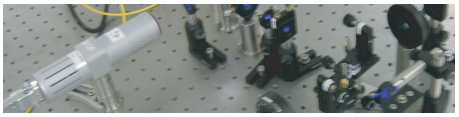
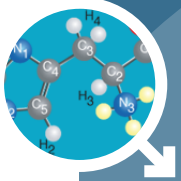


IQC Institute for Quantum Computing

University of Waterloo

ISSUE 5
WINTER
2007

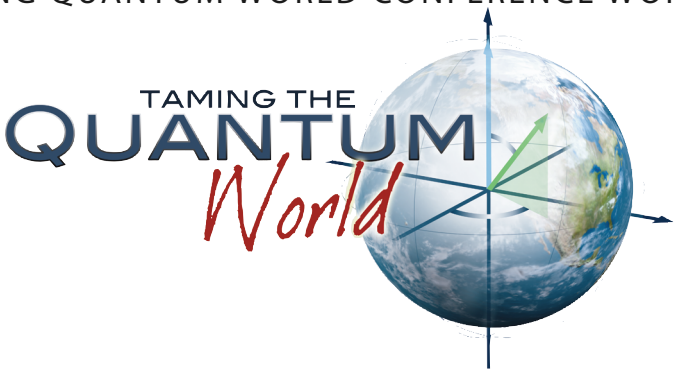


THE INSTITUTE FOR QUANTUM COMPUTING

NewBit

TAMING THE QUANTUM WORLD

IQC AND PERIMETER INSTITUTE JOIN FORCES FOR UPCOMING QUANTUM WORLD CONFERENCE WORKSHOP



The Institute for Quantum Computing and the Perimeter Institute for Theoretical Physics will be collaborating together to bring forth a month-long conference entitled, "Taming The Quantum World: Explorations Through A Full Spectrum of Quantum Research - From Foundations to Information Technologies."

It will be a series of international quantum events which will occur between May 27th and June 29th, 2007. All events are open to graduate students, post-doctoral fellows and faculty members and all are encouraged to participate.

Some of the events will be as follows:

May 27-31: Canadian Summer School on Quantum Information

June 1-5: Canadian Students' Quantum Information Conference

June 5-9: 35th Canadian Symposium on Operator Algebras and Their Applications

June 11-14: Theory and Realisation of Practical Quantum Key Distribution

June 18-23: 40th Anniversary of the Department of Combinatorics and Optimization

June 25-29: When Matter Meets Information: Entangling the Frontiers of Condensed Matter and Quantum Information Sciences

For full listings of events and information regarding the Quantum World series conference, please visit the website at: www.quantumworld.ca

CFI GRANT APPROVED

Dr. Eliot Phillipson, President and CEO of the CFI, was at the University of Waterloo to announce the inaugural recipients of the CFI's Leading Edge and New Initiatives funds, a major investment that will support 86 projects at 35 universities, colleges, research hospitals, and non-profit research institutions across the country.

"From Nano Structures to Quantum Information Processing: A Technology Incubator for the 21st Century." IQC Director, Raymond Laflamme, and Tong Leung, for the Nanotechnology program, will lead researchers from UW, the University of Western Ontario (UWO) and Sunnybrook Health Sciences Centre. CFI's leading edge fund is providing $17,955,697 and the project is worth $50,326,944.

The funding will equip research laboratories in a landmark quantum-nano building to be built at UW. The new centre will bring together top researchers in quantum information processing and nanotechnology engineering to advance fundamental knowledge and develop practical applications. The advances will develop new and practical quantum devices, such as first-generation sensors and nano-electro-mechanical systems, exploiting the laws of quantum mechanics with applications in computing, material science, sensing, medicine, manufacturing and other areas."

PROVINCIAL SUPPORT AWARDED

UW WELCOMES PROVINCIAL GOVERNMENT'S INVESTMENT IN RESEARCH AND INNOVATION

WATERLOO, Ont. (March 23, 2006) -- The University of Waterloo welcomes today's tremendous announcement by the Ontario government of substantial investments in research and innovation in two Waterloo-based institutes.

At Queen's Park this afternoon, in the budget announcement, Finance Minister Dwight Duncan pledged $100 million in new support: $50 million for the Institute for Quantum Computing at UW; and $50 million for the neighbouring Perimeter Institute for Theoretical Physics.

UW President David Johnston voiced praise for the far-reaching announcement.

"The announcement of the $100-million commitment supporting Perimeter Institute, and the Institute for Quantum Computing at the University of Waterloo, is a splendid, outstanding piece of province-building," said President Johnston. "In today's knowledge economy it is critical that we invest in fundamental research, and in the people who will take us to new frontiers of discovery. Premier McGuinty, as Minister of Research and Innovation, has shown superb leadership with this budget -- clearly understanding the importance of investment in research and innovation to Ontario's future."

Raymond Laflamme, Director of IQC, joined in commending the Ontario government initiative.

"This is tremendous news for our research program in the IQC. We are simply overwhelmed with this indication of faith in our research program into the fundamentals and laws of quantum physics," said Dr. Laflamme. "We have already been building a great team of international scholars. This funding will help us to ensure that our work will continue at a global level of excellence."

Support for the two institutes came as the province also announced substantial investment in other research and innovation projects: $17 million for 3 new awards to recognize new research and innovation talent; $25 million to establish the Premier Summit Awards to support excellence in medical research; $16.2 million for development of Phase II of MaRS Discovery Project; and $160 million for accelerating commercialization and growth of innovative startups.

The University of Waterloo Institute for Quantum Computing (IQC) at UW, and the independent Perimeter Institute for Theoretical Physics (PI), also in Waterloo, represent an emerging, highly focused cluster of international scientific research with transformative potential. Quantum theory has clearly demonstrated that quantum information processing - computing at the atomic and sub-atomic levels - will revolutionize cryptography. This holds profound implications for the security of IT systems including national defense, financial markets and healthcare systems. The scientific pursuit of the quantum computer will produce vital technological spin-offs. Early research findings indicate that quantum-based systems have the potential to produce powerful new technologies that will inevitably eclipse today's information processing devices. Waterloo Region is established as a magnet for top international talent in advanced physics research. This unique public-private partnership in this key strategic area ensures that Canada will lead the world in quantum technologies far into the future.

QuantumWorks MAKES ITS DEBUT

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

QuantumWorks is a new, NSERC-funded Innovation Platform that features a national network to link Canadian researchers with industrial and government agency partners. QuantumWorks will lead Canada into the next technological revolution - that of Quantum Information.

The QuantumWorks launch began on Wednesday September 27, 2006 with a conference that provided a unique opportunity for attendees to interact and exchange ideas regarding research and innovation with Canada's leading quantum researchers and industry and government representatives. Other launch events include an Intellectual Property workshop led by QuantumWorks partner Blake, Cassels & Graydon LLP and an Industry Workshop that brought together partners from all sectors to discuss the future of QuantumWorks.

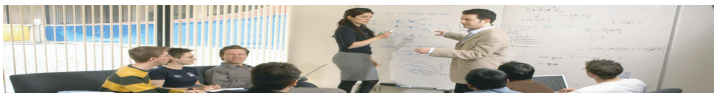
Welcome

The Institute is proud to have welcomed two new faculty members:

- Professor Kevin Resch joins us from the University of Queensland in Brisbane, Australia. He is an experimentalist with interests in optical quantum computing & communication, nonlinear optics, measurement, state reconstruction, and entanglement.
- Professor John Watrous, from the University of Calgary, joined us in July 2006 as an associate professor. His research focus is on the theory of quantum information and its applications to algorithms, complexity theory, and cryptography.

The Institute also welcomed a slew of new postdoctoral fellows:

- Rahul Jain hails from the University of California at Berkeley where he just completed a two year postdoctoral fellowship working with Professor Umesh Vazirani.
- Dmitry Gavinsky started in the summer of 2006, his area of expertise is in computer science, where he will be working with Professor Cleve.
- Dmitri Maslov, an NSERC post doctoral researcher is interested in the area of quantum circuits, quantum architectures and quantum control.
- Matt Leifer joined IQC in Winter 2007, Previously, Matt was with the Perimeter Institute for Theoretical Physics.
- Moshen Razavi joins us from MIT, where he received his Ph.D. in August 2006 and was Postdoctoral Associate until he joined IQC in January 2007.
- Simone Severini joins Professor Mosca's group at IQC. He was orginally from Tuscany, Italy and obtained his Ph.D. from Bristol.
- Christophe Couteau completed his PhD in Grenoble, France and is welcomed by Professor Gregor Weihs as they work on quantum dots for quantum computing purposes.
- Joe Fitzsimons joins us in June 2007 from Merton College, Oxford. His interests include globally controlled computation and measurement based quantum computation.



PROVING SUCCESS

Visitors

IQC IS HONOURED TO HAVE HOSTED THESE DISTINGUISHED GUESTS OVER THE WINTER OF 2007:

Henri Angelino - National Institute of Informatics
Kazumaro Aoki - NTT Basic Research Laboratories
Stephen Bartlett - University of Sydney
Stewart Beck - Canadian Federal Government
Devon Biggerstaff - University of Queensland *
Louis Boisvert - Canadian Federal Government
Parsa Bonderson - Caltech
Paul Busch - Perimeter Institute
Silvia Carrasco - Universitat Politecnica de Catalunya
Julien Chabé - Laboratoire de Physique, l'Université de Lille
Andrew Childs - Caltech
Joy Christian - Perimeter Institute
John Clarke - University of California, Berkeley
Bill Coish - University of Basel, Switzerland
Tom Corr - University of Waterloo
Pierre Coulombe - National Research Council
Thaddeus D. Ladd - Stanford University
Marie D'Iorio - National Research Council
Gurudev Dutt - Harvard University
Bris Elenkrig - Ontario Centres of Excellence
Simon Farbrother - City of Waterloo
Marian Florescu - University of California, San Diego
Rusins Freivalds - University of Latvia
Ivette Fuentes - Schuller
Atsushi Fujioka - NTT Basic Research Laboratories
Fred Fung - University of Toronto
Jay Gambetta - Yale
Ilja Gerhardt - ETH Swiss Federal Institute of Technology
Francois Grey - CERN
VP Guests - Elcan Optical Technolgies
Brenda Halloran - City of Waterloo
Sara Hastings-Simon - GAP-Optique, University of Geneva
Emile Hoskinson - CNRS
Evgeni Ilichev - IPHT, Jena, Germany
Anthony J. Leggett - University of Illinois at Urbana-Champaign
Gregg Jaeger - Boston University
Daniel James - University of Toronto
Yoshitaka Kagei - NTT Basic Research Laboratories

Continued on next page...

THE 12-QUBIT SYSTEM - AN INTERNATIONAL TRIUMPH

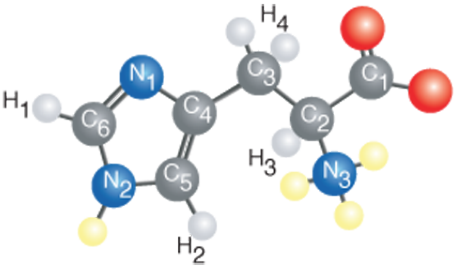
A research team including IQC Director, Raymond Laflamme, UW scientists, and members from the Massachusetts Institute of Technology hope to have a quantum computer that has the ability to process information at incredible speeds in the coming future. By harnessing the power and behaviour of atoms, this quantum computer will be able to perform trillions of operations in a single second and will dramatically change technology and our day-to-day world.

The team has successfully controlled 12-qubits (which is the highest number of bits in the world to date), by using the largest quantum information processor known to exist. A qubit is an atomic version of a classical computer bit. When comparing the quantum computer to the classical computer, it is able to compute much more information at a much faster rate using the many states of an atom.

In past developments, Laflamme and others made the first three-qubit computer prototype at the Los Alamos National Laboratory in New Mexico along with their seven-qubit quantum computer to follow in 2000. Currently, their work with 12-qubits "is a milestone towards developing quantum computers," Laflamme said.

Looking to the future, Laflamme will be working on bringing 2 methods of controlling quantum bits together in order to work with even larger numbers of qubits. The work being done will mark a transition from small-scale quantum computers to medium-scale, with between 10 and 40 qubits. Today, the medium-scale 12-qubit computer is following a laptop in speed, with the laptop being slightly slower.

Eventually, scientists are hoping to have control over more than 40 quantum bits. Which means the quantum computer will be more powerful than the fastest supercomputers of today.



We must remain patient however, as much research and development still needs to be done. As Laflamme explains, "You know the history of computers has been 50 years old. The history of quantum computers is only 10. So we should not expect that we do 50 years' work in just 10 years of time."

SIR ANTHONY LEGGETT LECTURES TO A FULL HOUSE

Friday, January 26th, 2007, the Centre for Environmental Information Technology opened its doors to welcome the public to share in a lecture event with special guest, Anthony J. Leggett of the University of Illinois at Urbana-Champaign. The response was overwhelming as an overflow of individuals filled the auditorium to its full capacity, flowing out into the lobby. The lecture entitled, "Does Everyday World Really Obey Quantum Mechanics" was presented from 2-3pm in room 1015.

Quantum mechanics has been enormously successful in describing nature at the atomic level and most physicists believe it is, in principle, the "whole truth" about the world even at the everyday level. However, such a view, at first glance, leads to a severe problem. In certain circumstances, the most natural interpretation of the theory implies that no definite outcome of an experiment occurs until the act of observation. For many decades this problem was regarded as merely philosophical – it was thought it had no consequences that could be tested in experiment. However, in the last dozen years or so, the situation has changed dramatically in this respect. Professor Leggett discussed the problem, some popular resolutions of it, the current experimental situation and prospects for the future.

For more information, please visit: www.iqc.ca/activities/seminar.php

PUBLIC SPEAKERS

WINTER COLLOQUIUMS

- January 10 - Caterina-Eloisa Mora
  "Quantum Kolmogorov complexity"
- January 11 - Marco Piani
  "Class of bound entangled states and non-decomposable witnesses associated to almost any set of pure entangled states"
- January 16 - Yi-Kai Liu
  "The N-representability Problem is QMA-Complete"
- January 17 - Fred Fung
  "Trojan horse attacks in practical quantum-key-distribution systems"
- January 18 - Roman Lutchyn
  "The kinetics of superconducting quantum circuits"
- January 22 - Pranab Sen
  "All problems in statistical zero-knowledge have a classical protocol secure against both classical and quantum verifiers"
- January 23 - Marian Florescu
  "Applications to classical and quantum information processing"
- January 25 - Bill Coish
  "Fine-tuning the dynamics of electron spins in quantum dots"
- January 26 - Anthony J. Leggett
  "Does Everyday World Really Obey Quantum Mechanics"
- February 01 - Jay Gambetta
  "Quantum optics with microwave photons in circuit QED"
- February 02 - Donny Cheung
  "Classical Post-processing for Low-Depth Phase Estimation Circuits"
- February 05 - Keith Schwab
  "Quantum Electro-Mechanics"
- February 07 - Ilja Gerhardt
  "Nano-Optics with Single Molecules"
- February 08 - Andrew Childs
  "Quantum algorithms and quantum state identification"
- February 12 - Stephen Bartlett
  "A simple nearest-neighbor two-body Hamiltonian system for which the ground state is a universal resource for quantum computation"
- February 16 - Yi-Bo Zhao
  "Problems with Continuous variable quantum key distribution"
- February 19 - Karol Zyczkowski
  "On Complex Hadamard Matrices and Mutually Unbiased Bases"
- February 19 - Seongshik Oh
  "Precision Material Engineering at Nanoscale: Elimination of Decoherence Sources in Superconducting Quantum Bits"
- February 19 - Scott Aaronson
  "The Limitations of Quantum Computers"
- February 26 - Gurudev Dutt
  "Qubits, Qrumbs, and Qibbles with Electron and Nuclear Spins in Diamond"
- February 28 - Emile Hoskinson
  "Two new devices based on macroscopic quantum phenomena: The superfluid 4He dc-SQUID and the superconducting dc-SQUID as a phase qubit"
- March 01 - Julien Chabé
  "Simple cold-atom systems as a probe for complex dynamics"
- March 12 - Christoph Simon
  "Towards Quantum Memories based on Photon Echo and their Application to Quantum Repeaters"
- March 12 - Tristan Meunier
  "Entanglement, decoherence and dissipation in quantum systems"
- March 19 - Evgeni Ilichev
  "Experimental investigation of superconducting flux and charge qubits"
- March 21 - Dmitry Gavinsky
  "Classical interaction cannot replace a quantum message"
- March 22 - Robert Schoelkopf
  "circuit qed: quantum optics and quantum computing on a superconducting chip"
- March 22 - Ben Lavoie
  "Su (2) and Su(3) intellegent states"
- March 26 - Mikhail Lukin
  "Novel quantum bits and quantum wires in solid state: from long coherence to scalability"
- March 30 - Donny Cheung
  "An Post-processing Algorithm for Abelian and .Dihedral HSP"
- April 02 - Sarvagya Upadhyay
  "Perferct Parallel Repetition of Quantum XOR Games"
- April 03 - Ivette Fuentes-Schuller
  "Entanglement in our relativistic quantum world"
- April 13 - Donny Cheung
  "Local Unitary Quantum Cellular Automata"
- April 13 - Simone Severini
  "Combinatorics and Quantum Entanglement: two case studies"
- April 23 - Jonathan Walgate
  "Local Knowledge"
- April 27 - Phillip Kaye
  "Cooling algorithms based on the 3-bit majority"
- April 27 - Chris Erven
  "On Free-Space Quantum Key Distribution and its Implementation with a Polarization-Entangled Parametric Down-Conversion Source"

Visitors

Atsushi Kanai - NTT Basic Research Laboratories
Amir Khandani - University of Waterloo
Drew Knight - University of Waterloo
Tetsutaro Kobayashi - NTT Basic Research Laboratories
Rudolfs Kreicbergs - University of Latvia
Akihiko Kudoh - NTT Basic Research Laboratories
Paul Kwiat - University of Illinois at Urbana-Champaign
Ben Lavoie - Lakehead University
Jonathan Lavoie - Université Laval
Yi-Kai Liu - University of California, San Diego
Sebastien Louis - Sokendai
Mikhail Lukin - Harvard University
Roman Lutchyn - University of Minnesota
Gerard Lynch - Ontario Centres of Excellence
Robin MacNab - Canadian Federal Government
Alan Madej - National Research Council
Peter Mascher - McMaster University
Tristan Meunier - Delft University of Technology
Caterina-Eloisa Mora - Institute for Theoretical Physics, University of Innsbruck
Marie-Lucie Morin - Federal Government
Eduardo Mucciolo - University of Central Florida
Bill Munro - Hewlett-Packard Laboratories, Bristol
Mio Murao - University of Tokyo
Kae Nemoto - National Institute for Informatics
Richard Normandin - National Research Council
Seongshik Oh - National Institute of Standards and Technology
Gina Passante - University of Winnipeg
Rune Pedersen - Technical University of Denmark
Marco Piani - University of Gdansk, Poland
Karlis Podins - University of Latvia
David Poulin - Caltech
Mark Romoff - Ontario Centres of Excellence
Mark Roseman - Government of Ontario
Robert Schoelkopf - Yale University
Keith Schwab - Cornell University
Pranab Sen - Tata Institute of Fundamental Research
Christoph Simon - GAP-Optique, University of Geneva
Urbasi Sinha - University of Cambridge
Agnis Skuskovniks - University of Latvia
Rolando Somma - Los Alamos National Laboratory
Yasaman Soudagar - École Polytechnique de Montréal
Deborah Stokes - Nortel Networks
Henry Stronks - Bruker BioSpin Canada
Leonard Susskind - Stanford University
Koutarou Suzuki - NTT Basic Research Laboratories
John Tennant - Canada's Technology Triangle Inc
Lluis Torner - Universitat Politecnica de Catalunya

Continued on next page...

FOCUSED ON RESEARCH

Visitors

Alexei Trifonov - MagiQ Technologies
Waterloo Unlimited - University of Waterloo
Peter van Loock - National Institute for Informatics
Rodney Van Meter - Keio University
Ralph Weber - Bruker BioSpin Canada
John Wilkinson - Government of Ontario
Atsuhi Yamada - Certicom Corp
Go Yamamoto - NTT Basic Research Laboratories
Agnese Zalcmane - University of Latvia
Yi-Bo Zhao - University of Science and Technology of China
Aleksandar Zivojinovic - British Consulate-Toronto
Karol Zyczkowski - Polish Academy of Sciences, Center for Theoretical Physics

Arrivals

PhD STUDENTS:

Behnood Ghamsari
Hauke Haseler
Matthias Heid
Avradip Mandal
Hamid Mohebbi
Tobias Moroder
Geir Ove Myhr
Jibran Rashid
Patrick Rebentrost
William Rosgen
Volker Scholz
Ioana Serban

MASTERS STUDENTS:

Julian Avila
Abhinav Bahadur
Ududec Cuzmin
Mohammad Derakhshani
Paul Dickinson
Chris Ferrie
Sevag Gharibian
Gus Gutoski
Georg Heinrich
Vickram Lakhian
Easwar Magesan
Jean-Luc Orgiazzi
David Ostapchuk
Devin Smith
David Yeung

RESEARCH ASSISTANTS:

Jeyran Amirloo Abolfathi
Erwann Bocquillan
Tracy Cui
Amir-Hossein Safavi-Naeini
Nina Ilic
Jonathan Lavoie
Mirette Sedarous

SUMMER STUDENTS:

Pierre-Luc Dallaire-Demers
Chantal Hutchinson
Joe Istead
Ryan Morris
Aaron Niedbala
Benjamin Schmidt
Stephanie Simmons

STAFF MEMBERS:

Peter Routledge

FIRST NII-WATERLOO WORKSHOP ON THE DESIGN OF DEVICES FOR DISTRIBUTED QUANTUM COMPUTATION

From March 12-15, IQC and The National Institute of Informatics hosted the first NII-Waterloo Workshop on the Design of Devices for Distributed Quantum Computation at the Institute for Quantum Computing. Rodney Van Meter and Kae Nemoto of the NII GROUP and Norbert Lütkenhaus and Raymond Laflamme of IQC organized the event.

The workshop brought together members of the NII quantum information group and researchers at the Institute for Quantum Computing at the University of Waterloo. The focus of the workshop was the design of devices for quantum communication and quantum computation, with emphasis on theoretical studies of optical nonlinearities and quantum memory interfaces for quantum repeaters and distributed quantum computation, and the efficiency of such systems for various applications. The goal is to develop research collaborations between NII and Waterloo, taking advantage of complementary abilities to further advance the state of the art.

About twenty researchers attended the workshop, five to eight from NII and a larger number from Waterloo, including Peter Van Loock, Sebastien Louis, Thaddeus Ladd, W.J. Munro, and Mio Murao. The workshop lasted four days, each consisting of several talks in the morning and focused working groups in the afternoons, including presentations from Sara Hastings-Simon and Christoph Simon.

More information available at:
www.iqc.ca/institute/news.php

DEPARTURES

IQC WISHES OUR MEMBERS ALL THE BEST AS WE SAY GOOD-BYE TO OUR POST-DOCTORAL FELLOWS, RESEARCH ASSISTANTS, AND STUDENTS:

- Alexander DeSouza
- William Donnelly
- Elham Kashefi
- Camille Negrevergne
- Kelly John Rose
- Matt Peloso

IQC'S YOUNGEST MEMBERS

IQC IS DELIGHTED IN CELEBRATING THE ARRIVALS OF OUR SMALLEST MEMBERS:

Michele and Nelia Mosca welcomed their daughter, Natalie Grace Mosca who was born March 7, 2007, at 6:46am, weighing in at 6lb 13ounces.

Joseph and Kate Emerson also had a daughter, Madeleine, born April 29, 2007 at 5am. She weighed in at 8.1 lbs and 21 inches.

For questions, comments or general feedback regarding the IQC Newsletter, please feel free to contact:
iqc@iqc.ca

IQC THANKS ITS PARTNERS FOR THEIR CONTINUING SUPPORT OF OUR VISION

MIKE LAZARIDIS

- AND -

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Canada Foundation for Innovation
Canada Research Chairs
Canadian Institute for Advanced Research
Centre for Applied Cryptographic Research
The City of Waterloo
Communications Securities Establishment
Helios/Oceana
Institute for Computer Research
Mathematics of Information Technology and Complex Systems
Natural Sciences and Engineering Research Council of Canada
Ontario Innovation Trust
Ontario Ministry of Research and Innovation
Ontario Research and Development Challenge Fund
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