

ISSUE 22 | WINTER 2014

A NEWSLETTER FROM THE INSTITUTE FOR QUANTUM COMPUTING, UNIVERSITY OF WATERLOO

# NEWM BIT

## Quantum cryptography: A HOT TOPIC

06 SCIENCE HIGHLIGHTS 08 JOHN PRESKILL LECTURES AT IQC 15 A SUCCESSFUL OPEN HOUSE



UNIVERSITY OF  
**WATERLOO**

**IQC**

Institute for  
Quantum  
Computing



UNIVERSITY OF  
WATERLOO



Institute for  
Quantum  
Computing

NEWBIT | ISSUE 22 | WINTER 2014

IN

# this issue

## THE LAZARIDIS QUANTUM NANOFAB FACILITY pg 04

Maximizing performance  
for our researchers

## SPARKING THE NEXT TECH REVOLUTION pg 10

Laflamme makes a quantum  
impression during UK summit

## NEW IQC ASSOCIATES pg 12

Amir Yakoby and Steve MacLean  
appointed IQC associates

## ON THE COVER

**Cover Photo by:** *Light Imaging*  
PhD student Jean-Philippe Bourgoin  
holding the free-space quantum receiver

## WINTER 2014

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## FROM THE EDITOR

As the summer closed, and a busy August full of cryptography conferences and schools ended, we started a new academic year with new faculty and new students.

Expansion continues at the Institute for Quantum Computing. Some of it still in the planning phase, but more labs at the Lazaridis Centre are being installed, as well as the Lazaridis Quantum NanoFab facility, featured in this issue of *NewBit*.

The research at IQC continues to be published in high impact journals. In this issue, we feature recent results published in *Nature Photonics* and the *Physical Review Letters*, as well as in the proceedings of two prestigious conferences. IQC research has also been covered outside of research publications. Since we began writing this issue up until December almost 80 media articles have been written about IQC by publications such as *The Economist*, *Maclean's*, *MIT Technology Review*, *Popular Science* and *naturejobs.com*.

One of the strategic objectives of IQC is to establish the institute as the authoritative source of insight, analysis and commentary on quantum information. Being featured in the media helps us achieve that objective, as do the numerous outreach activities that our members take part in. We highlight many of these activities in this issue including:

- » A scavenger hunt for girls interested in science
- » An IQC member featured on the *Star Spot* podcast
- » Public lectures
- » An open house
- » A special trip to India
- » A technology summit in the UK
- » A student mixer to bridge entrepreneurship and technology on campus.

Our activities and the recognition we receive continue to attract more students, postdoctoral fellows, faculty members, long-term visitors, funding opportunities and awards. This will all support and expand the groundbreaking research that is happening at IQC.

**JODI SZIMANSKI**, *Senior Communications Manager*





## cryptography: a hot topic

IQC hosted several events on quantum cryptography throughout July and August.

It started with the International Quantum Key Distribution (QKD) Summer School at the end of July. Graduate students and postdoctoral fellows headed to IQC to learn about how they could further their own research in cryptography. Almost a third of the researchers arrived from Canadian institutions, while others travelled from five different continents. Organized by professor **NORBERT LÜTKENHAUS** and postdoctoral fellow **OLEG GITTSOVICH**, the conference was sponsored by IQC, CryptoWorks21 and the Fields Institute for Research in Mathematical Sciences.

Just three days later the third international conference on quantum cryptography started at IQC. QCrypt 2013 was chaired by IQC's **VADIM MAKAROV**. Some interesting statistics about QCrypt 2013:

- » 9 invited speakers
- » Over 20 papers presented
- » 4 tutorials
- » 1 after dinner talk by a lock and locksmithing expert Marc Weber Tobias
- » 1 public lecture by John Preskill
- » Over 70 posters
- » Over 20 sponsors
- » 15 industry exhibits
- » 1 industry panel session with 5 industry experts.

Again with only three days between events, IQC was taken over by a new generation of cryptographers with the Quantum Cryptography School for Young Students. This year 41 high school students from Canada, the US, Poland, Romania, the Sultanate Of Oman, South Africa and China had the chance to learn about quantum cryptography through lectures, hands-on experiments and group work. For a week, these students experienced life on a university campus and had an introduction to quantum mechanics, information security and quantum cryptography. ■

»» **WEB** Tutorials and presentations from QCrypt 2013 are available on our YouTube channel <http://bit.ly/1biorf3>



## THE LAZARIDIS Quantum NanoFab FACILITY



THE TEAM IS WORKING TO MINIMIZE DOWNTIME AND TO MAXIMIZE SYSTEM PERFORMANCE FOR OUR RESEARCHERS. WE HAVE TAKEN STEPS TO ENSURE OPTIMAL PERFORMANCE OF THE MANY EXISTING RAC1 SYSTEMS ONCE THEY HAVE BEEN MOVED TO THEIR NEW HOME AT THE LAZARIDIS CENTRE. ”

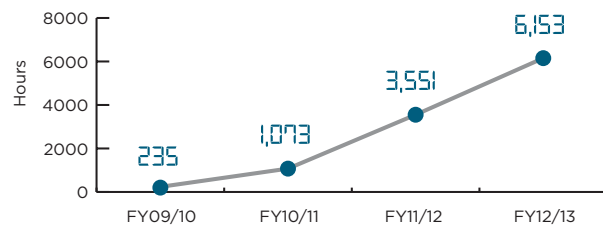
**VITO LOGIUDICE**  
Director of operations,  
Quantum NanoFab

The Quantum NanoFab Facility will open up new worlds for IQC and the Waterloo Institute for Nanotechnology (WIN). Lab members will be able to fabricate tiny devices with films that are in some cases just a few atomic layers thick, in some of the cleanest facilities available on campus. For researchers at IQC, it means the ability to fabricate a wide range of devices that they'll be able to use in experiments in their own labs.

As we move into the final stages of the cleanroom fitout in the Lazaridis Centre, the RAC1 Cleanroom/Fabrication Centre will soon be closing its doors to prepare for the upcoming equipment moves. When the Lazaridis Centre first opened, its cleanroom was a clean "box" still needing work to render it operational.

Once the environmental tests were successfully completed, AdvanceTEC LLC moved in to work on the design and installation of the many specialized services required by the lab equipment slated for installation in the facility.

The \$3.5M fitout project is extremely complex and requires the coordination of multiple companies and activities. The coordination is needed to ensure that all services are designed and installed to the very high standards typically demanded in industrial chip-making facilities such as those operated by Intel and Teledyne-Dalsa. Four months were needed for the fitout project's design and planning phase and an additional five to six months are needed for project execution.

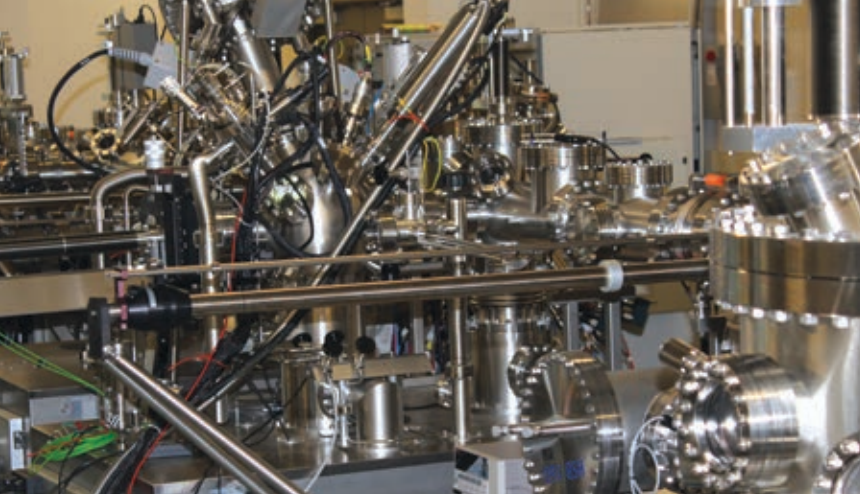


➤ RAC1 cleanroom saw an increase in traffic of >2500% in 4 years

Process repeatability is crucial – all systems need to work consistently, and much as they did at RAC, to avoid impacting the work of our researchers when operations at the Lazaridis Centre commence. To ensure process repeatability Logiudice's team uses an eight-page detailed checklist unique to each system that includes statistical process control data captured both pre- and post-move to ensure each system's post-move performance will be identical to or similar to its performance prior to the move.

Depending on system complexity, execution of the checklist for a single system will require up to 23 hours of process engineering work and up to 85 hours of equipment tech work as needed to prepare the system for its physical move and for its eventual re-certification. A total of 13 systems will be handled in this manner by the team's lead process engineer, **NATHAN NELSON-FITZPATRICK**, and the team's two senior equipment technologists, **BRIAN GODDARD** and **ROD SALANDANAN**.





» OMICROM-OXFORD multi-cluster thin film system

Here's an example: the *Oxford Instruments* cluster tool. This machine is equipped with two distinct chambers and is thus capable of two different film deposition techniques – Plasma-Enhanced Chemical Vapor Deposition (PECVD) and Atomic Layer Deposition (ALD) – which each enable novel research initiatives. The system can precisely deposit very thin and conformal films that are “grown” one atomic layer at a time.

The many services required for this one system make its move and re-certification highly complex. Services include many high purity gas lines as well as an exhaust abatement system for “scrubbing” system exhausts clean of toxic byproducts prior to release to the building’s central exhaust system. The cluster system is unique in that it will eventually interface with a mobile “vacuum-suitcase unit” which will permit freshly deposited ALD films to be transferred under vacuum to other vacuum systems located on campus, including the OMICRON-OXFORD multi-cluster thin film system located in **DAVID CORY**’s lab in the RAC2 building.

In addition to the 13 lab systems being moved, many new, highly specialized pieces of lab equipment are being added including seven custom wet benches. One of which is a four-tube furnace stack that can deposit films such as silicon carbide. Because silicon carbide can withstand extremely high temperatures, it is sometimes used in the fabrication of very specialized sensors such as those used in jet engines for example.

Before Quantum NanoFab operations ramp up in the Lazaridis Centre in April 2014, Logiudice’s team will hold several training and information sessions for existing Lab Members and members of the uWaterloo research community interested in using the facility. These sessions will serve to make the entire community aware of the more stringent operating procedures which will be implemented to ensure compliance with the facility’s much cleaner environment - up to 1,000 times cleaner - than that offered by the RAC1 Cleanroom.

Meticulous planning by Logiudice’s team will ensure not only the safety of the users of the cleanroom, but the highest operating standards for the facility itself and the state-of-the-art equipment it will house, to the overall benefit of its community of researchers using the lab. ■



» Furnace gas manifold

## » COMMISSIONING TEST RESULTS

» **ISO5** (less than 100 particles per cubic foot of air) and **ISO6** (less than 1,000 particles) design specifications have been met.

Generally, an office building has 500,000 to 1,000,000 particles per cubic foot of air.

» **VC-E Vibration test** criteria (<3 micrometres/sec) have also been met with excellent 3-axis values of <0.1 micrometres/sec measured in the electron-beam lithography bay for frequencies above 40Hz.

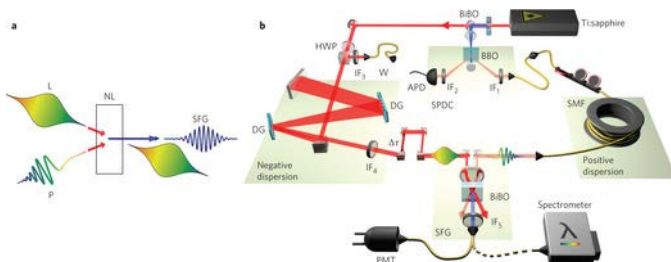
A typical office building tests at 2-3 millimetres/sec.

**These are some of the services being installed and routed within the Lazaridis Cleanroom under the scope of the fitout project:**

- » Power
- » Ultra high purity deionized water
- » Chemical waste neutralization
- » Clean, dry air (CDA)
- » Ultra high purity nitrogen gas
- » Toxic and heat exhausts
- » Process chilled water (PCW)
- » Over 20 types of high purity process gases
- » Environmental monitoring system
- » Toxic gas monitoring system

# SCIENCE HIGHLIGHTS

IQC faculty, postdoctoral fellows and students continue to conduct internationally recognized research into quantum information science. Here is a sampling of their cutting-edge research published recently in academic journals over the past term.



Single-photon bandwidth compression scheme



## WORKING TO MATCH BANDWIDTHS

NATURE PHOTONICS 7 (2013)

Four IQC researchers, along with a colleague from the University of Queensland, demonstrated bandwidth compression of a single photon. While photons are a prime candidate for creating quantum networks, different elements in the network may require photons with vastly different properties, such as central frequency and spectral bandwidth. Matching these requirements will be necessary for interfacing photonic quantum bits to quantum repeater nodes for communication. **JONATHAN LAVOIE** (PhD student), **JOHN DONOHUE** (PhD student), **LOGAN WRIGHT** (Undergraduate Research Assistant), **ALESSANDRO FEDRIZZI** (University of Queensland) and **KEVIN RESCH** (Associate Professor) upconverted single photons using a synchronization process to ensure that every frequency in the photon bandwidth can only convert into one central frequency. The team achieved a single-photon spectral compression by a factor of 40. This is a step toward arbitrary waveform generation for single and entangled photons. Work continues to eventually reach factors of >1000 to match a GHz photon to a MHz memory.

The paper, *Spectral compression of single photons*, was published by *Nature Photonics* in May. ■

## Quantum one-time programs

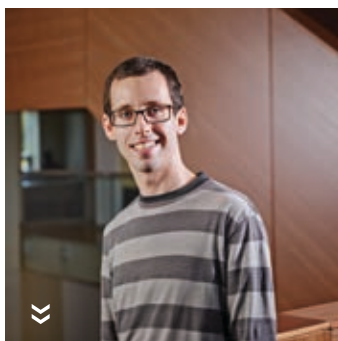
IQC Postdoctoral Fellow **GUS GUTOSKI** with IQC alumni **DOUGLAS STEBILA**, now at Queensland University of Technology and **ANNE BROADBENT**, now at the University of Ottawa, had a research paper accepted at the prestigious International Conference on Cryptology, CRYPTO 2013, in August. Their paper *Quantum one-time programs* showed that it is possible to build secure one-time programs even if used as part of a larger computer system that involves cryptography.

A one-time program can be thought of as a hypothetical computational device which allows a user to run a program on an input of his choosing a single time. In other words, it takes an input such as an algorithm from the user, runs a program and then self-destructs, forever securing the information. These programs are made out of extremely simple classical devices called one-time memory devices (hypothetical hardware devices used to show the existence of classical one-time programs), together with quantum operation. ■

## »» ACHIEVING UNIVERSALITY

PHYS. REV. LETT. 111, 090505

IQC PhD student **ADAM PAETZNICK** and former IQC faculty member, now at University of Southern California, **BEN REICHARDT**, made a significant contribution to the field of fault-tolerant quantum computation. To prevent accumulation of errors while performing encoded, but faulty, quantum operations, transversal operations are desired since single qubit errors do not spread to multiple qubits. Unfortunately, it is known that universal fault-tolerant quantum computing cannot be achieved using only transversal encoded quantum operations. Universality is typically achieved via the distillation of special resource quantum states. Paetznick and Reichardt demonstrated that for the class of “triorthogonal stabilizer codes”, they can achieve universality using only transversal operations and standard quantum error correction procedure, without the use of distillation. Moreover, based on the previous procedure, they derived a distillation protocol that is more efficient than previous state-of-the-art distillation methods. The paper, *Universal fault-tolerant quantum computation with only transversal gates and error correction* was published in *Physical Review Letters* in August. ■

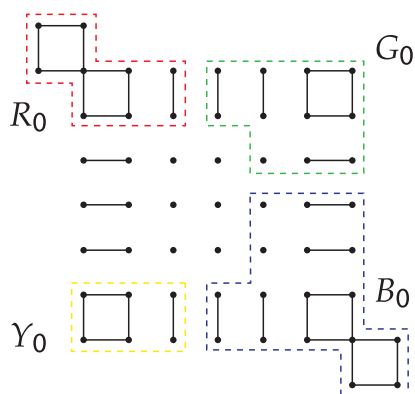


David Gosset

## »» Resolving the boundary between “easy” and “hard”

PROCEEDINGS OF FOCS 2013

In their article *Quantum 3-SAT is QMA<sub>1</sub>-complete*, published in the Proceedings of the IEEE 54<sup>th</sup> Annual Symposium on the Foundations of Computer Science (FOCS), IQC Postdoctoral Fellow **DAVID GOSSET** and his colleague **DANIEL NAGAJ** (University of Vienna), finally resolved the boundary between “easy” and “hard” for the quantum version of the satisfiability (SAT) problem. In computer science, the satisfiability problem is of central importance since it is equivalent to a wide array of other problems which arise in applications. The quantum version of the satisfiability problem is also relevant to the study of frustration-free Hamiltonians, which naturally arise in quantum error correction and play a central role in the field of Hamiltonian complexity and in condensed matter physics. ■



« The groundspace of

$$\mathbb{I} \otimes H_{\text{clock}}^{(9)} + H_{\text{clock}}^{(9)} \otimes \mathbb{I} + S^{(1,3)} + S^{(7,9)}$$

# » IQC OUTREACH

## » A focus on girls in science

On July 13, PhD student **CATHERINE HOLLOWAY** organized a scavenger hunt for a group of 10 girls attending a summer camp run by the Laurier Centre for Women in Science. Eight codebreaking stations were set up through the Lazaridis Centre to teach the girls about cryptography. Holloway was joined by fellow IQC students and high school students. ■



» **MILES CRANMER, SASHA CHUCHIN** and **RAYMOND LAFLAMME** look on as two participants work on a problem at one of the stations.



## JOHN PRESKILL

During QCrypt 2013, **JOHN PRESKILL**, the Richard P. Feynman Professor of Theoretical Physics from the California Institute of Technology, gave a public lecture at IQC. *Quantum Computing and the Entanglement Frontier* focused on why Preskill loves quantum entanglement. Self-proclaimed as “less weird than a quantum computer, and easier to understand,” Preskill explained how by exploiting quantum entanglement quantum computers should be able to solve otherwise intractable problems that could apply to cryptology, materials science and medicine. ■

## » EPISODE 36

Starring **MARTIN LAFOREST**



Senior Manager, Outreach, **MARTIN LAFOREST** appeared on *The Star Spot*'s 36<sup>th</sup> episode of their podcast. Titled *Quantum Computing: Space Science Meets Science Fiction*, Laforest answered questions about a number of topics to discover where science meets, or doesn't meet, science fiction, including quantum teleportation and quantum communications with extraterrestrials.

WEB <http://bit.ly/1hJyXa8> ■



Entrepreneurship on Campus group >>  
interacting in the Lazaridis Centre kitchen.



Photo credit: Wayne Hsu

## >> RUN BY AND FOR GRADUATE STUDENTS

Canadian-American-Mexican Graduate Student Physics Conference (CAM) 2013 was held at the University of Waterloo and Perimeter Institute August 15-18. IQC was not only a sponsor of CAM, but several of our students, as well as a faculty member and an associate, were involved in the conference.

- >> **Program committee** – PhD students **EVAN MEYER-SCOTT** and **RAZIEH ANNABESTANI**
- >> **Local organizing committee** – PhD students **EVAN MEYER-SCOTT**, **CHRISTOPHER PUGH**, **CATHERINE HOLLOWAY**, **JOHN DONOHUE**, **GREG HOLLOWAY**, **BEN CRIGER**, **RAZIEH ANNABESTANI**, **COREY RAE McRAE** and **AIMEE HEINRICHS** and Master's student **MEGAN AGNEW**
- >> **Parallel session presenter** – Master's student **LYDIA VERMEYDEN** presented *Experimental testing of Bell inequalities with marginal contributions*
- >> **Ask a Theorist session at the Grad House** – Associate Professor **JOSEPH EMERSON** and IQC Associate **ACHIM KEMPF**
- >> **Poster Session** – PhD student **VIBHU GUPTA** presented his poster *Quantum Discord as a Signature of Quantum Chaos* and PhD student **JOHN DONOHUE** presented his poster *Ultrafast Coherent Measurement of Time-bin Qubits Using Chirped Pulse Upconversion*. ■

## >> Bridging entrepreneurship and technology on campus

The University of Waterloo has several entrepreneurship programs on campus. The university is also known for the “technical” programs with the potential to innovate new products. Two MBET graduates **SEN SACHI** and **RAMZI SAMARA** joined forces with Master's student **COREY RAE McRAE** and Senior Manager, Outreach, **MARTIN LAFOREST** to create a bridge between the two groups. They called the evening *Entrepreneurship on Campus*.

The team of four invited five representatives from MBET, BET300 and Enterprise co-op, VeloCity, WIN and nanotechnology engineering, MDEI and IQC. One representative of each group had the opportunity to talk about their program and how it fits into the innovation ecosystem. Afterwards the students networked to learn more about each other and make connections. ■

## From Wonder to Wow

On October 1, Executive Director **RAYMOND LAFLAMME** participated in the Perimeter Institute for Theoretical Physics' BrainSTEM: Your Future is Now Festival as a guest lecturer. His lecture entitled *From Wonder to Wow: Why the quantum age is closer than you think* gave the audience a glimpse of how new technologies emerging from the quantum realm will change the ways we work, communicate and live in the future.

WEB <http://bit.ly/176eYEA> ■



- >> Organizers and committee members with invited speaker **MIGUEL ALCUBIERRE**, Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de México

## » Sparking the next tech revolution

Executive Director **RAYMOND LAFLAMME** traveled to the UK to speak at the third Bloomberg Enterprise Technology Summit in London. The conference, attended by top technology decision makers in the financial services sector, covered the most important technologies for the data-driven enterprise, including mobile technologies, open source, cloud computing, virtualization and security.

Laflamme was invited to join the Ontario Ministry of Economic Development, Trade and Employment at a lunch on *Accelerating a financial tech ecosystem* with The Honourable **DR. ERIC HOSKINS** along with **JANET ECKER**, President and CEO of Toronto Financial Services Alliance. He also spoke on a panel discussing big data called *Leveraging High Fidelity Data*.

According to Diane Brady, Senior Editor at Bloomberg Businessweek, in *Bloomberg Now*, "The Ontario contingent also left a deep impression, and not just because I grew up near Toronto. Part was due to the vision of how quantum mechanics will spark the next tech revolution, as laid out by Raymond LaFlamme." ■



» **RAYMOND LAFLAMME, JANET ECKER**  
and Minister **ERIC HOSKINS**

## UPCOMING EVENTS

» 2014 American Association for the Advancement of Science Annual Meeting

» **CHICAGO**  
February 13-17

» Quantum Frontier Distinguished Lecture

**JOHN KIRKLEY**,  
Physical Science  
Research Associate at  
Stanford University

» **IQC**  
Wednesday, March 26 ■



## Developing relationships in **INDIA**

Early in December, Executive in Residence **BOB CROW** travelled to India as a member of the Canada - India ICT Working Group. His trip provided an opportunity to reach out to India's quantum information community and Government of India officials. Crow was able to highlight and promote our relationship with the Raman Research Institute in Bangalore where former IQC researcher, now IQC Affiliate, Dr. Urbasi Sinha is an Associate Professor. Crow also gave a short talk and sponsored a banquet at the prestigious Haresh-Chandra Research Institute in Allahabad where the Indian quantum information research community was meeting. ■



# Around the INSTITUTE



## TOURS/VISITS

### Discussing Canadian Innovation



The Honourable **GREG RICKFORD**, Minister of State for Science and Technology, toured IQC with local MP **PETER BRAID** in November. While at IQC, Minister Rickford hosted a roundtable discussion on Canadian Innovation with members of the Waterloo community including **GEORGE DIXON**, VP University Research, University of Waterloo; **MAX BLOUW**, President, Wilfrid Laurier University; **RAYMOND LAFLAMME**, Executive Director IQC; **BOB CROW**, Executive in Residence, IQC; **COSIMO FIORENZA**, General Consul, Quantum Valley Investments; **MICHAEL DUSCHENES**, COO, Perimeter Institute; and **IAIN KLUGMAN**, President, Communtech.

➤ **RAYMOND LAFLAMME**, Minister **RICKFORD** and MP **PETER BRAID** ■



### Global quantum communications

General (Retired) **WALTER NATYNCZYK**, President of the Canadian Space Agency met with members of IQC on October 29. IQC members **THOMAS JENNEWEIN**, **MICHELE MOSCA** and **RAYMOND LAFLAMME** are working with the Canadian Space Agency on research into a global quantum communication system utilizing satellites. General Natynczyk took the helm at CSA in August. ■



(L-R) **BRENDON HIGGINS**, **THOMAS JENNEWEIN**, General **WALTER NATYNCZYK** (CSA), **CHRIS PUGH** (in behind), **RAYMOND LAFLAMME**, **CHRISTIAN CHOUINARD** (CSA) and **ERIC LALIBERTÉ** (CSA)

### A NEW PORTFOLIO

The Honourable **REZA MORIDI**, Minister of Research and Innovation and MPP for Richmond Hill visited IQC in July. IQC Executive Director, **RAYMOND LAFLAMME**, toured Minister Moridi through the labs in the Lazaridis Centre and the Research Advancement Centre and shared the exciting developments in quantum research that are part of the Minister's new portfolio. Moridi was appointed the Minister of Research and Innovation on February 11, 2013. ■

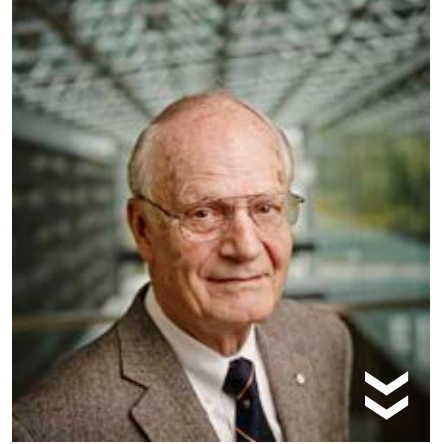
### Fujitsu visits IQC

A delegation from Fujitsu in Tokyo visited IQC on September 6. Mr. **SHIGERU SASAKI**, Senior Executive, Fujitsu and Mr. **HARUYUKI KODAMA**, Auditor, Fujitsu, were joined by Mr. **KOJIRO ICHIKAWA**, Trade Commissioner to Canada during their visit. Mr. Sasaki and his colleagues met with various IQC members and toured IQC labs as a first step in exploring partnership opportunities. ■



# » Around THE INSTITUTE

## » ANNOUNCEMENTS



### NEW IQC ASSOCIATES



**AMIR YACOBY**, a renowned experimental condensed matter physicist, has been appointed as an IQC associate and the Distinguished Research Chair in Condensed Matter.

A professor of condensed matter physics at Harvard University, Yacoby will spend three months each year as a visiting professor in Waterloo participating in research at IQC. His lab will focus on implementing quantum information processing in condensed matter systems.



Before **STEVE MACLEAN** was a Canadian astronaut and the president of the Canadian Space Agency, he was a physicist researching electro-optics, laser-induced fluorescence of particles and crystals and multi-photon laser spectroscopy.

His research at IQC will focus on the development of attosecond lasers. This type of laser would produce shorter and more powerful pulses of light to allow for images as precise as the space between atoms to be captured. ■

### IQC Board Chair shares experience and expertise

Not only has **TOM BRZUSTOWSKI**, chair of the IQC Board, taught at the University of Waterloo as a professor of Mechanical Engineering, he also served as Vice-President, Academic for a dozen years. He left the university to serve as a deputy minister in the Government of Ontario before being appointed the President of NSERC. After that he taught innovation in the Telfer School of Management at the University of Ottawa.

Tom recently moved back to Waterloo and will be sharing his experience and expertise on a regular basis to help move forward during its rapid growth over the next few years. He's spending his time renewing the Board of Directors, meeting with government officials and attending as many lectures as he can by both visitors and students to get more in depth knowledge of the many areas of IQC research. ■



» The winning team

### FORE!

Faculty, students and staff with all levels of golf prowess gathered at the Waterloo Golf Academy for the annual IQC golf tournament. It was one of the hottest days of summer, but we had a golf cart filled with water and popsicles to help the competitors stay in the game. Congratulations to the winners: Associate Professor **JOSEPH EMERSON**, PhD student **CHRIS PUGH** and Master's student **MIKE MAZUREK**. ■

### » Undergraduate research assistants

We had over 20 undergraduate research assistants join us for the spring term. Nine of the students attended the annual two-week Undergraduate School on Experimental Quantum Information Processing (USEQIP) in May before their work in the labs began. In addition to six uWaterloo students, we had students from UBC, UofT, McGill, Mount Allison and Harvard, as well as China, India, Slovakia and the UK. To help connect all the non-local students, they had the opportunity to live together in the on-campus townhouses. ■



## IN THE NEWS

### A pillar for building a quantum industry in Waterloo

*MIT Technology Review* highlighted the world-class research at IQC in an article called *The Bell Labs of Quantum Computing* on July 22. The article shared IQC's vision to build a quantum computer, along with the development of other quantum technologies with the potential for commercialization. It provided examples of some of the commercialization efforts happening at IQC, including the satellite project for secure global quantum communication. According to the article, the research and technology at IQC is just the start of **MIKE LAZARIDIS'** vision for Waterloo as the "Quantum Valley". ■

### GROWING A QUANTUM REPUTATION

In another article focusing on the growth of "Quantum Valley" in Waterloo, *naturejobs.com* featured IQC along with the Perimeter Institute on October 2. Executive Director **RAYMOND LAFLAMME** was interviewed in *Quantum mechanics: Waterloo gets physical* about the institute, its research and its projected growth. The writer also interviewed Assistant Professor **MATTEO MARIANTONI** about his decision to join IQC in 2012. Senior Manager, Outreach, **MARTIN LAFOREST** also weighed in to talk about the entrepreneurial spirit of our researchers – which led to startups such as Universal Quantum Devices, co-founded by Laflamme. ■

### Quantum communications highlighted in *The Economist*

*The Solace of Quantum* in *The Economist* on May 25 told a story about using quantum mechanics to stop Eve from eavesdropping on Alice and Bob. The research methods of Associate Professor **THOMAS JENNEWEIN** and his team were highlighted explaining how they are working to establish secure global quantum communication networks via satellite.

WEB <http://econ.st/1i51PUP> ■



## FROM THE IQC GSA

The IQC graduate student association (IQC GSA) is a group of five students dedicated to improving the already vibrant student life at IQC. Recently, the IQC GSA has organized student social events such as weekly lunch barbeques during the warm weather, a bowling night for new graduate students, a Halloween costume contest, and recurring board game and social nights at the University of Waterloo Grad House.

The future plans of the IQC GSA include a private screening of the film *Gravity* followed by a Q&A by celebrated Canadian astronaut Steve MacLean (tentatively scheduled for early March). Other upcoming events include a lecture series by industry speakers with careers in quantum computing and quantum information, as well as the first meeting of an entrepreneurship student group.

Corey Rae McRae ■



⤴ IQC Halloween costume contest

### A highlight this year

The Classical and Quantum Gravity (CQG) selected an article by Postdoctoral Fellow **EDUARDO MARTIN-MARTINEZ** and **NICHOLAS C. MENICUCCI** (Perimeter Institute) for the CQG Highlights of the year 2012-2013. *Cosmological quantum entanglement* was one of four articles selected under the category Quantum Cosmology. Highlights features some of the highest quality work in gravitational physics. ■

### Primary Guest Editor

Associate Professor **HAMED MAJEDI** is the Primary Guest Editor for a special issue of *IEEE* journal of selected topics in quantum electronics. *The Superconducting Quantum Electronics and Photonics* issue is scheduled for March/April 2015. ■

## **NEW COURSES/ WORKSHOPS**

### » **Quantum Computation and Complex Networks**

During the spring term we held a three-day workshop for researchers and students from diverse scientific areas to make connections and stimulate new relevant questions about quantum computation. Current work studying quantum many-body systems with tailored geometry and controlled information exchange will lead to solutions for large-scale quantum networks.

### » **Sir Anthony Leggett lecture series**

Sir **ANTHONY LEGGETT** offered a lecture series for the seventh time during his stay at IQC this past spring. This year, his 12 lectures focused on topological insulators and superconductors and topological quantum computing.

**WEB** To view the lectures, visit our Anthony Leggett 2013 Summer Lecture Series playlist on YouTube <http://bit.ly/1eSSI6C>

### » **Ion-Qubit Toolbox mini-course**

In late July **ROEE OZERI** of the Department of Complex Systems at the Weizmann Institute of Science in Israel presented a three-part mini-course at IQC. Ozeri reviewed the basic building blocks of quantum information processing with cold-trapped atomic ions with the main focus on methods to implement single-qubit rotations and two-qubit entangling gates, two building blocks necessary to build a universal set of quantum gates.

### » **Quantum-Safe-Crypto Workshop**

Sponsored by CryptoWorks21, IQC, BlackBerry and TeleTrusT, the European Telecommunications Standards Institute (ETSI) hosted the Quantum-Safe-Crypto Workshop in September in Sophia Antipolis, France. The goal of the Quantum-Safe-Crypto Workshop was to develop a strategy towards making quantum-safe technologies part of global standards to create a more secure global information and communication infrastructure. ■

## **AWARDS AND FELLOWSHIPS**

### **KEVIN RESCH**



Associate Professor **KEVIN RESCH** was named the Canada Research Chair in Optical Quantum Technologies. His research in generating new quantum states of light has potential in many areas, including quantum computing and medical imaging instruments.

### **KENT FISHER**



**KENT FISHER** received a top honour for his exemplary Master's thesis earning the Dean of Science Award at the Fall 2013 convocation ceremony. An IQC student has been awarded the University of Waterloo's Dean of Science Award for three of the last four years. He also won the Governor General Gold Medal.

### **CATHERINE HOLLOWAY AND CHRISTOPHER PUGH**



Two PhD students supervised by Associate Professor **THOMAS JENNEWEIN** received the IQC David Johnston Award for Scientific Outreach. The award valued at \$2,500 was awarded to **CATHERINE HOLLOWAY** and **CHRISTOPHER PUGH**. Both students show an outstanding commitment to scientific outreach and community engagement. To name but a few of their activities, both

volunteered at the Doors Open event at IQC in September, Holloway dedicates time to events dedicated to encouraging women in science and Pugh is often seen providing tours of IQC.

### **DENY HAMEL and SADEGH RAEISI**

Two IQC PhD students, **DENY HAMEL** and **SADEGH RAEISI**, were among five students awarded the 2013 Special Graduate Scholarship from the Department of Physics and Astronomy at the University of Waterloo. Both Hamel and Raeisi were recognized for excellence in their graduate research. Hamel's research focused on the implementation of quantum information using quantum optics, while Raeisi worked on optimizing the implementations of quantum algorithms.

### **SEVAG GHARIBIAN**

IQC Alumnus **SEVAG GHARIBIAN** was awarded the NSERC Banting Postdoctoral Fellowship based on his PhD research in approximation algorithms for quantum problems. The fellowship will support his postdoctoral research at the University of California at Berkeley. Gharibian was one of 23 successful applicants in the natural sciences and engineering field to receive this top Canadian fellowship.

### **GREG HOLLOWAY and ANSIS ROSMANIS**

The Fall 2013 IQC Achievement Award was given to **GREG HOLLOWAY** and **ANSIS ROSMANIS**. Holloway, a PhD student, studies under **JONATHAN BAUGH** and Rosmanis, also a PhD student, studies under **JOHN WATROUS**. ■



## » ARRIVALS

### Staff

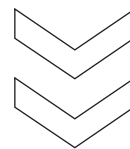
Bethany Mulder  
Jessica Schumacher  
Mary Feldskov

### Students

Chung Wai Sandbo Chang  
Matthew Novenster  
Rahul Deshpande  
Zimeng Wang  
Sean Walker  
Piers Lillystone  
Arnaud Carignan-Dugas  
Tyler Nighswander  
Jean-Phillipe Maclean  
Jeremy Bejanin  
Carolyn Earnest  
Darryl Hoving  
John Schanck  
Mirmojtaba Gharibi  
Li Liu  
Jihyun (Annie) Park  
Nayeli Azucena  
Rodriguez Briones  
Poompong Chaiwongkhot  
Olivia Di Matteo  
Joshua Young  
Nicolas Gonzalez  
Sumit Sijher

### Long-Term Visitors

Dr. David Rainer Kaltenbaek  
Sir Anthony Leggett  
Dominique Pouilot  
Guoming Wang  
Jesse Bingjie Wang  
Yi-Hang Yang  
Zhu Cao  
Zhen Sinha  
Ryan Sweke  
Igor Radchenko  
Douglas Stebila  
Michaël Simoen  
Robin Côte ■



We opened  
our doors  
to more than

1,200  
VISITORS

As part of *Doors Open Waterloo Region* event on September 21, we opened our doors to the Mike & Ophelia Lazaridis Quantum-Nano Centre. As a one-of-a-kind, modern facility it fit perfectly with this year's *Doors Open* theme: modern architecture. However, we did more than just show off the building – thanks to our faculty, postdocs, students and staff, we were able to offer the public a chance to peek into the quantum world.

The open house featured hands-on science exhibits in the Kid Zone and Discovery Zone hosted by IQC students, Engineering Science Quest and Let's Talk Science. Our researchers also hosted Ask the Scientist where the public could talk to a quantum scientist about their work. There was also an opportunity for children of all ages to attend the Q-Kids Science Show with Senior Manager, Outreach, **MARTIN LAFOREST**. In the afternoon, Canada Excellence Research Chair **DAVID CORY** told ghost stories about the quantum world to a sold-out crowd. He also shared some of the ways that quantum devices will change the world before he challenged the under 12 crowd try to win a quantum game. (Note: They understood it intuitively!)

**WEB** See more photos from the event at  
<http://on.fb.me/1dPn4dP>



## AAAS Symposium

Sunday, February 16 from 1:00-2:30 pm.

CHICAGO

Executive Director **RAYMOND LAFLAMME** will moderate a symposium entitled *Quantum Information Technology* at the 2014 American Association for the Advancement of Science Annual Meeting (AAAS) in Chicago. The symposium will focus on short to medium term innovation coming from quantum information research including quantum cryptography, quantum electronics and quantum sensors. Speakers include:

- » MICHEL DEVORET, Yale University
- » DAVID CORY, IQC
- » GREGOIRE RIBORDY, CEO, ID Quantique

**WEB** <http://bit.ly/1hjAf51>



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