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NewBit

Issue 15 | Winter 2011

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explore quantum science at
IQC's Open House



UNIVERSITY OF
WATERLOO

IQC

Institute for
Quantum
Computing

this issue

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Read about what Thomas Jennewein said will "open a new frontier of quantum optics."

THE QUANTUM FACTORY

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Find out more about the new blog!
quantumfactory.wordpress.com

SETH LLOYD LECTURES AT IQC

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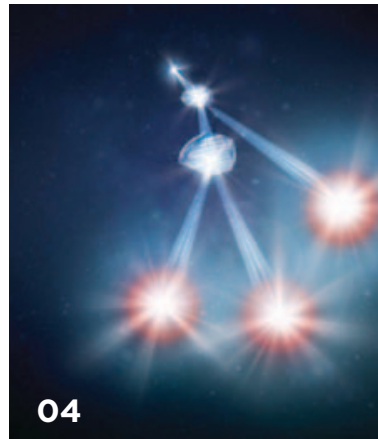
Find out what Seth Lloyd thinks about IQC, the universe as a quantum computer, and the importance of quantum information research.



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ON THE COVER

David Cory lectures during
IQC's annual Open House



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welcome to NewBit

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» WELCOME MESSAGE

Greetings from IQC

IQC aspires to make fundamental discoveries that will enable humanity to benefit from the information processing power of the quantum world. Success requires the hard work and dedication of the world's brightest minds: students, postdoctoral researchers, faculty, international collaborators and visitors. In the pages of this newsletter, you'll find scientific highlights from the last term and meet some of IQC's exceptional researchers.

Breakthroughs in quantum information processing require cutting-edge tools and facilities. In the past year, we've seen the opening of IQC's second building, Research Advancement Centre II, and we are eagerly anticipating our expansion into IQC's permanent home, the state-of-the-art Mike and Ophelia Lazaridis Quantum-Nano Centre this fall.

We are fortunate to have dedicated staff who work hard to provide vital support towards achieving our mission and allow IQC to be much greater than the sum of its parts.

We are also preparing the next-generation workforce — scientists, engineers, entrepreneurs, civil servants and others — from the children at our Open House to the IQC alumni who will apply the knowledge and skills obtained at Waterloo throughout the world.

We hope you enjoy the sampling of our activities and achievements over the past few months in this latest newsletter. Here's to our great successes so far and to more growth and breakthroughs ahead. ■



Raymond Laflamme | Executive Director, IQC

Michele Mosca | Deputy Director, IQC

Science Corner

IQC faculty, postdocs and students have continued to set the global standard for quantum information research over the past term. Here is a sampling of some of the cutting-edge research published recently in leading academic journals.



Alliance for Quantum Academia

In December, five IQC students traveled to the National University of Singapore's Centre for Quantum Technologies (CQT) to attend the first Graduate Student Congress on Quantum Information and Computation. **JEAN-PHILIPPE BOURGOIN, PETER GROSZKOWSKI, STACEY JEFFERY, ARTEM KAZNATCHEEV AND GELO NOEL TABIA** took the opportunity to share their research results and exchange ideas with the 35 or so participants from around the globe. ■

⤴ “DIRECT GENERATION OF PHOTON TRIPLETS USING CASCADED PHOTON-PAIR SOURCES”

IQC researchers **THOMAS JENNEWEIN, KEVIN RESCH, HANNES HÜBEL AND DENY HAMEL**, in collaboration with researchers in Austria and Australia, achieved a breakthrough in quantum optics with the direct generation of photon triplets. Their results were published in *Nature* 466, 601-603 (July 2010). ■



Anne Broadbent with John Milloy (left), David C. Onley and John Polanyi (far right)



Richard Cleve

⤴ AWARDS & HONOURS

ANNE BROADBENT, Polanyi Prize

ANNE BROADBENT, CIFAR Junior Fellow

RICHARD CLEVE, Royal Society Fellow

KEVIN RESCH, Outstanding Performance Award

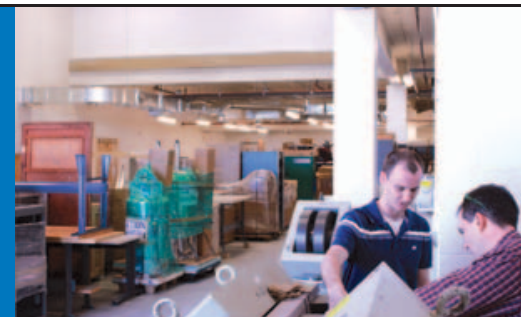
JOHN WATROUS, Outstanding Performance Award

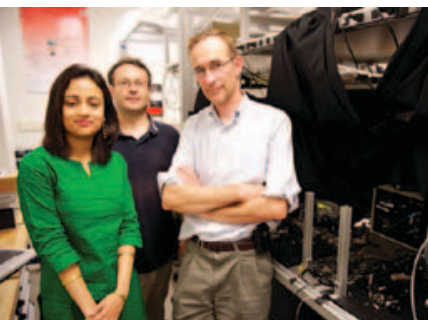
FRANK WILHELM, Outstanding Performance Award

HAMED MAJEDI, Distinguished Performance Award ■

RAC2 Labs

RAC2 is bustling with research these days. Check out the progress! >>





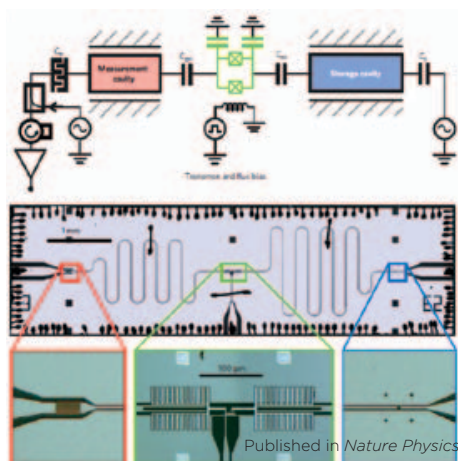
UNEXPECTED KUDOS

URBASI SINHA AND COLLEAGUES recently put Born's Rule — a fundamental precept of quantum mechanics — to the test with their triple-slit experiment. After publishing the results in the paper "Ruling Out Multi-Order Interference in Quantum Mechanics", *Science* 329, 418-421 (July 2010), Urbasi received a letter of thanks from an unexpected source:

*"Dear Dr. Sinha,
I am the son of Max Born, and I am greatly gratified that theoretical work he did in 1926 (when I was five) should now receive experimental confirmation."*

Gustav Born, UK.

From a letter dated Aug. 11, 2010 ■



Jay Gambetta

In their paper entitled "Quantum non-demolition detection of single microwave photons in a circuit", *Nature Physics* 6, 663-667 (June 2010), IQC Research Assistant Professor **JAY GAMBETTA AND COLLEAGUES** outlined techniques for detecting photons in microwave circuits with minimal disturbance.

In "Preparation and measurement of three-qubit entanglement in a superconducting circuit", *Nature* 467, 574-578 (September 2010), Gambetta and colleagues demonstrated three-qubit entanglement in a superconducting circuit. ■



QIP2011 CONFERENCE

IQC was well represented at the 14th Workshop on Quantum Information Processing in Singapore this January. Some IQC contributions include:

- » "Entanglement can increase asymptotic rates of zero-error classical communication over classical channels," by **DEBBIE LEUNG, LAURA MANCINSKA, WILLIAM MATTHEWS, MARIS OZOLS AND AIDAN ROY**
- » "Quantum interactive proofs with weak error bounds," by **TSUYOSHI ITO, JOHN WATROUS AND COLLABORATORS**
- » "On the solution space of quantum 2-SAT problems," by **JIANXIN CHEN, BEI ZENG AND COLLABORATORS**
- » "Quantum query complexity of minor-closed graph properties," by **ANDREW CHILDS AND ROBIN KOTHARI**
- » "Constructing elliptic curve isogenies in quantum subexponential time," by **ANDREW CHILDS AND COLLABORATORS**
- » "Finding is as easy as detecting for quantum walks," by **MARIS OZOLS AND COLLABORATORS ■**



Questions &



NEW

AWARD FOR IQC STUDENTS

The IQC David Johnston Award for Scientific Outreach



During a farewell reception for outgoing uWaterloo president David Johnston, IQC Director Raymond Laflamme announced

a new annual award recognizing students for outstanding commitment to scientific outreach and community engagement.

The IQC David Johnston Award for Scientific Outreach will award \$2,500 to up to three IQC students each year. This award is pending Senate Committee approval. Stay tuned to iqc.uwaterloo.ca for more details! ■



Get to know:

Jonathan Baugh

Faculty

Hometown? Chattanooga, TN

What first intrigued you about quantum science? That it shattered conventional wisdom, and that no one can explain why it is.

What are you currently investigating? Using spins — electronic and nuclear spins — to encode quantum information and form the basis for solid-state quantum computing technologies.

How would you briefly describe quantum information science to a complete layperson? I might say that a quantum computer is not constrained to being in a well-defined classical state — and therefore it is more powerful and more general than a classical one.

What hobbies/interests do you have away from IQC?

Playing music (guitar and piano), politics, travel.

What continues to pique your curiosity, scientifically or otherwise? Not only solving everyday research challenges, but also gradually gaining deeper insight into the way everything works.

Any random, interesting factoid about you, your lab or your scientific work? I originally studied to be a composer, but switched to Physics in my first year of University.

Answers

Get to know IQC researchers



Get to know:

Krister Shalm

Postdoctoral Fellow

Hometown? I was born in Ontario, but have moved around a lot. My parents are missionaries so I lived in Sri Lanka for two years and Pakistan for over 10 years. In between I also spent a couple of years in New Brunswick and Nova Scotia.

What first intrigued you about quantum science?

In my third year quantum mechanics course at Queen's the concept of a qubit was first introduced to me. I was fascinated by this idea and began to read up on quantum information. A fourth year project on quantum cryptography pushed me to pursue quantum information in graduate school.

How would you briefly describe quantum information science to a complete layperson?

The world of quantum mechanics is a strange place. Things in the quantum world do not behave as we would normally expect: quantum objects follow a different set of rules. For the past century we have been exploring this exciting new world, but only recently have we reached the point where we can start to take advantage of these new quantum rules to do things that were previously impossible.

Quantum mechanics may one day allow us to build computers capable of solving problems out of the reach of conventional computers or allow us to make better measuring devices. Already we are using quantum mechanics to share secret messages. The future is bright for quantum devices and technologies.

What hobbies/interests do you have away from IQC?

I am an avid Lindy Hopper (a type of swing dance). When I am not in the lab, I am probably dancing.

What continues to pique your curiosity, scientifically or otherwise? I have become interested in scientific outreach. It is a challenging problem trying to explain your work to people who are not well versed in your field. Trying to come up with ways to present my research to a lay audience has forced me to look at my own work differently.



Get to know:

Catherine Holloway

Student

Hometown? Antigonish, NS

What first intrigued you about quantum science? In junior high I wanted to be a science fiction writer, so I started reading about modern physics to come up with interesting scenarios for stories.

What are you currently investigating?

I am working on quantum key distribution in “real world” settings, like in existing information networks.

What scientist (past or present) inspires you, and why?

Janna Levin, because she is a serious physicist who also writes about art and science. [A theoretical cosmologist at Barnard College, Levin is author of the bestseller *How the Universe Got its Spots* and has written essays to accompany art exhibitions at galleries around England.]

How would you briefly describe quantum information science to a complete layperson?

It involves making the fuzzy lower resolution of the universe work for us.

What hobbies/interests do you have away from IQC?

I like running, swimming and biking. I also like to make generative art — using information or algorithms to create new designs. That can range from embroidering cross-stitch fractals to programming music videos that react to the pitch, volume or timbre of the music.

What continues to pique your curiosity, scientifically or otherwise? I like it when two seemingly unrelated fields, like biology and computer science, or art and physics, come together to produce new ideas. ■

Quantum

connections



The Quantum Factory Blog

He went to China to recruit the country's top minds to IQC and uWaterloo. Along the way, Martin Laforest traversed the Great Wall, hobnobbed with politicians, dined on octopus and snake, and of course spread the word about uWaterloo, IQC and the graduate program.

Check out Martin's China travelogue, and many other adventures in quantumness, on QuantumFactory, the brand new blog spearheaded by IQC's Communications & Outreach team. Interested in writing for the blog? Let us know!

Join us at quantumfactory.wordpress.com ■



Photo credit:
Melissa Tait, Waterloo Region Record



QCSYS

The Quantum Cryptography School for Young Students (QCSYS) is an exciting week-long program offered to students in Grades 10-12. This year the program will run through August 8-12. Check out iqc.uwaterloo.ca/conferences/qcsys2011 for more details. ■



UNDERGRADUATE SCHOOL
ON EXPERIMENTAL QUANTUM
INFORMATION PROCESSING



USEQIP on YouTube

The 2011 Undergraduate School on Experimental Quantum Information Processing runs from May 30 to June 10. The program is designed for third-year students in engineering, physics, chemistry and math with an interest in quantum information processing.

Check out a video of USEQIP 2010 and other clips on IQC's YouTube channel at www.youtube.com/quantumiqc ■



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youtube.com/quantumiqc



flickr.com/quantumiqc

Spreading the word

Postdoctoral fellow Anne Broadbent shared her passion for quantum science during talks she delivered to a pair of women's groups in recent months.

“ANNE’S PRESENTATION WAS FANTASTIC,” SAID PARTICIPANT MARY D’ALTON. “EVERYONE HAD A BRILLIANT TIME, AND IT OPENED THE EYES OF MANY PEOPLE.”

In November, Anne was invited to speak at Ladies’ Night Out, a women’s educational event in Listowel, not far from the rural homestead where Broadbent lives with her husband and young son.

According to event organizer Margaret McMahon, Broadbent’s talk was a fascinating and accessible introduction to the complexities of quantum information processing.

“Although quantum computers are a heavy topic, Anne was able to give the audience an explanation of what they are and how they work in language we could understand,” said McMahon. “There were lots of questions for Anne and she kindly answered them all.”

Her talk in Listowel caught the attention of the Waterloo Chapter of the International Women’s Forum of Canada, who visited IQC to hear Anne speak in January.

The group of about a dozen women from Waterloo Region’s business, academic and cultural sectors was fascinated by Anne’s talk about the motivations and goals of quantum information research. ■



◀◀ Raymond Laflamme leading the Waterloo Chapter guests through the NMR lab.

What

“ IF YOUR QUANTA ARE BROKE,
WE FIX ‘EM. ”

Seth Lloyd Said ...

Dr. Seth Lloyd, a self-described “quantum mechanic” (slogan: “if your quanta are broke, we fix ‘em”) from the Massachusetts Institute of Technology delivered a lunch-hour lecture at IQC about time travel. An internationally renowned figure in quantum information research, Lloyd took the time to share his thoughts on IQC and the importance of quantum information research. Check out the interview clips and the full lecture at iqc.uwaterloo.ca

SETH LLOYD ... ON THE UNIVERSE AS A QUANTUM COMPUTER

I’ve argued that the universe is a quantum computer. The universe itself is already processing information at the microscopic level all the time. When we build a quantum computer, we’re kind of coming in and hijacking the ongoing computation by making it compute something that we would like it to compute, rather than what it would normally be computing. We’re participating in the universal computation, rather than forcing the universe to compute. The fact that the universe, at bottom, is processing information and computing in a uniquely quantum mechanical way is, in some sense, uncontroversial. Though, when I make this argument it always seems to cause controversy.

... ON IQC

I’m extremely impressed by the Institute for Quantum Computing, which has recently surpassed my own institution, MIT, to become the largest quantum computing department in the world. So while I’m a bit dismayed by this, I am also very impressed, and I think it’s wonderful that the Canadian government and, perhaps most importantly, Mike Lazaridis, see the potential for quantum computing to be so important that they’re willing to support it to this fantastic degree. IQC and Waterloo are now a world-centre for quantum computing; everybody knows about it, everybody comes here, it’s a really fantastic place and there are wonderful things coming out of it.

... ON THE IMPORTANCE OF QUANTUM INFORMATION RESEARCH

Quantum information — the study of how information is registered and processed at the most fundamental levels — is not just a field that allows you to say, build quantum computers that factor large numbers; it really is a universal language for what’s happening at the microscopic level. As a result, it has broad applications not merely in quantum technologies, but in understanding how the structure of matter works ...and maybe understanding how the universe itself is put together. Quantum information has the potential for making a unified picture of the whole of physics. For that reason, investing in quantum information is the smart thing to do. ■

» Arrivals

Postdocs

Mohammad Ansari
Jianxin Chen
Robadeb Rahimi Darabad
Brendon Higgins
Piotr Kolenderski
Florian Ong
Emily Pritchett
Aidan Roy
Krister Shalm

Graduate Students

Razieh Annabestani
Kent Fisher
Nick Gigov
Luke Govia
Nupur Gupta
Fatin Haque
Catherine Holloway
Tomas Jochym-O'Connor
Artem Kaznatcheev
Xian Ma
Sergei Mikheev
Abel Molina
Mohamad Niknam
Kyungdeock (Daniel) Park
Om Patange
Wenling Qiao
Yuval Sanders
Gelo Noel Tabia
Christopher Wood
Mengyun Zhai

Undergraduate Students

Tessa Alexanian
Mark Cachia
Grant Cleary
Julian Glaessel
Erika Janitz
Andrew Kowalczyzyn
Thomas Lutz
Fil Simovic
Veli Tezgel

Long Term Visitors

Feng Guanru
Bettina Heim
Youning Li

Staff

Jeremy Chamilliard
Lisa David
Michaelangelo Finistauri
Melissa Floyd
Ajnu Jacob
Laszlo Petho
Rodello Salandanan
Ivar Taminiau
Carly Turnbull ■

» Recruitment

IQC is inviting applications for tenured or tenure-track faculty positions as well as graduate student and postdoctoral positions in all areas of quantum information research. Positions are currently available for cross-appointment in the Faculty of Mathematics, the Department of Chemistry and the Department of Physics and Astronomy at the University of Waterloo. Visit iqc.uwaterloo.ca/welcome/positions for more information. ■

QNC »

IQC's permanent home, the Mike & Ophelia Lazaridis Quantum-Nano Centre, is nearing completion.

To celebrate its opening later this year, and to commemorate IQC's upcoming 10th anniversary, IQC will host an exciting series of scientific and cultural events. Stay tuned to iqc.uwaterloo.ca for details! ■



Check us out! ⤴

New Website

IQC recently revamped and relaunched its website, iqc.uwaterloo.ca, with a new look, enhanced interactivity, audience-specific features and much more. The new site, created with input from IQC members and web design experts, serves as a news source, a recruiting tool, a learning resource and a gateway to IQC social media. Check it out! ■



« Where have you been?

Do you have a photo of yourself wearing an IQC hat or t-shirt somewhere outside of Waterloo? E-mail it to us for our "IQC Around the World" project! iqc@uwaterloo.ca ■



Martin Laforest at the Great Wall of China



More than 800 curious visitors explored the world of quantum information science during IQC's biggest-ever Open House, held Saturday Sept. 18, 2010. IQC was the most-visited site on Doors Open Waterloo Region, a day-long event that saw dozens of local buildings and institutions host open houses and tours. Thanks to the dozens of IQC students, faculty and staff who volunteered to make the Open House a resounding success. ■



LOOK FOR THE NEXT ISSUE OF **NewBit** COMING IN THE SPRING!