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NewBit

Issue 19 | Spring 2012

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IQC postdoc explores secure
cloud quantum computing



UNIVERSITY OF
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IQC Institute for
Quantum
Computing

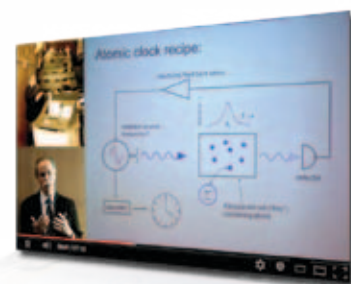
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IQC faculty, postdoctoral fellows and students have continued to set the global standard for quantum information research over the past term. Here is a sampling of their cutting-edge research published recently in academic journals.



⤴ A conceptual diagram of the blind quantum computing experiment

Broadbent, who also co-authored the 2009 theory paper on which the new implementation was based, said the breakthrough is “a great example of a theoretical result providing a new direction to experimental research.” ■

The team's results were published in *Physical Review Letters* in late 2011, and highlighted on *PhysOrg.com*. ■

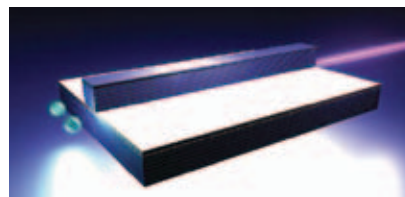
Dmitry Pushin sketches a neutron interferometer at IQC



» New chip advances quantum optics research

MONOLITHIC SOURCE OF PHOTON PAIRS, *PHYS. REV. LETT.* 108, (2012)

A collaboration between IQC and the University of Toronto has led to a new chip that could greatly advance optical approaches to quantum information technologies.



⤴ A diagram of the waveguide chip tested at IQC

Developed at U of T and tested at IQC, the waveguide chip can perform crucial functions that typically require the big, expensive equipment of a full optics lab.

The chip enables a new method for creating entangled pairs of photons at wavelengths useful for quantum information applications.

Such a chip could be integral to the development of scalable photonics-based quantum computers and other quantum technologies, says IQC postdoctoral fellow **ROLF HORN**, who tested the chip with former IQC professor **GREGOR WEIHS**.

The team's results were published in an April edition of *Physical Review Letters*, and spotlighted in a *Focus* article in the same issue. ■

» NEW IQC RESEARCHER TESTS QUANTUM CRYPTOGRAPHY

IQC welcomed research assistant professor **VADIM MAKAROV**, whose research focuses on finding and fixing vulnerabilities in quantum cryptography systems. Although quantum cryptography is perfectly secure in principle, hardware implementations can have loopholes. By discovering these loopholes and suggesting methods for fixing them, Makarov will play an important role in the establishment of quantum cryptosystems as a global standard for information security in the future. Makarov joined IQC in February following a postdoctoral fellowship at the Norwegian University of Science and Technology, where he ran a quantum hacking lab. ■



⤴ IQC welcomed Vadim Makarov in February 2012



⤴ Participants from the General Quantumness of Correlations mini-workshop

For two days in February, IQC hosted a "mini-workshop" during which attendees examined questions of non-classical correlations — including, but not limited to, quantum entanglement.

Roughly 20 participants discussed what it means for a correlation to be "quantum," and how such correlations can be tested, quantified and utilized in information processing. The Feb. 23 and 24 mini-workshop, called General Quantumness of Correlations, was organized by IQC research assistant professor **MARCO PIANI**, who received positive feedback about the event and hopes to explore different themes through similar mini-workshops in the future. ■

» Algorithms experts come together for IQC conference

A group of experts in quantum algorithms convened in Waterloo for several days in April to discuss key questions and breakthroughs in the field.

Roughly two-dozen researchers attended the "Recent Progress in Quantum Algorithms" conference, which was jointly hosted by the Institute for Quantum Computing and the Perimeter Institute.

Along with presentations and formal discussions, the conference included a number of informal discussion periods, aimed at forging new connections and sparking new ideas for investigation.

"It's great to have these opportunities to get together in one place," said conference co-ordinator Prof. **ANDREW CHILDS**. "When we get together, new ideas can emerge much more freely than when we're all at our separate institutions." ■

» Participants from the Recent Progress in Quantum Algorithms conference, held April 2012



"Girls in Science" explore IQC

Hoping to serve as role models for the younger generation, a group of female IQC students hosted a special event on April 22 for the Canadian Association for Girls in Science.



⤴ IQC students **RAZIEH ANNABESTANI** (left) and **ELENA ANISIMOVA** demonstrate polarization of light at the *Girls in Science* event held April 22.

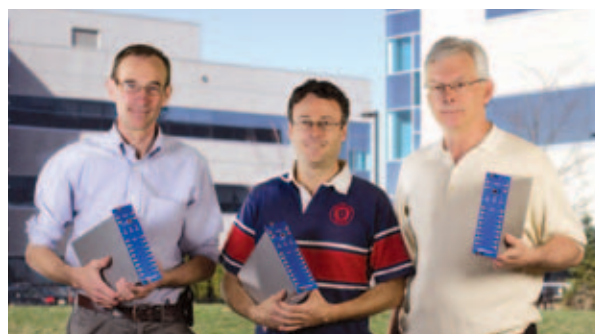
Approximately 15 elementary and high-school-age girls visited IQC for an afternoon of scientific discovery and fun.

The girls learned the basics of cryptography through activities and games, such as decoding secret messages from *The Hunger Games* and *Harry Potter*, and they explored principles of optics with lasers and fiber-optic cables.

Such events are aimed at giving young girls fun experiences in fields of science that are typically male-dominated, and introducing them to positive scientific role models.

IQC graduate student **CATHERINE HOLLOWAY**, who coordinated the visit, said the event was a great success, judging by the enthusiasm of the girls and the appreciative feedback she received from parents. ■

» From the lab to the marketplace: Universal Quantum Devices Inc.



⤴ UQD Founders **RAYMOND LAFLAMME**, **THOMAS JENNEW EIN** and **STEVE MACDONALD** holding the company's signature device.

Quantum science continues to move from pure research toward practical, commercially available devices, as demonstrated by the recent sale of made-in-Waterloo quantum technologies.

Universal Quantum Devices Inc. (UQD), a spin-off company that emerged last year from IQC optics research, builds and sells specialized devices for photonics research.

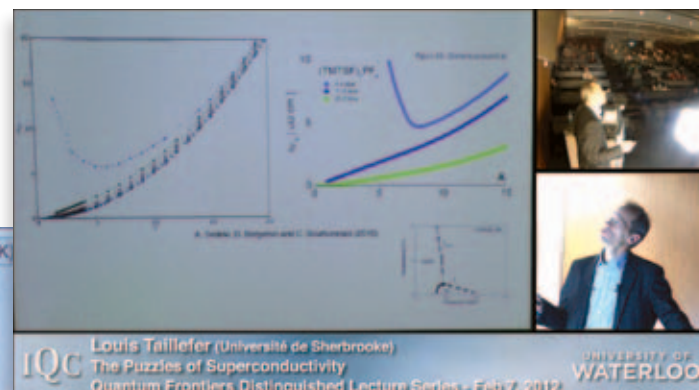
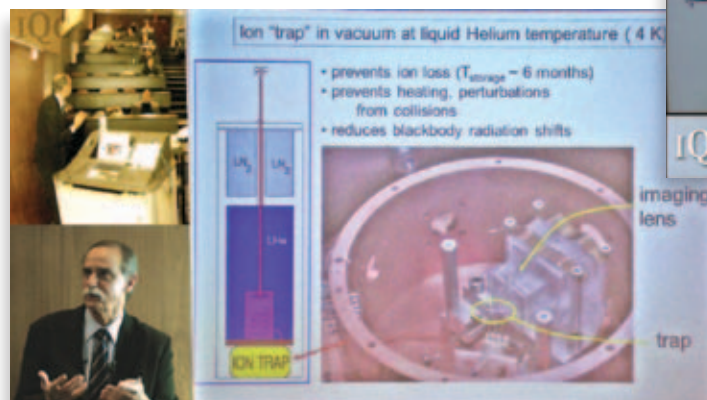
The company's signature technology, a novel logic unit conceived by UQD co-founder **THOMAS JENNEW EIN**, is a multi-purpose device that accomplishes many crucial tasks in quantum optics experiments.

In the spring of 2012, the company sold several pieces of its equipment to photonics laboratories around the world.

"This represents one of the first steps toward commercialization of practical quantum technologies," said UQD co-founder **STEVE MACDONALD**, who leads UQD alongside Jennewein and **RAYMOND LAFLAMME**. ■

» Lecture series explores *Quantum Frontiers*

The *Quantum Frontiers Distinguished Lecture Series* continued at the University of Waterloo this past term with a pair of lectures by leading-edge scientists.



» **DR. LOUIS TAILLEFER** at the February 2012 Quantum Frontiers lecture series

« **DR. DAVID WINELAND** at the January 2012 Quantum Frontiers lecture series

On Jan. 19, **DR. DAVID WINELAND** of the National Institute of Standards and Technology (NIST) explained how ion-trapping systems are being used for quantum information processing and the development of ultra-precise atomic clocks.

The atomic clocks he and his team have built are so accurate, Wineland explained, they will neither gain nor lose more than one second over the age of the universe.

On Feb. 7, **DR. LOUIS TAILLEFER** delivered a talk titled “The Puzzles of Superconductivity,” in which he explored what he called the “most remarkable property of matter” — the state in which electricity flows perfectly.

Both full lectures, as well as interviews clips with both Wineland and Taillefer, are now posted on the IQC *YouTube* channel at youtube.com/QuantumIQC

The next *Quantum Frontiers Distinguished Lecture*, to be held on June 21, will feature **DR. CHIP ELLIOTT**, Principle Investigator of the GENI (Global Environment for Network Innovations) project at BBN Technologies. Keep an eye on the IQC website for details about this and other upcoming lectures. ■

» JOIN THE Q+ HANGOUT



Imagine attending seminars by some of the world’s top scientists from the comfort of your own home (or office) — and actually interacting with the speakers, as if you’re right there in the lecture hall. That’s the goal of “Google+ Hangouts,” a new videoconferencing feature launched by Google’s social network. A hangout specializing in quantum information, fittingly titled Q+, has connected a number of institutions via virtual seminars approximately once a month, and an archive of sessions is being posted to *YouTube*. Learn more about participating in Q+ Hangouts at <http://qplus.burgarth.de/>. ■



» Going Coastal: IQC at AAAS

The Institute for Quantum Computing had a strong presence at the Annual Meeting of the American Association for the Advancement of Science (AAAS) in Vancouver this February. The AAAS Annual Meeting is the world’s largest scientific gathering, with an estimated 12,500 participants this year, ranging from scientists and journalists to policy-makers and the general public. IQC faculty members including **RAYMOND LAFLAMME**, **DAVID CORY** and **THOMAS JENNEWAIN** participated in panel discussions with international colleagues. Laflamme and other leading scientists were recognized for important contributions to their respective fields during the annual AAAS Fellowship breakfast.

MIKE LAZARIDIS delivered a fascinating and inspirational plenary speech about why he so strongly supports and invests in fundamental research centres such as IQC and Perimeter Institute. Thousands of people visited the IQC booth in the AAAS exhibition hall, where IQC members talked with dozens of media representatives, fellow scientists and the interested public. The IQC booth was also part of “Family Science Day” — one of the most well-attended events of the conference. IQC’s participation in the 2012 AAAS Annual Meeting resulted in immediate high-profile media coverage in outlets including *The Economist*, *Space.com*, *ABC Australia*, *Physics World* and more.

A. Professor **THOMAS JENNEWAIN** explains his work in secure quantum communications during a AAAS panel discussion.

B. IQC students **EVAN MEYER-SCOTT** and **DENY HAMEL** at the IQC Booth in the AAAS Exhibition Hall.

C. IQC Executive Director **RAYMOND LAFLAMME** receives his Fellowship in the American Association for the Advancement of Science in Vancouver.

D. Participants in the *Quantum Information Technologies: A New Era for Global Communication Panel*. Left to right: **MARTIN LAFOREST** (moderator), **ANTON ZEILINGER**, **THOMAS JENNEWAIN**, **MASAHIDE SASAKI**, **RAYMOND LAFLAMME**. ■



STAY CONNECTED with IQC



Questions & Answers

Get to know IQC researchers

» Get to know: Joseph Emerson | Faculty



Hometown?

Lakewood, Ohio. But I bounced back and forth between Cleveland and Montreal quite a bit.

What first intrigued you about quantum science?

Realizing that quantum information science gave a precise, quantitative (rather than qualitative) sense in which quantum mechanics is non-classical, and more enabling than classical mechanics.

What are you currently working on?

Lots of new things. Understanding how complex quantum systems exhibit generic features that justify classical thermodynamics, such as the 2nd Law. This is a very old problem for which we get new insights from the tools of quantum information theory. Also, I'm clarifying a recent result in which my students Victor Veitch and Chris Ferrie and I established an intriguing connection between quantum exponential computational speed-up and an old signature of non-classicality based on the onset of "negative probability" (which is mathematically defined but physically meaningless) in a framework where you try to force quantum mechanics into a classical, local-hidden variable picture.

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

Einstein, by far. You can't overestimate the depth and impact of his insights into physics, as well as the foundations of quantum theory. Lots of scientists think he couldn't accept the new quantum ideas — on the contrary, I think these critics couldn't understand the subtlety of Einstein's insights, particularly his realization that we need not reject the possibility of an underlying reality about which we only have partial knowledge.

How would you briefly describe what you do to a layperson?

In physics, when a situation is transformed from a state of disorder to increased order, such as tidying your bedroom, we call this "reducing the entropy" of the system. It takes work to do this. The quantum world is complex and we need to organize our understanding of it. So what I do is extract work from sugar and caffeine to lower the entropy in my mind and, hopefully, do the same for the minds of my colleagues, students and the general public!

What hobbies/interests do you have away from IQC?

I like playing with my kids, board games, foosball, golf, ball hockey, long walks on the beach. You know, the usual.

What continues to pique your curiosity, scientifically or otherwise?

I still don't understand the mystery of quantum mechanics... And won't stop until I do. So I need more sugar!

» Get to know: Madelaine Liddy Undergraduate Research Assistant



Hometown?

I grew up just North of Toronto in Vaughan, Ontario.

What first intrigued you about quantum science?

I first learned about quantum phenomena when I was a student in high school. At the Ontario Science Centre, my physics and chemistry profs each taught a unit on quantum chemistry and physics. During class we demonstrated things like wave interference patterns with water on an overhead projector and watched documentaries about quantum theory and mechanics. I've been hooked ever since!

What are you currently working on?

Currently I'm involved with the Earth's Field NMR project working in Prof. David Cory's group. The goal of this project is to detect and characterize the Earth's magnetic field using this device.

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

Ben Franklin, because he never stopped questioning things around him and never stopped exploring other areas outside science, including music, inventions, politics and writing. He understood the importance that science has in connection with everything else and that, in order to succeed in one area, you should be open-minded and well-rounded in others.

What hobbies/interests do you have away from IQC?

Two main interests I have away from IQC include training for triathlons and music. I enjoy playing the piano and singing, and am involved with the engineering jazz band and University of Waterloo choir.

What continues to pique your curiosity, scientifically or otherwise?

As I get closer to completing my undergrad studies in nanotechnology engineering and music, I am getting more and more interested in the materials that we are studying. More importantly, I am beginning to unite the theory we have been learning with the applications I've been seeing and experimenting with while on co-op.

» Get to know: Nathan Nelson-Fitzpatrick Nanofabrication Process Engineer



Hometown?

I grew up in Winnipeg, but I've spent the last 10 years in Edmonton.

What first intrigued you about quantum science?

I remember late into my first quantum mechanics course my professor was showing us how Schrödinger's equation applied to the Hydrogen atom explained atomic orbitals. It was very exciting to see how things (shapes and properties of orbitals) I had been taught in chemistry could be derived with a few equations in physics.

What do you do at IQC?

I'm a Nanofabrication Process Engineer in the Quantum NanoFab cleanroom. The cleanroom contains tools to deposit, pattern and etch a wide variety of materials at very small scales. These tools are similar to those used in the semiconductor industry and are available to all members of IQC. My job is to consult with lab members to help them realize the design they want to achieve with the tools, chemicals, and processes we have available in the Quantum NanoFab. I also create and document new recipes and protocols for the Quantum NanoFab community as their needs grow and change.

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

I would have to pick James Clerk Maxwell. I'm always impressed by the taming of complexity, so I'm inspired by scientists who unify different theories. When I was in undergrad (Engineering Physics) I actually had a hockey jersey with one of Maxwell's equations printed in place of a number.

How would you briefly describe your work to a complete layperson?

I help run the tools that make it possible for scientists to design experiments on a very small scale.

What hobbies/interests do you have away from IQC?

I enjoy bicycling, though I haven't found the time for it since I moved here. I'm still enjoying driving around and discovering new places in southern Ontario.

What continues to pique your curiosity, scientifically or otherwise?

I'm a sucker for documentaries about huge engineering projects, like the Hoover Dam and the Panama Canal. ■

» BEST WISHES



The Institute for Quantum Computing bid farewell in April to longtime lab guru **MIKE DITTY**, whose expertise has kept experimental facilities in tip-top shape since 2003.

Mike was an invaluable member of the IQC family as the institute quickly expanded from its original headquarters to the BFG Building and again into the Research Advancement Centres.

Thankfully, IQC will retain close ties to Mike when the institute expands again into the Mike & Ophelia Lazaridis Centre, as he is remaining at uWaterloo as the Manager of Infrastructure, Special Projects and Facilities for the Faculty of Science.

Best wishes, Mike, and we'll see you on main campus! ■

⤴ **RAY LAFLAMME** presents **MIKE DITTY** with a framed qubit chip nicknamed the "Itty Bitty Ditty Qubitty"

In the Community

» A new **SPIN** on quantum science at **TEDxWaterloo**



⤴ Krister Shalm (right, top) used swing dance, live music and magic to explain quantum science at TEDxWaterloo.

Photo used with permission – Darin White, makebright.com

To call it a “talk” would be a major understatement.

When IQC postdoctoral fellow **KRISTER SHALM** took to the stage at Centre in the Square for TEDxWaterloo last March, he became the ringleader of boisterous extravaganza that included a live band, an illusionist, several-thousand Smarties, hundreds of dancers and, of course, quantum physics.

Shalm’s 16-minute presentation at the third annual TEDxWaterloo was a multi-faceted celebration of nature’s “greatest love story,” as describes quantum entanglement.

As an optics researcher at IQC, Shalm tries to create and control the uniquely quantum correlation between two particles; as an avid swing dancer, he studies the beautiful symmetry that exists between two dance partners.

Onstage at Centre in the Square, Shalm bridged his two passions by orchestrating a dance — with eight live lindy hoppers onstage and hundreds more in pre-recorded choreography around the world — that conveyed the beauty of quantum entanglement.

A live band led by pianist **ROBERTA HUNT** provided the tune, and magician **DAN TROMMATER** created the illusion of entanglement with ordinary playing cards.

Shalm’s presentation became the buzz of the conference, generating dozens of positive tweets and rave reviews from attendees.

“It was amazing,” a breathless Shalm said after coming offstage. “It was everything I’d hoped it would be — and more.”

Video footage of Shalm’s presentation and all the TEDxWaterloo talks will be posted on www.tedxwaterloo.com. ■

» Arrivals

Research Assistant Professor
Vadim Makarov

Postdoctoral Fellow
Eduardo Martin-Martinez

Graduate Students
Naimeh Ghafarian
Sadegh Raeisi

Undergraduates
John Dengis
Egor Larionov
Ryan Marchildon
Cong Wang
Carrie Webster
Chris Sutherland
Seth Strimas-Mackey
Mehul Kumar
Mayank Mishra
Srijita Kundu
Mircea Rasvan Davidescu
Tae Sik Nam
Parsad Sarangapani

Long-Term Visitors
Vikram Sharad Athalye
Amin Baumeler
Antti Karlsson
Laura Piispanen ■

In a mind-bending mash-up of music and science, the Institute for Quantum Computing teamed up with the Kitchener-Waterloo Symphony to present “Quantum: Music at the Frontier of Science.”

The pair of sold-out concerts on Feb. 23 and 24 explored the parallel histories of music and



quantum science over the past century. With narration, visuals, “sound experiments” and an eclectic musical program, the symphony carried the audience on a journey into the quantum realm.

The concert was more than a year in the making, and was created with input from IQC faculty, postdocs, students and staff, who met regularly with K-W Symphony Music Director **EDWIN OUTWATER**.

“It has been a mind-blowing revelation,” Outwater said after the opening night performance at Kitchener’s Conrad Centre for the Performing Arts. “It made me look at the universe differently.”

An abridged video of the concert, and a behind-the-scenes “making of” documentary, are posted on IQC’s *YouTube* channel. ■

⤴ Edwin Outwater conducts the Kitchener-Waterloo Symphony in “Quantum: Music at the Frontier of Science”

Quantum Symphony

10th anniversary

Ten Quantum Years: Looking Back, Looking Ahead

The Institute for Quantum Computing is celebrating a decade of scientific discovery and innovation — and building for an even brighter future.

» COMMUNITY EVENTS

► Distinguished Lecture Series

Guest talks by renowned speakers in quantum science and nanotechnology.

► The Mike & Ophelia Lazaridis Quantum-Nano Centre Ribbon Cutting

Friday, September 21, 2012 – 10:00 am to 11:30 am

► Community Open House, Guest Lectures, Public Tours

Saturday, September 29, 2012



Quantum research will meet rock ‘n roll when one of Canada’s best-known science popularizers, Jay Ingram, leads his band — **JAY INGRAM AND THE QUBITS** — in a concert to cap off the Sept. 29 Open House.

Ingram, who co-hosted Discovery Channel’s *Daily Planet* for more than 15 years, will perform a custom-written show with his five-piece band and some special guests from IQC.

For more information, please visit:

iqc.uwaterloo.ca/10years ■

» SCIENTIFIC CONFERENCES

Throughout IQC’s 10th anniversary year, the institute will host more academic conferences and workshops than ever before.

Undergraduate School on Experimental Quantum Information Processing
May 28 – June 8, 2012
iqc.uwaterloo.ca/conferences/useqip2012/

12th Annual Canadian Summer School on Quantum Information
June 11-16, 2012
cssqi2012.iqc.uwaterloo.ca

9th Canadian Student Conference & 2nd AQuA Student Congress on Quantum Information
June 18-22, 2012
aqua2012.uwaterloo.ca

Quantum Cryptography School for Young Students
August 13-17, 2012

Quantum Innovators
September 6-9, 2012



Going **small**
in a **big** way

» September 2012 | **Grand Opening**



Mike & Ophelia Lazaridis Quantum-Nano Centre

Come celebrate with us!

Two world-class institutes:

The **Institute for Quantum Computing** and
the **Waterloo Institute for Nanotechnology**.

One state-of-the-art research facility
at the **University of Waterloo**.

Friday, September 21

Ribbon Cutting
Special Guests
VIP Reception

Saturday, September 29

Community Open House
Guest Lectures
Public Tours

UNIVERSITY OF
WATERLOO

IQC Institute for
Quantum
Computing

WIN WATERLOO INSTITUTE FOR
nanotechnology

 Ontario

 Industry
Canada Industrie
Canada

CANADA'S ECONOMIC
ACTION PLAN
D'ACTION
ÉCONOMIQUE DU CANADA

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