

*Commenced Publication in 1973*

Founding and Former Series Editors:

Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Editorial Board

David Hutchison

*Lancaster University, UK*

Takeo Kanade

*Carnegie Mellon University, Pittsburgh, PA, USA*

Josef Kittler

*University of Surrey, Guildford, UK*

Jon M. Kleinberg

*Cornell University, Ithaca, NY, USA*

Alfred Kobsa

*University of California, Irvine, CA, USA*

Friedemann Mattern

*ETH Zurich, Switzerland*

John C. Mitchell

*Stanford University, CA, USA*

Moni Naor

*Weizmann Institute of Science, Rehovot, Israel*

Oscar Nierstrasz

*University of Bern, Switzerland*

C. Pandu Rangan

*Indian Institute of Technology, Madras, India*

Bernhard Steffen

*TU Dortmund University, Germany*

Madhu Sudan

*Microsoft Research, Cambridge, MA, USA*

Demetri Terzopoulos

*University of California, Los Angeles, CA, USA*

Doug Tygar

*University of California, Berkeley, CA, USA*

Gerhard Weikum

*Max Planck Institute for Informatics, Saarbruecken, Germany*

Wim van Dam Vivien M. Kendon  
Simone Severini (Eds.)

# Theory of Quantum Computation, Communication, and Cryptography

5th Conference, TQC 2010  
Leeds, UK, April 13-15, 2010  
Revised Selected Papers

Volume Editors

Wim van Dam  
University of California  
Department of Computer Science  
Santa Barbara, CA 93106-5110, USA  
E-mail: vandam@cs.ucsb.edu

Vivien M. Kendon  
University of Leeds  
School of Physics and Astronomy  
Leeds, LS2 9JT, UK  
E-mail: v.kendon@leeds.ac.uk

Simone Severini  
University College London  
Department of Physics and Astronomy  
London, WC1E 6BT, UK  
E-mail: simoseve@gmail.com

Library of Congress Control Number: 2010941752

CR Subject Classification (1998): F, D, C.2, G.1-2, E.3, J.2

LNCS Sublibrary: SL 1 – Theoretical Computer Science and General Issues

ISSN 0302-9743  
ISBN-10 3-642-18072-8 Springer Berlin Heidelberg New York  
ISBN-13 978-3-642-18072-9 Springer Berlin Heidelberg New York

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

springer.com

© Springer-Verlag Berlin Heidelberg 2011  
Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India  
Printed on acid-free paper 06/3180

# Preface

The Conference on Theory of Quantum Computation, Communication, and Cryptography (TQC) is an annual meeting on theoretical aspects of quantum information processing. The goal of the conference is to foster developments in this rapidly growing, interdisciplinary field by providing a forum for the presentation and discussion of original research.

The fifth iteration of TQC was held during April 13–15, 2010, at the University of Leeds, United Kingdom. It included invited talks, contributed talks, and a poster session, as well as a rump session consisting of short talks on recent developments. Authors of selected contributed talks were invited to submit a paper to these proceedings.

TQC 2010 would not have been possible without the contributions of numerous individuals and organizations, and we sincerely thank them for their support.

In putting together the scientific program, we were very grateful for the hard work and advice of the Program Committee, listed herein. The logistics of the conference were expertly managed by the Organizing Committee, also listed herein, and we thank them for their efforts to make the conference a success.

We would like to thank the invited speakers, Frédéric Magniez, Kae Nemoto, Frank Verstraete, Ronald de Wolf, and Anton Zeilinger, for their contributions to the program.

We would like to thank the members of the Conference Series Steering Committee, Yasuhito Kawano, Michele Mosca, and Vlatko Vedral, for their important advice.

TQC 2010 was made possible by financial support from the British Computer Society, the Heilbronn Institute, the Quantum Information, Quantum Optics and Quantum Control Group of the Institute of Physics, the School of Mathematics of the University of Leeds, the School of Physics and Astronomy of the University of Leeds, the London Mathematical Society, the Sandia National Laboratories, the Institute for Quantum Computing at the University of Waterloo, and the Worldwide Universities Network, Leeds; we thank these organizations for their important contributions.

Finally, we would like to thank Springer for publishing the proceedings of TQC in the *Lecture Notes in Computer Science* series.

October 2010

Wim van Dam  
Vivien Kendon  
Simone Severini

# Organization

## Program Committee

Wim van Dam	University of California, Santa Barbara (Chair), USA
Simone Severini	University College London (Co-chair), UK
Dagmar Bruß	Heinrich Heine University, Germany
Andrew Childs	University of Waterloo, Canada
Matthias Christandl	Ludwig Maximilians University, Germany
Nilanjana Datta	University of Cambridge, UK
Aram Harrow	University of Bristol, UK
Peter Høyer	University of Calgary, Canada
Rahul Jain	National University of Singapore
Elham Kashefi	University of Edinburgh, UK
Debbie Leung	University of Waterloo, Canada
Hoi-Kwong Lo	University of Toronto, Canada
Juan Pablo Paz	University of Buenos Aires, Argentina
Francesco Petruccione	University of KwaZulu-Natal, South Africa
David Poulin	Université de Sherbrooke, Canada
Martin Rötteler	NEC, Princeton, USA
Miklos Santha	Université Paris Sud, France
Seiichiro Tani	NTT, Tokyo, Japan
Jean-Pierre Tillich	INRIA, Rocquencourt, France
Pawel Wocjan	University of Central Florida, USA

## Organizing Committee

Vivien Kendon	University of Leeds (Chair), UK
Martin Aulbach	University of Leeds, UK
Dave Bacon	University of Washington, USA
Stephen Bartlett	University of Sydney, Australia
Katie Barr	University of Leeds, UK
Stephen Brierley	University of York, UK
Katherine Brown	University of Leeds, UK
Barry Cooper	University of Leeds, UK
Peter Crompton	University of Leeds, UK
Vladimir V. Kisil	University of Leeds, UK
Neil Lovett	University of Leeds, UK
Stefano Pirandola	University of York, UK
Mike Stannett	University of Sheffield, UK
Rob Wagner	University of Leeds, UK

# Table of Contents

Asymptotically Optimal Discrimination between Pure Quantum States . . . . .	1
<i>Michael Nussbaum and Arleta Szkola</i>	
On Quantum Estimation, Quantum Cloning and Finite Quantum de Finetti Theorems . . . . .	9
<i>Giulio Chiribella</i>	
Simple Sets of Measurements for Universal Quantum Computation and Graph State Preparation . . . . .	26
<i>Yasuhiro Takahashi</i>	
Computational Depth Complexity of Measurement-Based Quantum Computation . . . . .	35
<i>Dan Browne, Elham Kashefi, and Simon Perdrix</i>	
Local Equivalence of Surface Code States . . . . .	47
<i>Pradeep Sarvepalli and Robert Raussendorf</i>	
Testing Non-isometry Is QMA-Complete . . . . .	63
<i>Bill Rosgen</i>	
Quantum Search with Advice . . . . .	77
<i>Ashley Montanaro</i>	
Simulating Sparse Hamiltonians with Star Decompositions . . . . .	94
<i>Andrew M. Childs and Robin Kothari</i>	
The Polynomial Degree of Recursive Fourier Sampling . . . . .	104
<i>Benjamin Johnson</i>	
Generalized Self-testing and the Security of the 6-State Protocol . . . . .	113
<i>Matthew McKague and Michele Mosca</i>	
A Conceptually Simple Proof of the Quantum Reverse Shannon Theorem . . . . .	131
<i>Mario Berta, Matthias Christandl, and Renato Renner</i>	
Geometric Entanglement of Symmetric States and the Majorana Representation . . . . .	141
<i>Martin Aulbach, Damian Markham, and Mio Murao</i>	
Monogamy of Multi-qubit Entanglement in Terms of Rényi and Tsallis Entropies . . . . .	159
<i>Jeong San Kim and Barry C. Sanders</i>	

Bypassing State Initialisation in Perfect State Transfer Protocols on Spin-Chains .....	168
<i>C. Di Franco, M. Paternostro, and M.S. Kim</i>	
Teleportation of a Quantum State of a Spatial Mode with a Single Massive Particle .....	175
<i>Libby Heaney</i>	
<b>Author Index</b> .....	187