

IQC Institute for Quantum Computing
www.iqc.ca

UNIVERSITY OF Waterloo

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THE INSTITUTE FOR QUANTUM COMPUTING

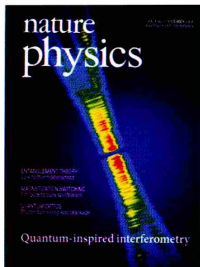
NewBit

COVER-WORTHY INTERFERENCE IQC RESULTS TAKE CENTRE STAGE

Nature Physics has selected an experimental result from IQC researchers for the front of the November 2008 issue. The image is an interference pattern from a novel interferometer developed by Rainer Kaltenbaek, Jonathan Lavoie, Devon Biggerstaff and Kevin Resch of the Quantum Optics Laboratory at IQC.

The image was taken from the article titled "Quantum-inspired interferometry with chirped laser pulses," which was also published in the November issue. The article describes a new method of interferometry with dramatic improvements over conventional methods especially for making measurements in highly dispersive or lossy materials. Interferometry is a technique to examine two or more waves by examining the interference pattern created by combining them. It is an important tool in a vast array of fields including astronomy, biomedical imaging, precision metrology, and optical quantum information.

The researchers started with interferometer based on the established Hong-Ou-Mandel effect, first observed in 1987, which offers some useful features for precise interferometric measurements such as automatic dispersion cancellation.



By rearranging the interferometer, they were able to use bright, "chirped" laser pulses instead of entangled photon pairs which are more difficult to detect. "We essentially ran these pulses through a 'time-reversed' Hong-Ou-Mandel, which is a device called a cross-correlator," explains Professor Kevin Resch, supervisor of the Quantum Optics Laboratory. "When we did this, and looked at the interference in the output light, it behaved [almost] exactly as the quantum interference, including the automatic dispersion cancellation."

By using chirped laser pulses, the new interferometry technique offers 10 million times more signal than that achievable with entangled photons. Kevin details the significance of the results, "It hits on the questions that I think all of us [in] quantum information are constantly asking like 'when are quantum effects really giving us an advantage over classical systems?' [As well,] practical applications for this kind of interference have already been identified through all of the work in studying quantum interference. Our technique, despite not needing quantum resources, may take these insights from quantum information science and make them viable."

...Continued on Page 2

TOP HONOURS ACADEMIC DISTINCTION

IQC Director, Raymond Laflamme was elected as a Fellow of the Royal Society of Canada (RSC) – the country's highest academic honour at a ceremony held in Ottawa, November 15th.



Above: Raymond Laflamme with Yvan Guindon, President of the Royal Society of Canada at the induction ceremony at the Canadian Museum of Civilization in Gatineau.

Says the Royal Society's citation, "Raymond Laflamme has solved both practical and theoretical problems of fundamental importance to quantum information processing, and has been a leader in bringing Canada to international prominence in this field. He elucidated theoretical approaches to quantum error correction, which set the benchmark in this field, and gave the first experimental demonstrations of these techniques."

Laflamme explains, "it is a real honor to become a Fellow of the Royal Society. I am indebted to my colleagues who have taught me so many things that have allowed the breakthroughs..."

...Continued on Page 2

EXPERTISE UNDER ONE ROOF



Visitors

IQC IS HONOURED TO HAVE HOSTED THESE DISTINGUISHED GUESTS OVER THE SPRING & SUMMER OF 2008:

- ▶ Henri Angelino - National Institute for Informatics, Japan
- ▶ Alexandre Blais - Yale University
- ▶ Harry Buhrman - Center for Mathematics and Computer Science, Netherlands (CWI)
- ▶ Daniel Browne - University College, London
- ▶ Aashish Clerk - McGill University
- ▶ Aaron Denney - University of New Mexico
- ▶ Otfried Gühne - Institute for Quantum Optics and Quantum Information, Austria
- ▶ Ross Hornby - Canadian Federal Government
- ▶ Richard J. Hughes - Los Alamos National Laboratory
- ▶ David Hume - National Institute of Standards and Technology
- ▶ Lawrence Ioannou - University of Cambridge
- ▶ Alexander Koujelev - Canadian Space Agency
- ▶ Jacob Krich - Harvard University
- ▶ Robin MacNab - Canadian Federal Government
- ▶ Denise Maurice - École Normale Supérieure
- ▶ Khaled Mnaymneh - University of St. Andrews
- ▶ Jonathan Oppenheim - University of Cambridge
- ▶ Jean-Michel Raimond - Kastler Brossel Laboratory, École Normale Supérieure
- ▶ Veena Rawat - Communications Research Centre Canada

COVER-WORTHY INTERFERENCE

...Continued from Title Page

The cover image is Figure 2a in the article, showing the spectrum of light emitted from the new interferometer as the delay of one wave is varied. The image shows that the interferometer emits essentially two frequencies which get closer together as the delay of the waves are balanced. At perfect match, the waves interfere destructively, which can be seen in the centre of the graph.

The complete article is available in *Nature Physics* Volume 4 (November 2008), pages 864 - 868 or online at www.nature.com

QIP SEMINAR SERIES

Mathematics of Information Technology and Complex Systems (MITACS) is sponsoring a quantum information processing seminar series at the Universities of Waterloo and Calgary and at McGill University from November 2008 to April 2009.

IQC was host to the lectures at the University of Waterloo during the month of November.

Daniel Browne from the University of London launched the seminar series with his lecture titled, "Computation from Correlation" on November 3rd. In this talk, he explored the new insights that can be gained into the computational resource power of entangled quantum states.

November 10th, Jonathan Oppenheim of the University of Cambridge discussed fully quantum distributed compression in his lecture, "Quantum Mutual Independence." This notion defines correlations shared between distant parties which are product with the environment.

The Seminar Series continues at IQC until April 2009.



MITACS

For more information on upcoming lectures, please visit IQC's seminar listing at www.iqc.ca/activities/seminar.php

Full program details are available at www.iqis.org/mitacs-qip/Seminars.htm

TOP HONOURS

...Continued from Title Page

"...that would not have otherwise happened, and also because these awards always come from the support of colleagues and members of the community."

The RSC is the senior national body of distinguished Canadian scientists and scholars. Currently comprised of approximately 1800 Fellows, men and women are selected across Canada by their peers in recognition of their outstanding scholarly, scientific and artistic achievements.

For more information regarding the RSC please visit: www.rsc.ca

ICFO/OCE CONFERENCE

Members of the Institute of Photonic Sciences (ICFO) and the Ontario Centres of Excellence (OCE) joined forces with IQC in October to exchange research interests and discuss the main goals and status of the ICFO-OCE collaboration project.

The meeting gave rise to intense discussions and future collaboration potentials were identified. Invited participants included:

- Antonio Acin (ICFO)
- Payam Abolghasem (Toronto)
- Luciano Cruz (Toronto)
- Boris Elenkrig (OCE)
- Nicolas Godbout (Montreal)
- Amr Helmy (Toronto)
- Martin Hendrych (ICFO)
- Hoi-Kwong Lo (Toronto)
- John MacRitchie (OCE)
- Morgan Mitchell (ICFO)
- Xiaofan Mo (Calgary)
- Angels Orduña Cao (OCE)
- Bing Qi (Toronto)
- Wolfgang Tittel (Calgary)
- Xingxing Xing (Toronto)
- Yi Zhao (Toronto)

Discussions revolved around 3 topic areas: 1) How to post-process data from experiments to turn them into secret keys. 2) The security analysis of realistic systems, where the quantum optical model deviates slightly from the first simplistic models in quantum optics. 3) Hacking attempts on quantum key distribution via intrusion attacks.

More information can be found at: www.oce-ontario.org and www.icfo.es

THRIVING INITIATIVES



Speakers

- 1 SEPTEMBER 8 – David Hume
"Quantum Logic Spectroscopy and the AI-Optical Clock"
- 1 SEPTEMBER 15 – Steve Flammia
"One-Way Quantum Computing in the Optical Frequency Comb"
- 1 SEPTEMBER 22 – Tzi-Chieh Wei
"Global geometric measure of entanglement in transverse-field"
- 1 OCTOBER 6 – Ben Reichardt
"Exact entanglement renormalization for string-net models"
- 1 OCTOBER 20 – Xiongfang Ma
"Quantum cryptography: from theory to practice"
- 1 OCTOBER 24 – Jacob Krich
"Generation and Destruction of Spin-Polarized Currents in Chaotic Quantum Dots"
- 1 OCTOBER 27 – Mark Saffman
"Observation of Rydberg blockade and collective encoding of quantum registers"
- 1 NOVEMBER 3 – Daniel Browne
"Computation from Correlation"
- 1 NOVEMBER 10 – Jonathan Oppenheim
"Quantum Mutual Independence"
- 1 NOVEMBER 12 – Otfried Gühne
"Multiparticle entanglement and decoherence"
- 1 NOVEMBER 13 – Richard J. Hughes
"Twenty three years of quantum key distribution"
- 1 NOVEMBER 17 – Jean-Michel Raimond
"Atoms and cavities: seeing in subtle ways"
- 1 NOVEMBER 21 – Alexander Koujelev
"Free-Space Laser Communication Research in the Canadian Space Agency"
- 1 NOVEMBER 24 – Alexandre Blais
"Quantum optics with microwave photons and superconducting qubits"
- 1 DECEMBER 1 – Sevag Gharibian
"Strong NP-Hardness of the Quantum Separability Problem"
- 1 DECEMBER 3 – Gus Gutoski
"Properties of Local Quantum Operations with Shared Entanglement"
- 1 DECEMBER 4 – Jean-Luc F.X. Orgiazzi
"Packaging and Characterization of NbN Superconducting Nanowire Single Photon Detectors"
- 1 DECEMBER 5 – Debbie Leung
"Continuity of quantum channel capacities"
- 1 DECEMBER 8 – Ferdinand Schmidt-Kaler
"Quantum Information Processing with Ions"
- 1 DECEMBER 15 – Andrew Sachrajda
"An update on the NRC spin qubit project"

QUANTUM INFORMATION REACHES PARLIAMENT

Members of the Canadian Federal Government paid a visit to IQC in October to gain a better understanding of the research conducted at our facilities.



Above: Ross Hornby, Robin MacNab, with IQC Director, Raymond Laflamme.

Canadian Ambassador to the European Union, Ross Hornby joined Robin MacNab, Deputy Director of Investment, Science & Technology on an informative tour led by IQC Director, Raymond Laflamme.

Exposed to our overall research objectives and basic quantum knowledge, the pair witnessed first-hand experiments in all of our laboratories.

QNC BUILDING UPDATE

Since breaking ground on June 9th, construction has commenced on the Mike and Ophelia Lazaridis Quantum-Nano Centre on UW's campus.

The latest developments are seen below.



Above: Progress as of October 3rd, 2008



Above: Progress as of November 25th, 2008

HIGH-PROFILE RELATIONS

Veenat Rawat, President of Communications Research Centre Canada, visited IQC's campus on November 24th.

Veenat successfully linked IQC with Alexander Koujelev of the Canadian Space Agency and staff in the Executive Branch of the White House Office of Science and Technology.

Both parties have officially established relations with IQC, expressing great interest in our research and overall structure. Future plans for cooperative developments and projects are to come.



CLEANROOM UNDER CONSTRUCTION

Design and construction of the temporary fabrication facility officially began this Fall. The facility will be installed in the Research Advancement Centre and will include a cleanroom rated class 10,000 or better. The facility will occupy a total area of 1,600 square feet, of which 900 will be cleanroom certified.

IQC has remained proactive, acquiring equipment and supplies to allow several research activities to progress during the Quantum Nano-Centre's construction phase.

Included is a tool-set consisting of all major components required in the fabrication of a large array of semi-conductor based devices. The facility will include optical lithography, an assortment of fume hoods, PECVD deposition, PVD deposition, and reactive ion etching capabilities.

In addition, a state-of-the-art, high resolution direct write e-beam lithography system has recently been acquired for installation in the facility in early fall 2009. The ISOTWO is Raith's flagship model and will incorporate several features which will serve to further enhance the tools available to our scientists for their research.

Equipment installation will commence over the course of Summer 2009 and basic facility operations are expected to begin in September.

JOINING THE RANKS

RECRUITING NEW POSTDOC'S, STAFF & STUDENTS

Gorjan Alagic *Postdoctoral Researcher*

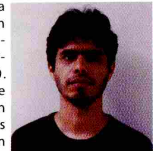
Gorjan successfully completed his Ph.D. in Mathematics at the University of Connecticut in 2008, under the supervision of Alexander Russell. He joined IQC as a Postdoctoral Fellow in the Fall of 2008.



Gorjan's primary fields of research are quantum computation and abstract harmonic analysis. In particular, he is interested in quantum algorithms for algebraic problems, decoherence in quantum walks, and uncertainty principles on groups.

Alexandre Martins de Souza *Postdoctoral Researcher*

Alexandre received a Bachelor degree in Physics from Fluminense Federal University, Brazil, in 2000. After that, he completed an M.Sc. in High Energy Physics at the Brazilian Center for Research in Physics in 2003 and a Ph.D in Quantum Computing at the same institution in 2008.



He is interested in experimental NMR quantum information processing, entanglement, Bell's inequalities, spin chains and interface between solid state qubits and photonic qubits.

Colin Bell *Computer Support Specialist*

Colin has six years of experience as an R&D support developer at telecom and networking companies in Ottawa, Ontario and one year of experience as a Computer Science tutor with the Instructional Support Group at the David R. Cheriton School of Computer Science. He recently completed degree requirements for his BMath at UW.



His professional interests lie in Knowledge Management and Information Technology best practices and he is looking forward to providing IQC with technologies that will improve operational efficiency for both administrators and researchers.

NEW STUDENTS

Graduate Students:

Ben Criger
Jennifer Fung
Deny Hamel
Robin Kothari
Kurt Schreiter
Mike Zhang

Research Assistants:

Andreas Brunner
Nikesh Dattani
Likun Hu
Botan Khani

AU REVOIR COUTEAU'S

After 3 years with IQC, Research Assistant Professor Christophe Couteau and his family sadly waved goodbye as they headed back home to France in November.

To honour their time spent here, IQC hosted a farewell party for the family on November 7th in the presence of friends, family, and fellow colleagues.



Above: Christophe and Sharon opening gifts at their farewell party.

At IQC, Christophe took on a Research Assistant Professor position in the Photonic Entanglement Lab and led his group to push the boundaries of optical quantum information processing.

Sharon Couteau helped co-found the IQC Spousal Network and organized and attended many events alongside their 3 daughters, Gisele, Caitlin, and Brenna.

"We will miss everyone," said Sharon. "IQC was more like a big family than anything else."



Departures

We bid farewell to members who are leaving us for the short, and for the longer term, and wish them the best of luck in their future endeavours.

↳ Christophe Couteau
Research Assistant Professor

↳ Rahul Jain
Postdoctoral Fellow

↳ Martin Laforest
Graduate Student

↳ Caterina-Eloisa Mora
Postdoctoral Fellow

↳ David Ostapchuk
Graduate Student

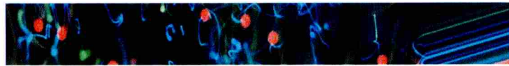
↳ Marcus Silva
Graduate Student

For a full listing of IQC Alumni, please visit www.iqc.ca/people and click on "Former Members"

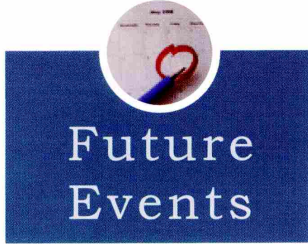
Did You Know?

IQC has officially been added to Wikipedia.

Take a look!
www.wikipedia.org



NEWSWORTHY MATERIAL



Future Events

TQC WORKSHOP 2009

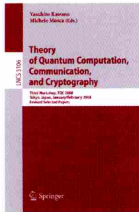
Hosted this year by IQC, TQC 2009 will focus on theoretical aspects of quantum computation, quantum communication, and quantum cryptography – subfields of quantum information processing.

The overall objective is to bring together researchers enabling them to interact with each other to share problems and recent discoveries. It will consist of invited talks, contributed talks, and a poster session. Springer will publish a selection of the papers in the official post-proceedings in the *Lecture Notes in Computer Science*, as seen below.

Date: May 11 - 13, 2009

Invited Speakers:

- Masato Koashi (*Osaka University*)
- John Preskill (*Caltech*)
- Miklos Santha (*Université Paris Sud*)
- Graeme Smith (*IBM Watson*)
- Stephanie Wehner (*Caltech*)



For more information and to register for the upcoming TQC Workshop, please visit www.iqc.ca/tqc2009

For questions, comments or general feedback regarding IQC

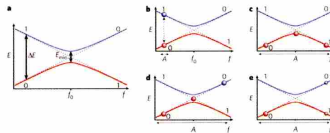
contact:

iqc@iqc.ca

A SHIFT IN SPECTROSCOPY

IQC Professor Frank Wilhelm was recently selected to author a "news and views" piece for the journal *Nature* about an article in the same issue titled, "Amplitude spectroscopy of a solid-state artificial atom" by David M. Berns et al.

Berns describes a complimentary spectroscopic technique in which the energy levels of artificial atoms are probed by varying the amplitude of radiation while the frequency remains tuned to a specific spectrum feature.



Above: Use of avoided energy-level crossing for amplitude spectroscopy.

Professor Wilhelm's thoughts were featured as "Experimental physics: A shift in spectroscopy" in *Nature* 455, 41-43 (4 September 2008).

HIGHLIGHTING IQC'S FABRICATION FACILITY

The Waterloo Record's 2008 *Spirit of Innovation Technology Spotlight* showcased a selection of researchers, businesses and new developments in the region, including IQC's fabrication facility.

The fabrication facility is where quantum computing and nanotechnology unite. It is host to the creation of specified tools such as computer chips for experiments in both fields.

The actual creation of these materials "is not a trivial task," Director of Operations, Vito Logiudice explains. "What we are doing is adapting the capabilities that allow us to make computer chips to these novel research initiatives."

The full article can be viewed at <http://techspotlight.therecord.com/>

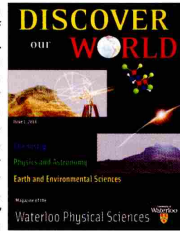
For current developments on IQC's fabrication facility, please see Page 4.



ANOTHER LOOK AT QUANTUM THEORY

Ph.D. student Lana Sheridan was featured in the premiering 2008 issue of *Discover our World*, Magazine of the Waterloo Physical Sciences at the University of Waterloo.

Lana explained in detail the basics of quantum theory. "Quantum mechanics is an intriguing theory that seems to run counter to the intuition people have from their everyday experiences in the "classical" world," she says. "A world that is very well described by Newton's theory of classical mechanics."



She continues by identifying how quantum mechanics opens the doors to new kinds of technology and quantum information processing that are impossible using the classical theory alone.

Discover our World aims to provide insights into the various teaching and research activities in the area of Physical Sciences through articles written by Waterloo professors, students, and alumni. To view Lana's full published article, please visit www.science.uwaterloo.ca/programs/physical_sciences.html

PERSPECTIVE ON HAWKINGS

Theoretical physicist, Stephen W. Hawking's upcoming visits to IQC and Perimeter Institute (PI) scheduled for next Summer were featured on CTV News in November.

Hawking's visits will last for 1 month on an annual basis. We hope IQC will become a second home for the honorary professor and initiate sparks to fly when his creative and original thinking melds to our own researchers'.

A future connection with PI and the Centre of Theoretical Cosmology in Cambridge, England will be in the talks in addition to the developing research ideas.

Ph.D. student, Gina Passant commented in an interview saying, "[Hawking's] going to attract other great minds to the area, so we're going to not only learn from him, but from other people around the world as well."

Developments on Hawking's visits will be updated on IQC's website, www.iqc.ca

OUTSIDE THE SCIENCE

TRICK OR TREAT

The hallways of IQC were filled with little ballerinas, dragons, princesses, dinosaurs, and pumpkins. On October 31st, trick r' treaters eagerly ventured from office to laboratory to seminar room, in search of Hallowe'en treats, goodies and toys.



Thank you to all of the students, professors and staff members who dressed up for the event and generously helped out.

MEET & GREET BBQ

The rainy weather proved to be no road block for IQC's 2nd Annual Meet & Greet BBQ on September 12th. Held this year on location, we welcomed a wave of new students, postdoctoral researchers and staff members.



Ice-breaker and road hockey games kicked off the afternoon as we got better acquainted with our new members and gave everyone a chance to walk away with some great prizes.

For full listing of new members, see Page 3.

HEADING BACK TO THE FARM

On October 11th, IQC members and their families visited the KimGlow Farm in Waterloo to take part in the Family Fall Festival. Jumping aboard the hayride, the farm showcased a haunted barn, animal petting zoo, glow in the dark mini-golf course, a corn maze, face painting and pony rides, all for the Hallowe'en themed event.



Feeding our indulgences with the tempting concession stands, Grandma Flo's Fritter House and Fairy Floss Hut, while the kids

bounced around in the balloon-filled giant pumpkin or were amused by the numerous clown shows featured throughout the day.

IQC members even got to walk away with their very own pumpkin from the 15-acre patch full of gourds, Indian corn, and of course pumpkins of all shapes and sizes, ready to be carved for the upcoming holiday.



For more information about KimGlow Farms, please visit www.kinglo.com

VISITS FROM THE STORK



On October 25th, Jay, Sarah, and big brother Maddox Gambetta welcomed a new baby girl, Evangeline Violette to their family.

Congratulations to Michele, Nelia, and big sister Natalie Mosca as they welcomed a baby boy, Michael Joseph on October 28th.



On October 3rd, Kurt and Meredith Schreier welcomed a new baby boy, Jack to their family.

Gregor and Birgit Weihs welcomed Florian Samuel to their family on December 20th in Innsbruck, Austria.



Athletics

▶ TABLE TENNIS TOURNAMENT

Drill! Flip! Block! Smash! Players rolled their shoulders, stretched their arms, and cracked their fingers in preparation for the Table Tennis Tournament held on October 24th. Three leagues were determined after the preliminary matches, which separated the varying skill levels. After a grueling afternoon, the winners paddled their way to victory. Congratulations to the winners:

Tobias Moroder – Pro League
Easwar Magesan – Intermediate League
Lirong Si – Beginner League



Other finalists included Peter Groszkowski, Aleksandrs Belovs, and Brendan Osberg. Thank you to Post-doc, Mohsen Razavi for organizing the tournament.

▶ HOCKEY

Regular ball hockey games were played over the course of the Fall months, held in the IQC parking lot at 4:30 every Tuesday afternoon. Once the snow falls, players will take to the ice covered pond behind RAC to continue the games on Friday's. No matter your skill level, everyone is encouraged to come out and participate.



For more information about regular ice hockey games, please contact Brendan Osberg.

IQC THANKS ITS PARTNERS FOR THEIR
CONTINUING SUPPORT OF OUR VISION



MIKE LAZARIDIS

- AND -

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The NewBit Issue 10
IQC Communications & Media Relations
Wendy Reibel <wreibel@iqc.ca>
Meghan Huras <mhuras@iqc.ca>

Institute for Quantum Computing
200 University Avenue West
Waterloo, Ontario, Canada
N2L 3G1

Phone: (519) 888-4021
Fax: (519) 888-7610
E-mail: iqc@iqc.ca

www.iqc.ca