

6 GET TO KNOW IQC RESEARCHERS **08** TEN QUANTUM YEARS

# NewBit

Issue 18 | Winter 2012

## **O4** Canada's Research Excellence

IQC hosts major funding announcement



UNIVERSITY OF WATERLOO I OF Computing



## this issue

#### FUNDING ANNOUNCEMENT pg 04

IQC hosted the Canada Excellence Research Chairs funding announcement.

## IQC'S 10<sup>th</sup> ANNIVERSARY

Celebrations have begun! Find out how IQC will mark this milestone.

## TEDXUW

IQC postdoc has ideas worth spreading.

#### ON THE COVER

Prof. David Cory shows experimental equipment to Kitchener-Waterloo MP Peter Braid (centre) and Minister of State (Science and Technology) Gary Goodyear.

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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 leading academic journals.

#### » Quantum behaviour in eye of beholder

PHYS. REV. LETT. 107, 230406 (2011)

A recent *Physical Review Letters* paper co-authored by IQC researcher **RADU IONICIOIU** suggests that counterintuitive quantum behaviour is in the eye of the beholder.

Ionicioiu and **DANIEL TERNO** of Australia's Macquarie University proposed a new approach to understanding wave-particle duality. This duality is at the heart of Bohr's complementarity principle, which says that the study of complementary phenomena requires mutually exclusive experimental apparatuses.

The researchers proposed an experimental setup in which parts of the apparatus are simultaneously present or absent (in quantum "superposition"), which suggests a reinterpretation of Bohr's principle.

The "morphing" of a photon in this experiment between "particle" and "wave" suggests that these properties are not inherent, but a reflection of how we "look" at the photon.



A photon showing "morphing" behaviour between wave and particle.



Scanning electron micrograph of a device identical to the one measured.

#### QUANTUM DOTS RESEARCH YIELDS "SIMPLE YET ELEGANT" RESULTS

## SCIENTIFIC REPORTS 1, ARTICLE NUMBER: 110, OCTOBER 2011

A collaboration between researchers at IQC and in Australia has led to deeper understanding of quantum dots as a tool for quantum computation.

IQC doctoral candidate **FARZAD QASSEMI** co-authored a paper published in an October edition of the online journal *Scientific Reports*. The research team outlined how to minimize the unwanted interactions inherent to quantum information processing by using nuclei in silicon.

"The results are a key milestone in unravelling the full potential of highly coherent spin qubits," said Qassemi.



#### SEARCH FOR NEW CERCS LAUNCHED AT IQC



IQC was chosen by the federal government as the ideal setting in which to announce the next stage of a Canada-wide science funding totalling \$53.5 million.

On Nov. 28, Science Minister Gary Goodyear officially launched the search for the next 10 Canada Excellence Research Chairs — top international scientists recruited to Canada.

The new funding is on top of the \$190 million the federal government allotted in 2010 to attract 19 international researchers, including IQC faculty member **DAVID CORY** (above), Canada Excellence Research Chair in Quantum Information Processing. The CERC funding has enabled Cory and his team to pursue cutting-edge research into quantum sensors, actuators and other practical quantum technologies.

"Quantum information is poised to burst out of the lab and transform industry," Cory said during the ceremony. "And it can happen right here."

#### >> Experimental "tango" draws attention

PHYS. REV. LETT. 107, 170503 (2011)

A result by IQC researchers has been likened to a "tango" between nuclei and electrons in an article published in October on the *American Physical Society* website.

The "Viewpoint" article describes how IQC experimentalists put nuclear spins "into lockstep" with instructions from an electron. The article was sparked by a *Physical Review Letters* paper coauthored by IQC researchers **YINGJIE ZHANG, COLM RYAN, RAYMOND LAFLAMME** and **JONATHAN BAUGH**.



The magnetic dipole field produced by an electron spin, and a malonic acid molecule.

The IQC researchers developed a novel method for controlling qubits using nuclear spins, which capitalizes on the "anisotropic hyperfine interaction" between an electron and two nuclear spins in a solid-state system.

"The future of the technique described in this paper seems bright," lauded the Viewpoint article.  $\blacksquare$ 

#### >> IQC team advances error correction

PHYS. REV. LETT. 107, 160501 (2011)



An advance made by an IQC research team in experimental quantum error correction was recently showcased on the prominent science website **PhysOrg.com**.

The IQC research team demonstrated a three-qubit error correcting code using the magnetic resonance of carbon nuclei in a single crystal (their results were published in *Physical Review Letters*).

"We've shown that there is the control possible to perform error correction in solid-state systems where the information is encoded on nuclear spins," IQC postdoctoral fellow **OSAMA MOUSSA** said in the *PhysOrg* article.

#### >> STACK EXCHANGE

A group of IQC students is launching an online community where users can share expertise in quantum information science — with the most useful contributions rising to the top.

The Quantum Information and Foundations Stack Exchange site uses a "reputation" system, which gives prominence to the content deemed most helpful by users around the world.

The site is currently in the "commitment" stage — roughly 50 of the required 200 users have signed on so far. When the site becomes fully operational, it will "be a great tool for researchers everywhere," said PhD student **CHRIS FERRIE.** 





#### IQC Executive Director named APS Fellow

For his pioneering contributions to quantum information science, IQC Executive Director **RAYMOND LAFLAMME** has earned a fellowship in the American Physical Society.

The selection committee recognized Laflamme "for his visionary leadership in the field of quantum information science, and for his

numerous fundamental contributions to the theoretical foundations and practical implementation of quantum information processing, especially quantum error correction and linear optical quantum computing."

"I am delighted that my work has been recognized by the scientific community of the American Physical Society," said Laflamme. "But such work would not be possible without the vital collaborations I've had with colleagues including the faculty, postdoctoral fellows and students at IQC, as well as within the University of Waterloo and abroad."

### >> New Graduate Student Association

Thanks to the ever-growing number of students at IQC, the institute's first-ever Graduate Students' Association was created this past fall.

The association will oversee events and issues - both academic and social - important to IQC students.

The association has already overseen the creation of a *StackExchange* website, where users can post questions and provide answers about quantum information science. The association is planning a number of social events in the near future, including pub nights, snow tubing, laser tag and more.

Leading the association in its inaugural year are **CATHERINE HOLLOWAY** (president) and **TOMAS JOCHYM-O'CONNOR** (vice-president). For more information, visit: iqc.uwaterloo.ca/iqcgsa

#### >> WALRUS ARTICLE EXPLORES QUANTUM VALLEY

In the January 2012 issue of *The Walrus* magazine, journalist **DON GILLMOR** writes that "Silicon Valley will be eclipsed by Quantum Valley, and Waterloo will be poised to capitalize on the moment."

In an article titled *The Invention of Waterloo*, Gillmor examines how this mid-sized Canadian community has emerged from its industrial and agricultural past to become a science and technology epicentre "that big cities should emulate."





#### QIP 2012 Conference

IQC was well represented at the 15th Workshop on Quantum Information Processing in Montreal this December. Some IQC contributors included:

- "Quantum query complexity of state conversion," by BEN REICHARDT and collaborators
- "Hardness of approximation for quantum problems," by SEVAG GHARIBIAN and collaborators
- "A quantum information cost trade-off for the Augmented Index function," by ASHWIN NAYAK and collaborators
- "Discrete simulations of continuous-time query algorithms that are efficient with respect to queries, gates and space," by RICHARD CLEVE, DOMINIC BERRY and SEVAG GHARIBIAN
- "Parallel approximation of min-max problems with applications to classical and quantum zero-sum games," by GUS GUTOSKI and collaborators
- "Hedging bets with correlated quantum strategies," by ABEL MOLINA and JOHN WATROUS
- "Span programs for functions with constantsized 1-certificates." by ALEKSANDRS BELOVS

Gillmor interviewed innovation leaders from around Waterloo, including IQC Executive Director RAYMOND LAFLAMME.

"With quantum mechanics, we are learning to speak the language of atoms and molecules," Laflamme tells Gillmor. "Before, we could look at the effects, but we could hardly control them. Now we have the right language, the right tools and the right methods for controlling them."

# Questions & Answers

## Get to know IQC researchers

## **Get to know:**

Radu Ionicioiu | Research Assistant Professor



#### Hometown?

Bucharest, Romania; hot summers, cold winters — good training for Waterloo.

## What first intrigued you about quantum science?

The strangeness and out-of-this-world logic. Some quantum aspects (think complementarity) are like Zen koans – they freeze your flow of thought and suspend your thinking in disbelief. No wonder Bohr, Schrödinger and Bohm sought inspiration in Eastern philosophy and Buddhism.

## What are you currently working on?

Trying to make sense of the aforementioned strangeness by finding connections between quantum mechanics and foundations of mathematics and logic. I believe we have to distill from quantum experiments new mathematical tools to do the job. We can't use classical concepts to understand the quantum world (you can't use a hammer to cut the grass).

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

As a teenager, it was Einstein — the iconic physicist who single-handedly changed the paradigm of space and time. Later Dirac, for his capacity to make connections between seemingly disconnected topics. Then Feynman, for his unconventional thinking, his passion for science and his scientific integrity.

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

Imagine you arrive on a planet with laws so different than the ones you're used to (think Solaris) that all your intuitions are useless. Your task is not only to describe this new world, but also to make sense of it, to come up with a narrative behind your observations. You have first to understand what's going on and then reconcile your home-brew intuition with the new one.

## What hobbies/interests do you have away from IQC?

I like photography, especially street photography and black and white. Car design and modern architecture are two other topics I enjoy.

## What continues to pique your curiosity, scientifically or otherwise?

Ideas transcending our way of thinking, breaking everyday intuitions.



## >> Get to know: Florian Ong | Postdoctoral Fellow

Hometown? Verzé, Burgondy, France. Barely a thousand inhabitants, land of vineyards and cows, forests and hills.

#### What first intrigued you about quantum science?

Intuition and common sense have long been reliable tools for building models, making precise predictions, and understanding nature. But a few phenomena have stood up and forced the human brain to go beyond reason and deal with some craziness.

#### What are you currently working on?

I'm an experimentalist interested in mesoscopic condensed matter physics, an exciting world where nanoscale systems hang out with microwaves and millikelvins. I'm currently studying hybrid devices made up of superconducting circuits and semiconducting quantum dots.

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

I admire thinkers like Aristotle, da Vinci and Pascal, who made essential contributions to disparate fields of knowledge. Times have changed, overspecialization became the rule, and now research and business are so entangled that a single discovery can have dramatic environmental and economical consequences. In that context, I'm inspired by scientists like Ignacio Chapela, Jacques Testart and others who have had the courage to tackle the societal impact of their research whatever the political/financial consequences.

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

Depends on how "lay" the person is... It goes from "I take a piece of metal, I shrink it, I put it in a big fridge, then it starts to behave very weirdly" to much deeper discussions. I found out that people who have no scientific background, but instead are versed into esotericism, have a puzzling intuition about quantum mechanics.

#### What hobbies/interests do you have away from IQC?

Playing music on various instruments, like accordion, piano, guitar, didgeridoo and jawharp. Sweating outdoors, preferably in a wild mountainous environment. Owing to Ontario's flatness, I focus on road running and cycling, and next year I'll be part of the Canadian team at the Duathlon World Championship (any sponsors welcome!)

#### What continues to pique your curiosity, scientifically or otherwise?

Everything. I'm a real nerd, trying to absorb any information from random facts to theories I barely understand.



#### >> Get to know: Aimee Heinrichs | Masters Student

Hometown? I'm from Penticton, British Columbia - the land of peaches, beaches, and the lake monster Ogopogo.

#### What first intrigued you about quantum science?

I was surprised that the strange and mysterious effects of quantum mechanics can be found in something as "normal" and "boring" as light. There was a whole field of quantum-related research with applications to the real world I knew nothing about. Call me a bandwagon-jumper but I had to be part of it.

#### What are you currently working on?

Homework. I am also currently working on an application of entangled two-photon absorption in biological imaging. Eventually, I want to see if the molecules used for two-photon absorption in biological imaging could be suitable as a medium for two-qubit interactions in linear optics quantum computing.

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

The more I learn about science, the more I respect the scientists who came before me. I'm inspired by the scientists I meet every day and, when "I grow up," I want to be like them.

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

I play with lasers and crystals and do magic. I'm working on a project to merge the respective technologies of quantum optics and biological imaging to investigate whether certain molecules can be useful for quantum computing.

#### What hobbies/interests do you have away from IQC?

I enjoy backpacking with friends and family in this great place called "the outdoors." I also practice my experimental skills in cooking Thai food and baking various types of cheesecakes.

#### What continues to pique your curiosity, scientifically or otherwise?

I love understanding things today that I didn't yesterday. I'm also still amazed by how complicated mathematics can describe the world around me.

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## **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.

IQC officially launched on Nov. 26, 2002, with just a small group of researchers and a big vision: to become a world-leading hub for research in quantum information.

"In just 10 years, our growth and success have been incredible," says IQC Executive Director Raymond Laflamme. "IQC is now known around the world as a premier centre for quantum information science."

To commemorate IQC's 10th Anniversary year, the institute will host a slate of activities — ranging from scientific conferences to cultural events — aimed at showcasing the research, the scientists and the future of the institute. "The excitement hasn't abated at all over 10 years," says Laflamme. "In fact, it's ramping up. The next year, and many years to come, will be tremendously exciting for IQC and quantum information research as a whole."

IQC's 10th anniversary will be marked by another giant leap in the evolution of the institute — the expansion into the Mike & Ophelia Lazaridis Quantum-Nano Centre at the University of Waterloo.

"IQC has exceeded all my expectations in its first 10 years, and the momentum keeps building," says Laflamme. "We have the people, the expertise and resources to truly lead the quantum revolution."

#### >> SCIENTIFIC CONFERENCES

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

#### Distinguished Lecture Series

January 19, 2012

David J. Wineland, National Institute of Standards and Technology Recent Progress in Quantum Algorithms April 11-13, 2012

qa2012.iqc.uwaterloo.ca

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



✓ Participants in USEQIP 2011

Participants in Tropical QKD 2011 >>

**08** IQC

More anniversary details will be posted at iqc.uwaterloo.ca/10years



### >> 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

Community Open House, Guest Lecturers, Public Tours Saturday, September 29, 2012

#### Quantum: Music at the Frontier of Science

#### February 23 and 24, 2012

A musical and educational collaboration between IQC and the Kitchener-Waterloo Symphony.



Tropical QKD June 25-29, 2012

Quantum Cryptography School for Young Students

August 13-17, 2012

Next Generation of Quantum Researchers

Early September 2012

Decoherence & Friends, Wojciech Zurek's 60th Birthday

September 10-14, 2012

Quantum Information Processing with Spins and Superconductors

Dates to be confirmed

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✓ Participants in QCSYS 2011

#### Twitter @QuantumIQC

# In the Community



## » TEDxUW

"Physics is a poem that nature has written about how the universe works," said IQC postdoctoral fellow **KRISTER SHALM** during his talk at the inaugural TEDxUWaterloo on Nov. 12.

In a captivating and inspirational talk, Shalm described the three personal discoveries that forever changed his life: poetry, physics and dance.

Shalm explained how his seemingly disparate passions — whether wrangling photons in an IQC lab or lindy-hopping to Dixieland jazz — form the poetry of his life.

The talk, which was webcast live, generated plenty of positive buzz on Twitter, with such tweets as: "Krister Shalm is the most engaging physicist I've ever seen."

The entire talk is posted on **tedxuw.com**. Shalm will also be a featured speaker at TEDxWaterloo on March 21, 2012.

## ✤ IQC Holiday Food Drive

The IQC family gave back to the community of Waterloo Region this holiday season by donating more than 700 items — that's 580 pounds — to the Food Bank of Waterloo Region, exceeding our goal of 500 items.

## SEASONAL GATHERING

For IQC's extended family



(Left) Four year old **JONAS GOERTZ** visits with Santa Claus at IQC's annual seasonal gathering held on December 1 at the University Club on main campus.

(Right) MIA BAUGH, daddy JONATHAN and Santa.

## >> Arrivals

 $(\mathbf{N})$ 

Research Assistant Professor Radu Ionicioiu

Postdoctoral Fellow David Gosset

#### Students

Elena Anisimova Feyruz Kitapli Daniel Puzzuoli

#### Undergraduates

Zheng Cui Madelaine Liddy Martin Otto Aakash Ravi Dusan Sarenac

#### Long-Term Visitors

Jun Li Carmello Scarcella Hou Shiyao

Staff Matt Fries



## Where have you been?

Do you have a photo of yourself wearing an IQC hat or t-shirt somewhere outside of IQC? E-mail us at **iqc@uwaterloo.ca** or join us at **flickr.com/quantumiqc** 

Check out the map in RAC1 by the NMR lab to see more photos of IQC Around the World!



Raymond Laflamme in Doha, Qatar for the World Conference of Science Journalists

IQC 11

## Save the dates

Grand Opening of the Mike & Ophelia Lazaridis Quantum-Nano Centre

Two weekends of special events to launch the next big thing in the quantum revolution.

**Ribbon Cutting Ceremony Special Guests VIP** Reception

**Community Open House Guest Lecturers Public Tours** 

>>> Friday, September 21, 2012 >>> Saturday, September 29, 2012

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









