UBC Department of Physics & Astronomy

10th Canadian Summer School on Quantum Information

July 17-30, 2010

University of British Columbia
Vancouver, Canada

a place of mind UBC

PiTP

MITACS

Pacific Institute for the Mathematical Sciences

CIFAR
CANADIAN INSTITUTE for ADVANCED RESEARCH

D-Wave

QuantumWorks
QUANTUM INFORMATION NETWORK CANADA
RÉSEAU DE L'INFORMATION QUANTIQUE CANADA

I. TABLE OF CONTENTS

I. Table of Contents 2

II. About The Summer School 3

III. Organizers 4

IV. List of Participants 5

V. Programme 8

VI. Conference Venue 9

Hennings Building 11

Irving K. Barber Learning Centre 11

Abdul Ladha Science Student Centre 11

VII. Summer School Lecture Topics & Lecturers 12

Childs & Wocjan: Quantum Algorithms 12

Admin & Lidar: Adiabatic Quantum Computation, Decoherence-Free Subspaces & Noiseless Subsystems, and Dynamical Decoupling 13

Brown & Raussendorf: Measurement-based Quantum Computation 14

Bonesteel: Topological Quantum Computation 15

Gottesman: Quantum error correction 16

van den Nest & **Verstraete**: Classical Simulation of Quantum Systems 17

Godsil: Graph Theory In Quantum Information 19

Spekkens: Foundations of Quantum Mechanics 20

VIII. Additional Activities 21

Summer School Reception – July 17th 21

D-Wave Tours – July 22nd & July 25th 21

Lunch Time Talks 21

D'Alessandro: Dynamical and Combinatorial Analysis of Quantum Walks on Graphs 21

Hotta: Energy-Entanglement Relation for Quantum Energy Teleportation 21

UBC Museum of Anthropology Tour - July 30th 22

Summer School Evaluation 22

II. About The Summer School

This summer school on quantum information marks the 10th anniversary of the highly renowned series. Previous events (2001-2009) were held in Toronto, Montreal, Calgary, and Waterloo. It follows the tradition of educating young researchers (prospective and current graduate students, as well as post-docs) on the rapidly-evolving field of quantum information science and brings together the world's experts from different areas.

This year the emphasis will be on quantum algorithms and models of quantum computation, with particular attention to mathematical methods. We are planning to include one advanced topic which is not so traditional for a summer school in quantum information, namely “Foundational aspects of quantum mechanics”.

The importance of quantum information was first widely recognized in 1982 when Feynman conjectured that a quantum computer would efficiently simulate quantum systems, while a universal Turing machine (“classical computer”) could not. A first breakthrough came in the mid-1990s, when Peter Shor showed that the quantum computer could efficiently determine the factors of large numbers, whereas this problem is believed to be intractable on a classical computer. Since then, a burst of research activities on the quantum realm of communication, models of computation and algorithms, and implementation of many proposed quantum information processing tasks, had rapidly given rise to a new subfield of science – quantum information science.

The Summer School will consist of a 5-day block and a 4-day block. Embedded between these two blocks, the Workshop on quantum algorithms, computational models, and foundations of quantum mechanics will take place, thus giving students a rare learning opportunity to see real-world applications of quantum information science research.

III. ORGANIZERS

General Contact: info@qi10.ca

Website: http://qi10.ca

Local Organizers

Robert Raussendorf

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Scientific Organizers

Mohammad Amin, D-Wave Systems Inc., Burnaby, BC

Petr Lisonek, Simon Fraser University

Robert Raussendorf, University of British Columbia

Barry Sanders, University of Calgary

Pradeep Kiran Sarvepalli, University of British Columbia

Tzu-Chieh Wei, University of British Columbia

IV. List of Participants

Damian **Abasto**, University of Southern California, United States

[+]*Mohammad **Amin**, D-Wave Systems Inc., Burnaby, BC, Canada

Toshihico **Arimitsu**, University of Tsukuba, Japan

Naoko **Arimitsu**, Yokohama National University, Japan

Colin **Benjamin**, University of Georgia, United States

*Nick **Bonesteel**, Florida State University, Tallahassee, FL, USA

Daniel **Brod**, Universidade Federal Fluminense, Brazil

*Daniel E. **Browne**, University College, London, UK

Zhenwei **Cao**, Virginia Tech, United States

*Andrew **Childs**, University of Waterloo, Canada

Cheung **Chun Hung**, Personal Status, Hong Kong

Seth **Cottrell**, NYU, United States

Raphael **Dias da Silva**, Universidade Federal Fluminense, Brazil

Domenico **D'Alessandro**, Iowa State University, United States

Pieter **de Wet**, University of South Africa, South Africa

Byron **Drury**, Massachusetts Institute of Technology, United States

Adam **D'Souza**, University of Calgary, Canada

Guillaume **Duclos-Cianci**, Université de Sherbrooke, Canada

Sara **Ejtemaee**, Simon Fraser University, Canada

Amira **Eltony**, University of British Columbia, Canada

Amir **Feizpour**, Univ. of Toronto, Canada

Chris **Ferrie**, University of Waterloo, Canada

Samuel **Fletcher**, University of California, Irvine, United States

John **Gamble**, University of Wisconsin, United States

Sreejith **Ganesh Jaya**, PennState, United States

Andres **Garcia Saravia Ortiz de Montellano**, Cinvestav Merida, IPN, Mexico

* Chris **Godsil**, University of Waterloo, Canada

Leonard **Goff**, University of British Columbia, Canada

*Daniel **Gottesman**, Perimeter Institute, Waterloo, ON, Canada

Gurpreet Kaur **Gulati**, National University of Singapore, Singapore

Poya **Haghnegahdar**, UBC, Canada

Pinja **Haikka**, Turku Center for Quantum Physics, University of Turku, Finland

Wolfram **Helwig**, University of Toronto, Canada

Maritza **Hernandez**, N/A, Canada

Alba Marcela **Herrera Trujillo**, Universidad del Valle, Colombia

Dominic **Hosler**, University of Sheffield, United Kingdom

Ching-Yu **Huang**, National Taiwan Normal University, Taiwan

Sakshi **Jain**, Indian Institute of Technology, Bombay, India

Kebei **Jiang**, Louisiana State University, United States

Vishaal **Kapoor**, University of British Columbia, Canada

Faizal **Karim**, UBC, Canada

Michael **Kastoryano**, University of Copenhagen, Denmark

Toru **Kawakubo**, Kyoto University, Japan

Artem **Kaznatcheev**, McGill University, Canada

Muhammad Mubashir **Khan**, University of Leeds, United Kingdom

Botan **Khani**, Institute of Quantum Computing, University of Waterloo, Canada

*Daniel **Lidar**, University of Southern California, Los Angeles, CA, USA

Yoshiyuki **Kinjo**, The University of Tokyo, Japan

Juergen **Klein**, Private, Canada

Margo **Kondratieva**, memorial university, Canada

Niels **Kurz**, Georg-August University Goettingen, Germany

Raymond **Lal**, University of Oxford, United Kingdom

Ting Fai **Lam**, The Chinese University of Hong Kong, Hong Kong

Olivier **Landon-Cardinal**, Université de Sherbrooke, Canada

Jixin **Liang**, Simon Fraser University, Canada

Cedric Yen-Yu **Lin**, University of British Columbia, Canada

[+]Petr **Lisonek**, Simon Fraser University, BC, Canada

Hui Yi **Lu**, SFU, Canada

Javier **Martínez**, CSIC, Canada

Robert **Matjeschk**, Leibniz Universität Hannover, Germany

Mario **Michan**, UBC, Canada

Abel Molina **Prieto**, University of Waterloo, Canada

Mike **Mullan**, NIST, United States

Lenore **Mullin**, University at Albany, SUNY, United States

Syoujun **Nakayama**, Tokyo University, Japan

Sandeep **Narayanaswami**, Pennsylvania State University, United States

Oktay **Olmez**, Iowa State University, United States

Hamid **Omid**, UBC, Canada

Veiko **Palge**, University of Leeds, United Kingdom

Jihyun (Annie) **Park**, University of British Columbia, Canada

James **Pope**, University of Oxford, United Kingdom

Kristen **Pudenz**, University of Southern California, United States

Masud Rana **Rashel**, University of Bradford, United Kingdom

[+]*Robert **Raussendorf**, University of British Columbia, Canada

Bhaskar **Roy Bardhan**, Louisiana State University, United States

Kenneth **Rudinger**, University of Wisconsin- Madison, United States

Tomas **Rybar**, Physical Institute, Slovak academy of Sciences, Slovakia

Junghee **Ryu**, Hanyang University, Korea (South)

Sina **Salek**, University of Manchester, United Kingdom

+Pradeep Kiran **Sarvepalli**, University of British Columbia, Canada
Matthew **Scholte-van de Vorst**, UBC, Canada
Kaushik **Seshadreesan**, Louisiana State University, Baton Rouge, United States
Zahra **Shadman**, Heinrich-Heine-Universität Düsseldorf, Germany
Cheng **Shen**, University of Waterloo, IQC, Canada
Sevim **Simsek**, Iowa State Department, United States
Fang **Song**, Pennsylvania State University, United States
*Robert **Spekkens**, Perimeter Institute, Waterloo, ON, Canada
Christoph **Spengler**, University of Vienna, Austria
Bharath **Srivathsan**, National University of Singapore, Singapore
Subhash **Tangella**, University of Madras, India
Shahab **Tasharrofi**, Simon Fraser University, Canada
Elena **Tolkacheva**, D-Wave Systems, Canada
Pashootan **Vaezipoor**, Simon Fraser University, Canada
*Maarten **van den Nest**, Max-Planck-Institut für Quantenoptik, Garching, Germany
*Frank **Verstraete**, Universität Wien, Austria
+Tzu-Chieh **Wei**, University of British Columbia, Canada
*Pawel **Wocjan**, University of Central Florida, Orlando, FL, USA
Jinshan **Wu**, UBC, Canada
Tzyh Haur **Yang**, National University of Singapore, Singapore
Jingfu **Zhang**, University of Warerloo, Canada
Dong **Zhou**, University of Wisconsin-Madison, United States
Weifeng **Zhou**, CUNY, United States
Bojan **Zunkovic**, University of Ljubljana, Slovenia

* Summer School Lecturers

+ Summer School Organizers

V. Programme

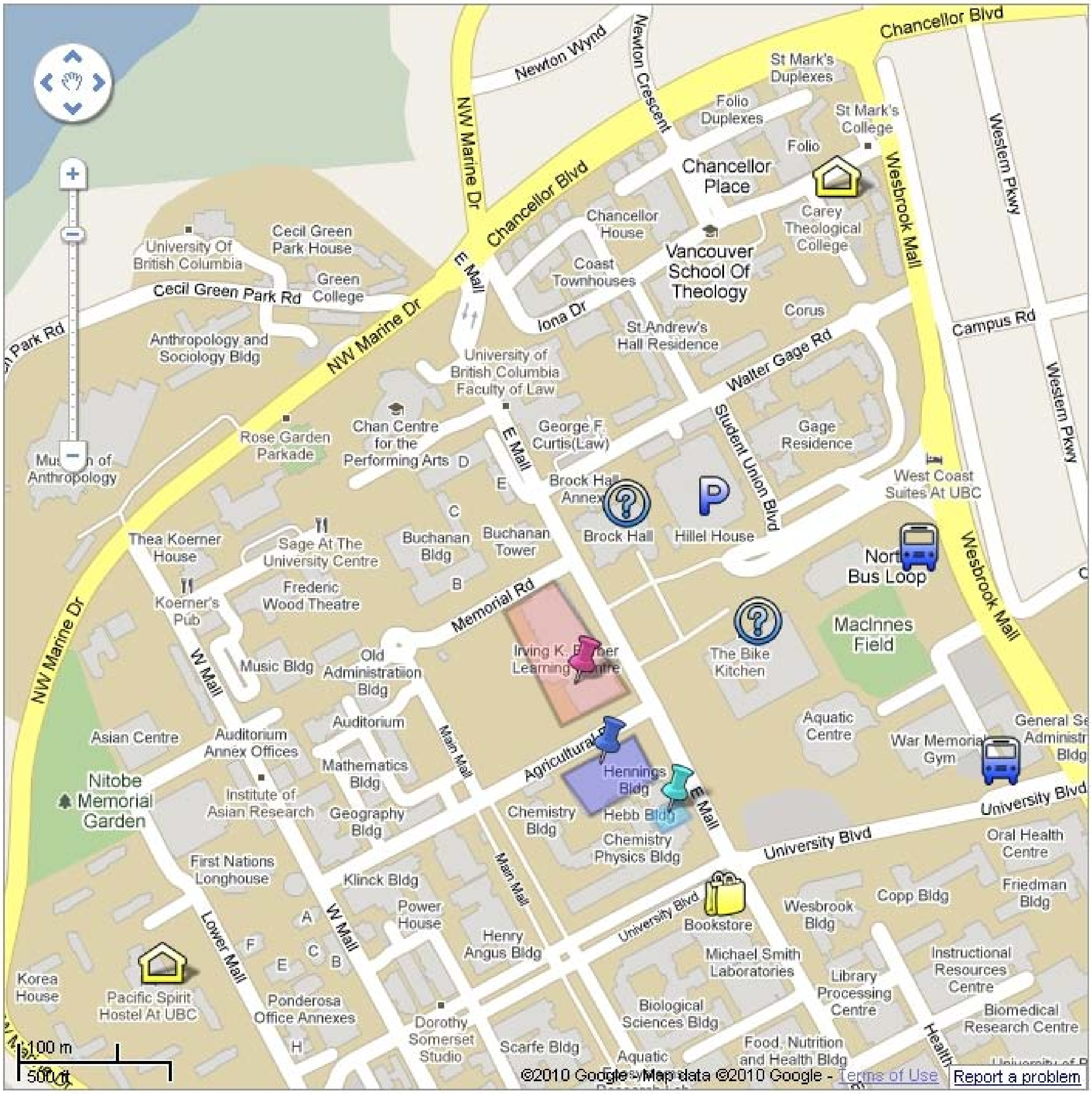
First Week:

July 17 – 21	Sat, 17th Henn 201	Sun, 18th IBLC 182	Mon, 19th Henn 201	Tues, 20th Henn 201	Wed, 21st Henn 201	Thurs, 22nd
9:00-10:15	Introduction (Raussendorf, 10 min) * Quantum Algorithms (Wocjan/Childs)	Quantum Algorithms (Wocjan/Childs)	Quantum Works Presentation (Sean Collins, 10min) * Quantum Algorithms (Wocjan/Childs)	Classical Simulation (van den Nest)	Adiabatic Quantum Computation (Lidar/Amin)	Optional Activity: D-Wave Tour
10:15-10:45	Coffee Break					
10:45-12:00	Quantum Algorithms	Quantum Algorithms	Quantum Algorithms	Classical Simulation	Adiabatic Quantum Computation	
12:00-2:00	Lunch Break				Talk 12:30-1:15 Domenico D'Alessandro	
2:00-3:15	Quantum-Error Correction (Gottesman)	Quantum-Error Correction (Gottesman)	Graph Theory (Godsil)	Graph Theory (Godsil)	Adiabatic Quantum Computation	
3:15-3:45	Coffee Break					
3:45-5:00	Quantum-Error Correction	Quantum-Error Correction	Graph Theory	Graph Theory	Adiabatic Quantum Computation	
5:00-6:00	Break					
6:00-8:00	QI10 Reception @ Abdul Ladha Centre					

Second Week:

July 24 – 30	Mon, 26th Henn 201	Tues, 27th Henn 200	Wed, 28th Henn 200	Thurs, 29th Henn 201	Fri, 30th
9:00-10:15	Foundations of Quantum Mechanics (Spekkens)	Classical Simulation (Verstraete)	Classical Simulation (Verstraete)	Measurement-based Quantum Computation (Browne/Raussendorf)	Optional Activity: Museum of Anthropology Tour
10:15-10:45	Coffee Break				
10:45-12:00	Foundations of Quantum Mechanics	Classical Simulation	Classical Simulation	Measurement-based Quantum Computation	
12:00-2:00	Lunch Break		Talk 12:30-1:15 Masahiro Hotta	Lunch Break	
2:00-3:15	Foundations of Quantum Mechanics	Topological Quantum Computation (Bonesteel)	Topological Quantum Computation (Bonesteel)	Measurement-based Quantum Computation	
3:15-3:45	Coffee Break				
3:45-5:00	Foundations of Quantum Mechanics	Topological Quantum Computation	Topological Quantum Computation	Measurement-based Quantum Computation	

VI. Conference Venue



QI10 lecture venue

Hennings Room 200 & 201

QI10 lecture venue

IBLC Room 182

QI10 Reception

Hennings Building (Henn)

6224 Agricultural Road

Ike Barber Learning Centre (IBLC)

1961 East Mall

Abdul Ladha Science Student Centre

2055 East Mall

North Parkade

The parkade closest to the meeting location (Hennings building)

North Bus Loop (Main Bus Loop)

The main bus loop - for diesel buses
#99, #44, #84, #41, #43, #49, #258, #480

2nd Bus Loop

2nd bus loop for cable buses
#4, #17, #9

Info Centre

Brock Hall 1874 East Mall

Info Centre (run by students)

6138 Student Union Blvd (Student Union Building)
Not the official information centre, but the students there should be able to answer any general questions

UBC Bookstore

Meet up for D-Wave tours
6200 University Boulevard

Carey Centre - Invited Speaker Accommodation

5920 Iona Drive

Vanier Place - Financial Support Winners Accommodation1935 Lower Mall

1935 Lower Mall

All of the QI10 lectures will be held in the Hennings Building and the Ike Barber Learning Centre.

July 17 (Sat) - Henn 201
July 18 (Sun) - IBLC 182
July 19 to 21 (Mon-Wed) - Henn 201
July 26 (Mon) - Henn 201
July 27 to 28 (Tues-Wed) - Henn 200
July 29 (Thurs) - Henn 201

HENNINGS BUILDING (HENN)

6224 Agricultural Road, Vancouver, BC

The Hennings Building is the home of the UBC Department of Physics & Astronomy. Some of the Summer School sessions will be held in this building. On some days Summer School lectures will be held in room 200 or 201 of the building. The easiest way to find Henn 200 and 201 is to enter the building from the north side entrance.

IRVING K. BARBER LEARNING CENTRE (IBLC)

1961 East Mall, Vancouver, BC

Opened in 2008, this renovated learning space contains a library, reading rooms, teaching and learning facilities, meetings rooms, cafe, and much more. On some days Summer School lectures will be held in room 182 (Victoria Learning Centre) of the Learning Centre.

ABDUL LADHA SCIENCE STUDENT CENTRE

2055 East Mall, Vancouver, BC

The Abdul Ladha Centre is the Home of the UBC Science Undergraduate Society. It is a social space to encourage both informal and organized academic, club, and social activities and interactions for those students enrolled in the Faculty of Science at the University of British Columbia Vancouver. It is the location for our Summer School reception.

VII. Summer School Lecture Topics & Lecturers

Childs & Wocjan: Quantum Algorithms

Quantum information offers the possibility to solve certain problems dramatically faster than is possible with classical computers. In these lectures, we will give an introduction to quantum algorithms. We will begin with an overview of the quantum circuit model and some elementary examples of quantum speedup. Next, we will introduce the quantum Fourier transform and show how it can be used to estimate the eigenvalues of a unitary operator. Using phase estimation, we will describe Shor's algorithm for factoring integers. We will also describe Grover's search algorithm, and will conclude with a discussion of recent quantum algorithms based on quantum analogs of random walks.

Andrew Childs received his Ph.D. in physics in 2004 as a Herz Foundation Fellow at the Massachusetts Institute of Technology. He is currently an assistant professor in the Department of Combinatorics and Optimization and the Institute for Quantum Computing at the University of Waterloo. Previously, he was a Lee A. DuBridge Postdoctoral Scholar at the Institute for Quantum Information at the California Institute of Technology. His interests include the theory of quantum information processing, especially algorithms for quantum computers.

Pawel M. Wocjan is Assistant Professor in Computer Science at the University of Central Florida. He received his Ph.D. and his M.S. from the Karlsruhe Institute of Technology in 2003 and 1999, respectively. Prior to joining the University of Central Florida in 2006, he was a postdoctoral scholar in computer science at the Institute for Quantum Information, California Institute of Technology, from 2004 till 2006. He received a National Science Foundation CAREER Award for his research on quantum computing in 2008. His main research interests are quantum algorithms for algebraic problems, quantum-walk-based algorithms, quantum complexity theory, and quantum control theory. His secondary research interests include approximation algorithms, randomized algorithms, online algorithms, algebraic geometry, and number theory.

ADMIN & LIDAR: ADIABATIC QUANTUM COMPUTATION, DECOHERENCE-FREE SUBSPACES & NOISELESS SUBSYSTEMS, AND DYNAMICAL DECOUPLING

[Amin] In the first half of the day, adiabatic quantum computation (AQC) will be introduced as a universal scheme of quantum computation and an alternative to the gate model quantum computation. Adiabatic quantum optimization (AQO) will then be introduced as a subset of AQC, and its relation to quantum phase transitions will be discussed. The effect of noise on AQO using realistic environmental noise models will be discussed. We'll end with a presentation of the practical implementation of AQO using superconducting circuitry and some single-qubit and multi-qubit experimental results.

[Lidar] The second part of the day will start by covering several advanced topics in AQC, including a sketch of the proof of the equivalence between AQC and the circuit model, rigorous formulations of the adiabatic theorem, the geometry of AQC, and a time-optimized ("brachistochrone") approach to AQC. We'll then switch gears and provide an introduction to decoherence-free subspaces, noiseless subsystems, dynamical decoupling, and hybrid methods in which they are combined. The emphasis will be on the underlying unifying symmetry principles which enable quantum errors to be avoided by encoding. Time permitting, we'll return to AQC and discuss how it can be made resilient to decoherence.

Mohammad Amin is a senior scientist at D-Wave Systems Inc. He did a PhD in condensed matter theory under the joint supervision of Profs. Ian Affleck and Philip Stamp at the University of British Colombia (Canada) in 1999, and a short postdoc at Simon Fraser University (Canada), before joining D-Wave in Jan. 2000. His current research interest includes superconducting qubits, adiabatic quantum computation, decoherence, and quantum phase transitions.

Daniel Lidar is a professor of Electrical Engineering and Chemistry at the University of Southern California, and holds a cross-appointment in Physics. He obtained his Ph.D. in Physics from the Hebrew University of Jerusalem in 1997. He was a postdoc at UC Berkeley from 1997 to 2000, then an assistant professor and later associate professor of Chemistry at the University of Toronto from 2000 to 2005, with cross-appointments in Mathematics and Physics.

His research interests lie primarily in the theory and control of open quantum systems, with a special emphasis on quantum information processing. His past interests include scattering theory and disordered systems. He is the Director and co-founding member of the USC Center for Quantum Information Science & Technology <http://cqist.usc.edu/> (CQIST). He is a recipient of a Sloan Research Fellowship and is a Fellow of the American Physical Society.

BROWN & RAUSSENDORF: MEASUREMENT-BASED QUANTUM COMPUTATION

There are two fundamentally different ways of evolving a quantum state: unitary evolution and projective measurement. Unitary evolution is deterministic and reversible, whereas measurement is probabilistic and irreversible. Despite these differences, it turns out that universal quantum computation can be built on either. In this lecture we are concerned with quantum computation by measurement. We give an introduction to the subject, and discuss various aspects of this field, ranging from physical realization to fault-tolerance and foundations of quantum mechanics.

Dan Browne gained his PhD at Imperial College London in 2004 under the supervision of Martin Plenio. The subject of his thesis was implementations of quantum information processing in cavity QED and optics. Before commencing his PhD, he was a DAAD-funded research scholar at LMU university in Munich, working with Hans Briegel and Robert Raussendorf on measurement-based quantum computation. He was a Junior Research Fellow at Merton College Oxford from 2004-2007 and is now a lecturer and Leverhulme research fellow at University College London. His research interests include quantum computation theory, implementations of quantum information processing, and the quantum properties of many-body systems.

Robert Raussendorf is Assistant Professor at the University of British Columbia. He obtained his PhD from the Ludwig Maximilians University in Munich, Germany in 2003. He was postdoc at Caltech and at the Perimeter Institute for Theoretical Physics, and is scholar of the Cifar Quantum Information program and Sloan Research Fellow 2009 - 2011. His main research interest is in models of quantum computation, in particular measurement-based quantum computation, and in fault-tolerance.

BONESTEEL: TOPOLOGICAL QUANTUM COMPUTATION

Certain exotic states of matter, so-called non-Abelian states, have the potential to provide a natural medium for the storage and manipulation of quantum information. In these states, localized particle-like excitations (quasiparticles) possess quantum numbers which are in many ways analogous to ordinary spin quantum numbers. However, unlike ordinary spins, the quantum information associated with these quantum numbers is stored globally, throughout the entire system, and so is intrinsically protected against decoherence. Quantum computation can then be carried out by dragging these quasiparticles around one another so that their trajectories sweep out world-lines in 2+1-dimensional space-time. The resulting computation depends only on the topology of the braids formed by these world-lines, and thus is robust against error.

In these lectures I will review the theory of non-Abelian states, including the necessary mathematical background for describing the braiding of their quasiparticles. I will then introduce the basic ideas behind topological quantum computation and demonstrate explicitly that certain non-Abelian quasiparticles can indeed by used for universal quantum computation by showing how any quantum algorithm can be "compiled" into a braiding pattern for them. I will also discuss the most promising experimental systems for realizing non-Abelian quasiparticles, focusing primarily on fractional quantum Hall states.

Nick Bonesteel received his Ph.D. from Cornell University in 1991. He is currently Professor of Physics at Florida State University. His research includes generally condensed matter physics, correlated electrons, quantum Hall effect, and quantum computing using topological approaches.

GOTTESMAN: QUANTUM ERROR CORRECTION

Errors are likely to be a serious problem for quantum computers, both because they are built of small components and because qubits are inherently more vulnerable to error than classical bits because of processes such as decoherence. Consequently, to build a large quantum computer, we will likely need quantum error-correcting codes, which split up quantum states among a number of qubits in such a way that it is possible to correct for small errors. I will give an overview of the theory of quantum error correction and a discussion of fault-tolerant quantum computation, which applies quantum error-correcting codes to allow more reliable quantum computations. I will cover Shor's 9-qubit code, stabilizer codes, CSS codes, and the threshold theorem, which says that arbitrarily long reliable quantum computations are possible, provided the error rate per gate or time step is below some constant threshold value.

Daniel Gottesman is a faculty member at the Perimeter Institute in Waterloo, Ontario. He got his Ph.D. at Caltech in 1997, and did postdocs at Los Alamos National Lab and Microsoft Research, after which he served in the UC Berkeley CS department as a Long-Term CMI Prize Fellow with the Clay Mathematics Institute. His main research interests are quantum error correction, fault-tolerant quantum computation, quantum cryptography, and quantum complexity.

VAN DEN NEST & VERSTRAETE: CLASSICAL SIMULATION OF QUANTUM SYSTEMS

The study of quantum computations that can be simulated efficiently classically is of interest for numerous reasons. On a fundamental level, such an investigation sheds light on the intrinsic computational power that is harnessed in quantum mechanics as compared to classical physics. More practically, understanding which quantum computations do not offer any speed-ups over classical computation provides insights in where (not) to look for novel quantum algorithmic primitives. On the other hand, classical simulation of many-body systems is a challenging task, as the dimension of the Hilbert space scales with the number of particles. Therefore, to understand the properties of the systems, suitable approximation methods need to be employed.

The lectures will be divided into two parts. In the first part we discuss classical simulation of quantum computation from several perspectives. We review a number of well-known examples of classically simulatable quantum computations, such as the Gottesman-Knill theorem, matchgate simulation and tensor contraction methods. We further discuss simulation methods that are centred on classical sampling methods (‘weak simulation’), and illustrate how these techniques outperform methods that rely on the exact computation of measurement probabilities (‘strong simulation’).

The second part focuses on "Entanglement and variational wavefunctions in quantum many body physics". We review the idea of entanglement in quantum many-body systems and how it helps us to understand the success of numerical renormalization group methods. In particular we will discuss a few variational wave-function based methods for simulating strongly correlated quantum systems, which include (1) matrix product states (2) multiscale entanglement renormalization ansatz (3) projected entangled pair states and (4) continuous matrix product states for quantum field theories.

Maarten van den Nest received his Ph.D. degree in 2005 at the Katholieke Universiteit Leuven, Belgium. Since 2008, Maarten has been a postdoctoral researcher in the Max Planck Institute for Quantum Optics in Garching, in the group of Ignacio Cirac. In the period 2006-2008 he was a postdoctoral researcher in the group of Hans Briegel in the Institute for Quantum optics and Quantum Information in Innsbruck. He has obtained his PhD in the Katholieke Universiteit Leuven in 2005. Maarten Van den Nest is interested in various theoretical aspects of quantum information and computation. This includes understanding the relationship between quantum and classical computation, the study of measurement-based computing and graph states, as well as the exploration of various connections between quantum information and other fields, such as statistical physics.

Frank Verstraete received his Ph. D. degree in 2002 at the University of Leuven under supervision of Profs. B. De Moor and H. Verscheld. From 2002 to 2004 he was a research fellow in the theory group of I. Cirac at the Max-Planck Institut für Quantenoptik, Garching, and from 2004 to 2006, a research scholar in the Institute for Quantum Information headed by J. Preskill at Caltech. Since October 2006, he is a Professor at the Fakultät für Physik at the Universität Wien. He is a recipient 2007 HERMANN KÜMMEL Early Achievement Award in Many-body Physics.

GODSIL: GRAPH THEORY IN QUANTUM INFORMATION

There are a number of significant problems in quantum information where there is an interesting connection with graph theory. Gleason's theorem proves an interesting result about graph coloring. There are grounds to hope that graph isomorphism can be dealt with more efficiently on a quantum computer. Discrete quantum walks are defined on graphs. Graph states underly measurement-based quantum computing and play an important role in quantum codes. Even questions about mub's and sic-povm's, which appear to be entirely geometrical, are related to classical problems in graph theory. I aim to discuss these problems, and to provide an introduction to the related graph theory.

Chris Godsil graduated from the University of Melbourne in 1979. He spent two years at the Montanuniversitaet Leoben (Austria) and five years at Simon Fraser University. In 1987 he moved to the department of Combinatorics and Optimization at the University of Waterloo, where he is still lodged. He has written two books (Algebraic Combinatorics and, with Gordon Royle, Algebraic Graph Theory) and, with Ian Goulden and David Jackson, founded the Journal of Algebraic Combinatorics. His next book might not have "algebraic" in the title, but nothing is certain.

SPEKKENS: FOUNDATIONS OF QUANTUM MECHANICS

The field of quantum foundations seeks to answer questions such as: What do the elements of the mathematical formalism of quantum theory represent? From what physical principles can the formalism be derived? What are the precise ways in which a quantum world differs from a classical world and other possible worlds? These lectures will cover some important foundational topics which touch upon these questions, in particular, operational and realist interpretations of the formalism, the quantum measurement problem, nonlocality and contextuality.

Robert Spekkens received his B.Sc. in physics and philosophy from McGill University and completed his M.Sc. and Ph.D. in Physics at the University of Toronto. He held a postdoctoral fellowship at Perimeter Institute and an International Royal Society Fellowship at the University of Cambridge. He has been a faculty member at Perimeter Institute since November 2008. His research is focused upon identifying the conceptual innovations that distinguish quantum theories from classical theories and investigating their significance for axiomatization, interpretation, and the implementation of various information-theoretic tasks. Topics of current research include: the view that quantum states are states of knowledge rather than states of reality, quantum contextuality, and the information-theoretic approach to reference frames and superselection rules.

VIII. Additional Activities

Summer School Reception – July 17th

Join us at the free event and meet the other QI10 participants!

Date & Time: July 17th, 2010 from 6pm to 8pm

Location: the Abdul Ladha Science Student Centre, 2055 East Mall, Vancouver, BC

D-Wave Tours – July 22nd & July 25th

Tour 1: July 22nd with bus pick up at 1pm outside of the UBC Bookstore. Tour will start at 2pm (2-4pm).

Tour 2: July 25th with bus pick up at 2pm outside of the UBC Bookstore. Tour will start at 3pm (3-5pm).

Each will include a two-hour tour to the D-wave lab and a simple demo of a working system, designed mostly for physicists. Bus transportation has been arranged. After the tours participants will be brought back to UBC and dropped off at the Bookstore.

A signup sheet will be available for participants to sign up on the first two days (July 17th and 18th) of the Quantum Information Summer School. If you are unable to locate the signup sheet, or would like to sign up after July 18th, please email Theresa Liao (info@qi10.ca) to sign up.

Lunch Time Talks

There are two lunch time talks during the summer school. Each talk is approximately 45 minutes.

D'Alessandro: Dynamical and Combinatorial Analysis of Quantum Walks on Graphs

Iowa State University, USA

Date & Time: Wednesday, July 21st at 12:30pm

Location: Henn 201

Hotta: Energy-Entanglement Relation for Quantum Energy Teleportation

Tohoku University, Japan

Date & Time: Wednesday, July 28th, 12:30pm

Location: Henn 200

UBC Museum of Anthropology Tour - July 30th

The visit is to be scheduled for July 30th between the open hours of the museum (10am – 5pm).

The tour is guided, at the cost of $12 for students and Seniors, and $14 otherwise. If interested, please sign up the tour-sheet which will be provided on July 26th.

Here is some more information about the UBC Museum of Anthropology:

MOA. A place of extraordinary architectural beauty. A place of provocative programming and vibrant, contemporary exhibitions. A place of world arts and cultures.

The Museum of Anthropology at the University of British Columbia is world-renowned for its collections, research, teaching, public programs, and community connections. It is also acclaimed for its spectacular architecture and unique setting on the cliffs of Point Grey. The Museum houses some 36,000 ethnographic objects and 535,000 archaeological objects, many of which originate from the Northwest Coast of British Columbia. MOA's Multiversity Galleries provide public access to more than 10,000 objects from around the world, and The Audain Gallery, MOA's new 5,800 sq ft temporary exhibition hall, showcases world-class travelling exhibits as well as those developed in-house.

The Museum of Anthropology building was designed by renowned Canadian architect Arthur Erickson. A building highlight is a set of massive doors carved in 1976 by four master Gitxsan artists, Walter Harris, Earl Muldoe, Art Sterritt, and Vernon Stephens. Other highlights include the 15-metre glass walls of the Great Hall, beneath which stand towering totem poles from the Haida, Gitxsan, Nisga'a, Oweekeno and other First Nations; the Rotunda, where Bill Reid's massive sculpture, "The Raven and the First Men" is displayed; and the Koerner Ceramics Gallery, home to 600 pieces of 15-19th c. pottery.

For more information, visit the UBC Museum of Anthropology website:
www.moa.ubc.ca

Summer School Evaluation

We would like to know what you think of the summer school. Your feedback is very important for us in developing future events. An online evaluation form will be available after the summer school at our website: http://qi10.ca

An email reminder will be sent out after the summer school. We thank you in advance for your help.