s Law The final update for this edition is an attempt to capture Feynman s interest in artificial intelligence and artificial neural networks Eric Mjolsness now a Professor of Computer Science at the University of California Irvine was a Teaching Assistant for Feynman s original lecture course and his research interests are now the application of artificial intelligence and machine learning for multi scale science He has contributed a chapter called Feynman on Artificial Intelligence and Machine Learning that captures the early discussions with Feynman and also looks toward future developments This exciting and important work provides key reading for students and scholars in the fields of computer science and computational physics   Coding Theory and Cryptology Harald Niederreiter,2002 The inaugural research program of the Institute for Mathematical Sciences at the National University of Singapore took place from July to December 2001 and was devoted to coding theory and cryptology As part of the program tutorials for graduate students and junior researchers were given by world renowned scholars These tutorials covered fundamental aspects of coding theory and cryptology and were designed to prepare for original research in these areas The present volume collects the expanded lecture notes of these tutorials The topics range from mathematical areas such as computational number theory exponential sums and algebraic function fields through coding theory subjects such as extremal problems quantum error correcting codes and algebraic geometry codes to cryptologic subjects such as stream ciphers public key infrastructures key management authentication schemes and distributed system security   **ARTIFICIAL INTELLIGENCE** Joost Nico Kok,2009-12-20 Artificial Intelligence is a component of Encyclopedia of Technology Information and Systems Management Resources in the global Encyclopedia of Life Support Systems EOLSS which is an integrated compendium of twenty Encyclopedias The Theme on Artificial Intelligence provides the essential aspects and fundamentals of Artificial Intelligence Definition Trends Techniques and Cases Logic in Artificial Intelligence AI Computational Intelligence Knowledge Based System Development Tools It is aimed at the following five major target audiences University and College

Students Educators Professional Practitioners Research Personnel and Policy Analysts Managers and Decision Makers
    Quantum Computing Eleanor G. Rieffel,Wolfgang H. Polak,2014-08-29 A thorough exposition of quantum computing and the underlying concepts of quantum physics with explanations of the relevant mathematics and numerous examples The combination of two of the twentieth century s most influential and revolutionary scientific theories information theory and quantum mechanics gave rise to a radically new view of computing and information Quantum information processing explores the implications of using quantum mechanics instead of classical mechanics to model information and its processing Quantum computing is not about changing the physical substrate on which computation is done from classical to quantum but about changing the notion of computation itself at the most basic level The fundamental unit of computation is no longer the bit but the quantum bit or qubit This comprehensive introduction to the field offers a thorough exposition of quantum computing and the underlying concepts of quantum physics explaining all the relevant mathematics and offering numerous examples With its careful development of concepts and thorough explanations the book makes quantum computing accessible to students and professionals in mathematics computer science and engineering A reader with no prior knowledge of quantum physics but with sufficient knowledge of linear algebra will be able to gain a fluent understanding by working through the book

Quantum Computation Quantum Error Correcting Codes And Informati Book Review: Unveiling the Magic of Language

In an electronic era where connections and knowledge reign supreme, the enchanting power of language has become more apparent than ever. Its power to stir emotions, provoke thought, and instigate transformation is truly remarkable. This extraordinary book, aptly titled "**Quantum Computation Quantum Error Correcting Codes And Informati**," written by a very acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound affect our existence. Throughout this critique, we shall delve into the book is central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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