NEWBIT

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

ISSUE 28 | WINTER 2016

It's a bird, it's a plane... it's QUANTUM CATS

UNIVERSITY OF WATERLOO | IQC Institute for Quantum Computing

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UNIVERSITY OF WATERLOO | IQC Institute for Quantum Computing

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ON THE COVER

A "scene" from the Quantum Cats game

Cover Photo by: IQC

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FROM THE EDITOR

Since its founding, the Institute for Quantum Computing at the University of Waterloo has been a leader in driving the next great technological revolution. Housing both theorists and experimentalists, IQC has the opportunity to not only contribute to fundamental science, but apply quantum information science to technology.

A great example – **NAYELI AZUCENA RODRIGUEZ BRIONES** – a PhD student we feature in this issue. Although her research is theoretical, in her words: "you are trying to find out how the universe works and at the same time, you are crafting new technologies."

Our featured laboratory, the Quantum Photonics Devices Lab, is also driving device research and fundamental research. Led by **MICHAEL REIMER**, the team is developing new quantum photonic device technologies. In 2013, his research in this area made him an integral part of a startup called Single Quantum.

Our researchers aren't the only ones developing something new. With the help of several of our researchers and the University's Games Institute, we launched a new app – *Quantum Cats*. This *Angry Birds* style game is a way for us to reach more people and introduce them to quantum mechanics.

Learn more about the app on page 6 and then make sure you download it if you haven't already. After all, it's not really a game if you're learning, right?

JODI SZIMANSKI, *Senior Communications Manager*

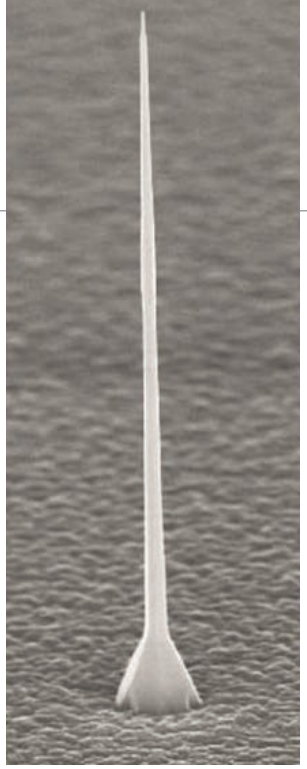
Driving device technologies and fundamental research forward

Building a quantum photonics lab from the ground up

Currently, secure quantum information is limited by the distance single photons can travel before they are absorbed in optical fibres and lost in data transmission. To extend the distance that single photons can travel and therefore extend the distance of secure quantum communication, we need new quantum photonic device technologies. Some of the new possibilities include adjustable – or tunable – quantum light sources using photonic nanowires to generate entangled photon pairs on demand and quantum repeaters to relay a quantum signal over a longer distance.

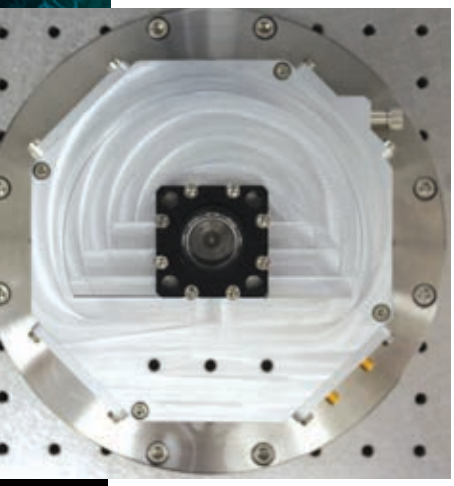
Developing these devices is part of the mission of **MICHAEL REIMER**'s Quantum Photonic Devices Lab research group at IQC. Reimer's research group is also developing a photonic interface between stationary and flying qubits for use in a quantum network, as well as quantum photonic circuits to perform quantum operations on a compact semiconductor chip using photons. Reimer spent two years in industry as a research and development engineer at a company that designs and manufactures products for optical communications networks. Through this experience he gained insight into what types of devices are needed for real-world applications in this field and focused his research goals on developing those devices.

Reimer adjusts the custom-designed, closed-cycle, low temperature cryostat.



Semiconductor nanowire after growth process with unique tapered shape to efficiently extract light from the quantum emitter

Since joining IQC last February as an assistant professor, jointly appointed to the Department of Electrical and Computer Engineering, Reimer has been acquiring equipment and coordinating the renovation of his lab in the Research Advancement Centre (RAC) 1 building, located on the University of Waterloo's north campus. The RAC 1 building itself has also been undergoing renovations, a project led by Reimer as the main faculty contact. Once complete, all RAC 1 labs will be outfitted with nitrogen service, compressed air and chilled water to run compressors and other equipment. Temperature and humidity controls will also be added to each lab.



The top window in the custom-designed, closed-cycle, low temperature cryostat, along with a second window located at the side, allows for excitation and collection of the nanowire sample by a photon from two directions.

It takes hardware to make hardware

Anchored on two optics tables, Reimer has sourced, purchased and, in some cases, even designed the lab equipment that his research group will use to further develop hardware for future quantum technologies and to test fundamental questions in quantum photonics.

"The heart of the lab," as Reimer calls it, is a custom-designed, closed-cycle, low temperature cryostat that is the first of its kind in North America and one of only two cryostats in the world like it. Reimer worked closely with Attocube, a nanotechnology applications company, to design this unique piece. "I took many of the cryostats I've worked with in the past ten years and put the best parts of them together into this one 'super' cryostat," said Reimer. Part of the cryostat's unique design is where it sits – right in a hole in the optics table, where it is protected from vibrations. The cryostat's motor and servicing lines for compressed gas run underneath the table.

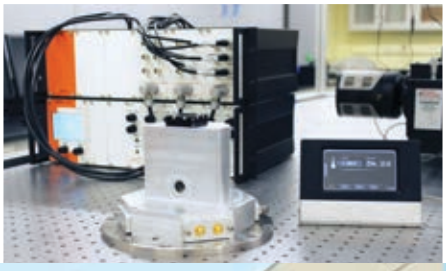
The cryostat is controlled by a touchscreen interface and has two configurations. By swapping out a module, it can be used to test either tunable quantum light sources or integrated quantum photonic circuits. In both cases, its job is to keep nanowire samples at very low temperatures – as low as four degrees Kelvin, equivalent to –269 degrees Celsius. There are two windows, one at the side and one at the top, to allow excitation and collection of the nanowire sample by a photon from one of two different directions. While designing the cryostat, Reimer was thinking long term and built in an option to operate it electrically as well as optically. "Eventually I want to be able to excite the nanowires electrically to eliminate the need for the laser," he said. "It's like a compact semiconductor device." The electrical lines can also control the wavelength of the quantum light source, an important building block of a quantum repeater.

NANOWIRES AS A QUANTUM LIGHT SOURCE

Nanowires are nanostructures that are "grown" from gases. To construct an efficient quantum light source, first, an indium phosphide (InP) nanowire core is grown using phosphine and trimethylindium gases with a gold particle used as a catalyst during the growth as well as to position the nanowire. Arsine is introduced for a few seconds to form the quantum dot in the nanowire. Next, the growth conditions are changed to favour radial growth and a waveguide shell is wrapped around the quantum dot with a tapered tip. Here, the quantum dot emits single pairs of entangled photons while the tapered nanowire waveguide is used to efficiently extract the light towards the communication channel.

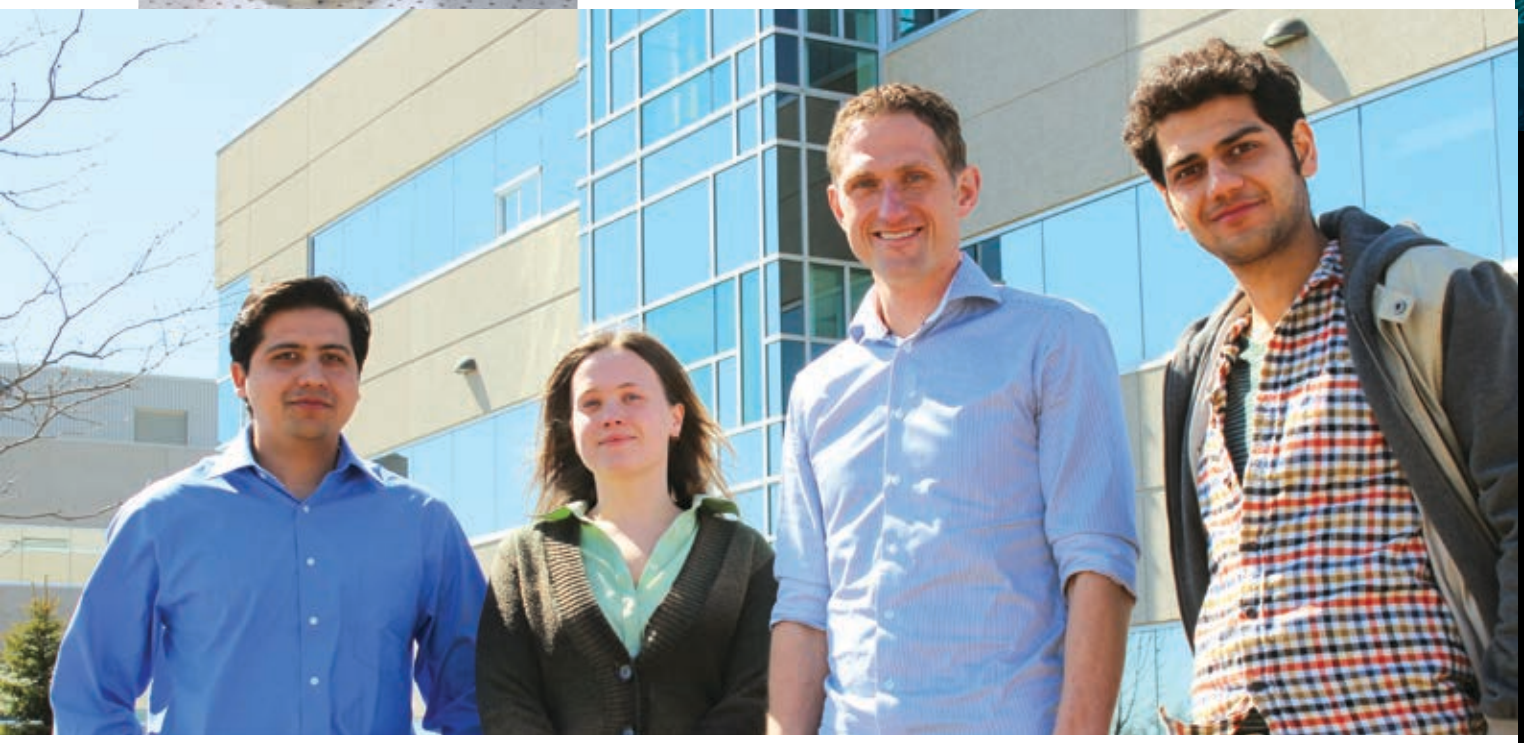
Reimer uses nanowires that are only made at the National Research Council of Canada in Ottawa. They are one of the best quantum light sources currently available in the world.

The custom-designed closed-cycle, low temperature cryostat in Reimer's lab is operated by a touchscreen interface.



Scheduled for installation this spring is the picosecond pulsed laser, which provides the precision required when working with nanowire-based quantum light sources. The laser pulse duration must be short enough to produce photons on-demand, while simultaneously producing a narrow linewidth to excite only the desired optical transitions of the quantum dot.

There are also two spectrometers in the lab equipped with single-photon detectors and charge-coupled device (CCD) cameras for characterization of photons and nanophotonic structures. This equipment measures the energy spectrum of each nanowire sample and can also perform quantum state tomography by correlating a photon on one detector with another photon in the second detector, called cross-correlation spectroscopy. Performing quantum state tomography shows what the quantum entangled state looks like.



Quantum Photonic Devices Lab research group members (L to R): **MOHD ZEESHAN**, **SANDRA GIBSON**, **MICHAEL REIMER**, **ARASH AHMADI**. Missing from photo are **DOLLY RUIZ** and **STEPHANEY DALEY**.

Powered by people

Of course it takes more than just state-of-the-art lab equipment to advance experimental research in this area. Reimer credits the ability of his strong team to utilize the lab equipment to its full potential and achieve ambitious research milestones. In the past year, he's grown his team to five members including postdoctoral fellow **SANDRA GIBSON**, PhD students **ARASH AHMADI** and **MOHD ZEESHAN**, Master's student **DOLLY RUIZ** and **STEPHANEY DALEY**, who attended the Undergraduate School on Experimental Quantum Information Processing (USEQIP) at IQC last spring.

"We are nearly there," said Reimer. He anticipates the lab will be fully operational early in the spring term. "It's been quite a process. The finished lab will position IQC to move quantum photonic device technologies and fundamental quantum photonics research forward." ■

It's a bird, it's a plane...it's

QUANTUM CATS

Sharing quantum information science and technology with the world, one quantum cat at a time.

The concepts of quantum science may often seem confusing or unintuitive to some – Einstein himself described quantum effects as "spooky." Now, as quantum technologies emerge from research labs – from highly secure communications to ultra-sensitive devices to powerful computers – and begin to transform the way we live, work and play, it's becoming increasingly important to share quantum science with the world and make it accessible to the public.

That's where the *Quantum Cats* come in. Meet Classy, Schrö, Digger and Fuzzy:

CLASSY

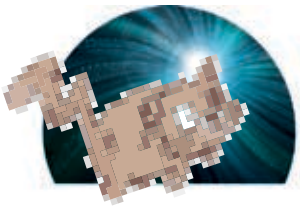
A classic cat. She acts like you would expect – you know where she's going and where she's been. She follows the laws of Newton and Galileo.

SCHRÖ

You never know if Schrö is in the box or if he's not. He has the ability to be in multiple states at the same time. He could be here, he could be there or both!

DIGGER

Watch this cat! He will suddenly appear on the other side of a barrier, even when he doesn't have the energy to go over it or break it down.



FUZZY

You are never certain where you'll find this cat. There's a fundamental limit on how much information you can know about her.

6K

DOWNLOADS

These four cats get launched to break open boxes and save kittens in the game *Quantum Cats*, a new quantum-inspired version of the popular game *Angry Birds™*. Developed in partnership by IQC and the University of Waterloo Games Institute, *Quantum Cats* introduces the concepts of quantum science in a fun, accessible way. The game is easy to pick up and fun to play for all ages. All it takes is one swipe to launch a cat!

"We wanted to take science that people think is hard and make it fun," said **TOBI DAY-HAMILTON**, Associate Director, Communications and Strategic Initiatives at IQC. "Working with the Games Institute, we were able to create something that exceeded our expectations." Students and faculty members from across campus collaborated in the ideation, the science and development of the game.

2,345 cats were launched at the IQC Open House on October 3 and since then the game has been downloaded more than 6,000 times. Have you launched Classy, Schrö, Digger or Fuzzy yet? Download *Quantum Cats* at **quantumcats.ca** and launch away!

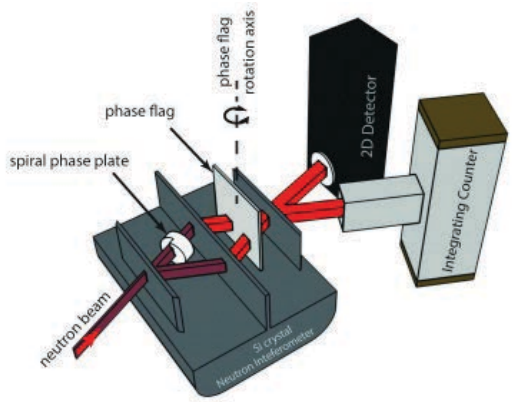
The people behind *Quantum Cats*

Game development:
JAMES WALLACE, **VICTOR CHEUNG**, **MIKE BROWN**, **JAGGER NAST**, **KEITH McLEAN**

IQC contributors:
JUAN MIGUEL ARRAZOLA, **TOBI DAY-HAMILTON**, **JOHN DONOHUE**, **CAROLYN EARNEST**, **KENT FISHER**, **AIMEE GUNTHER**, **SARAH KAISER**, **MARTIN LAFOREST**, **JEAN-PHILIPPE MacLEAN**, **MIKE MAZUREK**, **THOMAS McCONKEY**, **ANGELA OLANO**, **CHRISTOPHER PUGH**, **JEFF SALVAIL**, **JODI SZIMANSKI** ■

SCIENCE HIGHLIGHTS

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



The interferometer for testing orbital angular momentum of neutrons.

Controlling orbital angular momentum of neutron waves

An experiment by a team of researchers shows, for the first time, that a wave property of neutrons, Orbital Angular Momentum (OAM), can be controlled by any specified value. This newfound control of neutron OAM states means that researchers can now use neutron OAM beams to see inside materials that optical, x-ray or electron OAM beams can't penetrate. This control can help measure the magnetism in magnetic materials, for example, as well as enable deeper probes of superconducting and chiral materials.

IQC Research Assistant Professor **DMITRY PUSHIN**, a member of the Department of Physics at the University of Waterloo, and collaborator **CHARLES CLARK** of the Joint Quantum Institute in Maryland conceived of the idea to control neutron OAM. Pushin designed the experiment that uses neutrons created by a nuclear reactor at the National Institute of Standards and Technology (NIST) and passes them through a Mach-Zehnder interferometer.

WEB **http://bit.ly/control-oam-neutron-waves** ■

INFINITY IS A BIT CLOSER

Mathematician David Hilbert proposed the Hilbert Hotel Paradox thought experiment in 1924 to demonstrate infinity – the mathematical notion of no limits. Researchers from the universities of Strathclyde, Glasgow, Rochester, Ottawa and IQC associated the rooms with quantum states and then looked for a way to vacate every second level, given that a quantum system has an infinite number of quantum states.

Physical Review Letters published the results in the paper *Quantum Hilbert Hotel* in October. IQC postdoctoral fellow **FILIPPO MIATTO** proposed the use of Orbital Angular Momentum (OAM) states of light to implement the Hilbert Hotel protocol. OAM is associated with the rotation of an object around a fixed axis and in the case of a light beam, to the rotation of the optical phase around the direction of propagation.

By showing that they could physically realize the Hilbert Hotel Paradox, the researchers also found that they could perform deterministic non-linear interactions on the OAM by pre-sorting and then applying distinct Hilbert Hotel operation to the distinct OAM components. This opens up new possibilities for quantum information and computation operations.

WEB **http://bit.ly/hilbert-hotel-feasibility** ■

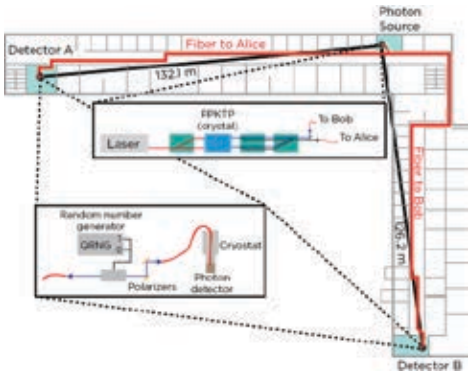
SCIENCE
HIGHLIGHTS

CLOSING THE LOOPHOLES

Researchers in Canada, the United States and Europe, led by the National Institute of Standards and Technology (NIST) in Boulder, Colorado and IQC alumnus **KRISTER SHALM,** have ruled out classical theories of correlation with remarkably high precision. A group, including IQC members **EVAN MEYER-SCOTT**, **YANBAO ZHANG**, **THOMAS JENNEWEIN** and alumnus **DENY HAMEL,** built and performed an experiment that shows the world is not governed by local realism.

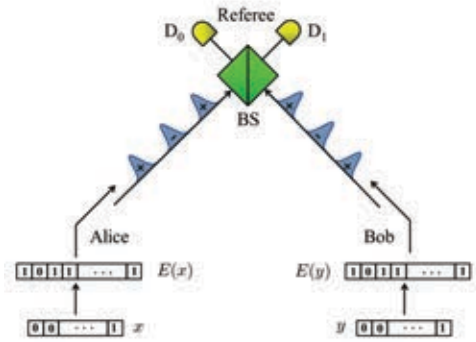
Local realism states that the world is predictable and only influenced by its immediate surroundings. Work by John Bell allowed scientists to experimentally test the hypothesis that nature is governed by local realism through measuring entangled particles to find the strength of their correlations due to technological limitations. Scientists had to make additional assumptions to show local realism was incompatible with their experimental results. This opened three possible loopholes – locality, freedom-of-choice and fair-sampling.

With new detectors built by NIST and a new high-performance photon source, researchers now have the technology needed to perform the Bell test and close all three loopholes simultaneously. The paper, *A strong loophole-free test of local realism*, appeared in *Physical Review Letters* in December. The results could have great significance for device-independent quantum communication.



WEB **http://bit.ly/loophole-free-test** ■

A proof-of-concept demonstration of quantum fingerprinting beats the best known classical protocol



Quantum fingerprinting protocol

IQC researchers **NORBERT LÜTKENHAUS**, **JUAN MIGUEL ARRAZOLA** and **SHIHAN SAJEED**, in collaboration with researchers from the group of Professor **HOI-KWONG LO** at the University of Toronto, experimentally demonstrated a quantum fingerprinting system that can transmit less information than the best known classical protocol.

In this problem, Alice and Bob receive inputs and based on these inputs, they send a message to a third party – the referee. The referee uses this received information to determine whether the inputs to Alice and Bob are equal, and the goal is to do this by transmitting as little information as possible. By modifying a version of a commercial Quantum Key Distribution (QKD) system using optical components, the researchers were able to transmit messages up to 100 Mbits with 66% less information than the best known classical protocol over a five-kilometre standard fibre operating at telecom wavelengths. *Nature Communications* published the results *Experimental quantum fingerprinting with weak coherent pulses* in October.

WEB **http://bit.ly/quantum-fingerprinting-c-pulses** ■

CONFERENCES

QUANTUM INNOVATORS

Exploring the frontier of quantum physics and engineering was the focus of the fourth Quantum Innovators conference hosted by IQC. Fifteen of the most promising young researchers in this field came together from October 4-7 to share their work and make new connections. Among the participants was **ADAM WEI TSEN**, now Assistant Professor at IQC and the Department of Chemistry. ■

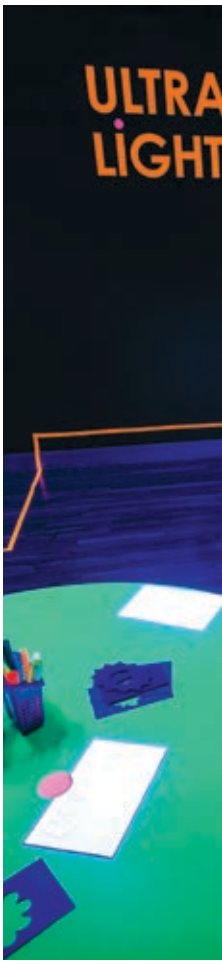
Building tomorrow's quantum-safe cryptography

Industry, academic and government collaborators gathered in Seoul, Korea October 5-7 to discuss next steps in creating a quantum-safe cryptographic infrastructure at the third annual Workshop on Quantum-Safe Cryptography, presented in partnership by IQC and the European Telecommunications Standard Institute (ETSI). Discussions focused around the latest in cryptographic requirements from industry and administration as well as sharing potential solutions emerging from recent research.

IQC board member and CEO of Approach Infinity Inc., **MARK PECEN**, and IQC faculty members **THOMAS JENNEWEIN**, **NORBERT LÜTKENHAUS** and **MICHELE MOSCA** presented at the workshop. They also contributed to the ETSI whitepaper, *Quantum Safe Cryptography and Security; An introduction, benefits, enablers and challenges*, along with IQC PhD students **JENNIFER FERNICK** and **SARAH KAISER**, Senior Technical Associate **BRIAN NEILL**, Master's student **JOHN SCHANCK** and IQC alumnus **DOUGLAS STEBILA**.

WEB **http://bit.ly/2015-ETSI-white-paper** ■

IQC OUTREACH



Celebrating LIGHT

Light, although often unnoticed, plays a vital role in our daily lives. The United Nations (UN) General Assembly named 2015 as the **International Year of Light and Light-based Technologies** (IYL 2015) to recognize "the importance of raising global awareness about how light-based technologies promote sustainable development and provide solutions to global challenges in energy, education, agriculture and health." From medicine to communication, light has played an integral part in advancing science throughout the 21st century.

A group of graduate students from the University of Waterloo Student Chapter of the Optical Society (OSA) brought light to life in *LIGHT Illuminated*, an exhibition featured at THEMUSEUM in downtown Kitchener from October 2015 to March 2016. IQC PhD students **AIMEE GUNTHER**, **MIKE MAZUREK**, **KENT FISHER**, **JEAN-PHILIPPE MacLEAN** and **SARAH KAISER** along with Master's student **IAN ANDREWS** from the Department of Physics and Astronomy created and curated the exhibition to share their knowledge and celebrate light in honour of IYL 2015.

"The idea was to create a fun, hands-on exhibition for all ages where we could educate and entertain the local community on the uses of light in everyday technologies," said MacLean, who studies experimental quantum optics. The group of students designed and, in many cases, built interactive modules and activities demonstrating light concepts.

Photo credit: Brent Wettlaufer, THEMUSEUM

The students collaborated with local industry partners to develop more than a dozen activities about light for the exhibit, including a race against the speed of light, a coloured light mixing station and a laser maze. The American Physical Society, Christie Digital, COM DEV, FiberTech Optica, Teledyne DALSA, the University of Waterloo, Wizard Labs and students from Waterloo's Knowledge Integration program were among the supporting community partners.

THEMUSEUM welcomed over 40,000 community members through *LIGHT Illuminated*. IQC's Manager, Special Projects **ANGELA OLANO** played a significant role in guiding the students through the creation of the exhibit. "The OSA students put enormous effort into *LIGHT Illuminated* over the past year. They succeeded in creating a professional and relevant educational experience for the community," stated Olano. ■

TALKS & TOURS

SCIENCE WITHOUT BOUNDARIES

Politicians and professionals from industry, academia, the not-for-profit sector, as well as federal and provincial governments gathered in Ottawa to continue the conversation on science, technology and innovation policy at the seventh Canadian Science Policy Conference (CSPC) November 25-27.

IQC's Executive in Residence, **ROBERT CROW**, was part of the Science Without Boundaries panel discussion that focused on the internationalization of science and how Canada can maximize the benefits of its participation in science projects spanning global borders. Joining Crow on the panel, which was moderated by **ANDREW POTTER** (Ottawa Citizen), were **JONATHAN BAGGER** (TRIUMF), **MARK DIETRICH** (Compute Canada) and **HEATHER DOUGLAS** (University of Waterloo). ■

Thinking about QIP from different disciplines

In November, faculty members **RAYMOND LAFLAMME**, **DAVID CORY** and **GUO-XING MIAO** participated in the CIFAR-China QIS Program Meeting at Tsinghua University. Laflamme co-organized the event that was hosted by the Institute for Interdisciplinary Information Sciences (IIIS), Tsinghua University and the Canadian Institute for Advanced Research (CIFAR). The goal of the program is to bring together researchers who think about quantum information processing from different disciplines such as physics and computer science, and help each other understand the field from a new perspective.

The three-day program included 12 invited talks, the first of which was given by Laflamme about algorithmic cooling. The other talks covered hot topics in the field including quantum noise, quantum entanglement and quantum topography. ■

IQC OUTREACH

CONFERENCES

A new program for high school teachers

IQC welcomed 20 high school science educators for the very first Teaching Quantum Technology (TQT) workshop December 5-6. Through lectures and hands-on activities, teachers gained a deeper understanding of quantum mechanics, with a focus on how to bring quantum information science and technology back to their classrooms to share with their students. Senior Manager, Scientific Outreach **MARTIN LAFOREST** guided the teachers through scientific concepts including wave-particle duality, superposition, quantum computing algorithms, entanglement and quantum cryptography. TQT participants used pens to demonstrate the uncertainty principle, measured the width of a hair with the double-slit experiment and witnessed a demonstration of quantum cryptography using coins and boxes.

WEB **https://uwaterloo.ca/iqc/tqt**

Sharing, educating, inspiring

MARTIN LAFOREST connected with almost 150 students from Woodlands High School, North Park Secondary School, the Waterloo Unlimited enrichment program and students who attended the Information and Communications Technology ZOOM Career Day in the fall. More than half toured IQC and its labs, and 72 students got hands-on experience with quantum mechanics in a lab workshop.

UPCOMING CONFERENCES

Quantum Physics and Logic
June 6-11
University of Strathclyde

Information Theoretic Interpretations of Quantum Mechanics
June 11-12
University of Western Ontario

Relativistic Quantum Information North
June 21-24
Institute for Quantum Computing, University of Waterloo

Women in Physics Canada
July 27-29
University of Saskatchewan

Workshop on Representation Theory in Quantum Information
August 15-18
University of Guelph

DISCOVERING QUANTUM INFORMATION SCIENCE AND TECHNOLOGY

IQC hosted an open house on Saturday, October 3 as part of Waterloo's Reunion weekend festivities. More than 700 Waterloo alumni and community members learned about quantum information research from students and faculty members and explored hands-on science activities hosted by Waterloo's Let's Talk Science and Engineering Science Quest groups. Other highlights included a Q-Kids Science Show and a fireside chat with executive director **RAYMOND LAFLAMME**, guided by radio host **MIKE FARWELL** on embracing the quantum revolution.

Along with the launch of *Quantum Cats*, two interactive experiences, also developed in partnership with the Games Institute, debuted at the open house:

- **A virtual lab tour** of **THOMAS JENNEWEIN**'s quantum optics lab using video and audio clips to explain the lab's components and their use,
- **A self-guided building tour mobile application** that provided facts and figures to guests about the architecture and science happening at the Lazaridis Centre.

Around the INSTITUTE

student PROFILE:

NAYELI AZUCENA RODRIGUEZ BRIONES

Innovation from discovery

A naturally curious **NAYELI AZUCENA RODRIGUEZ BRIONES** always wanted to pursue post-graduate studies. Since middle school, Rodriguez Briones has enjoyed solving mathematical problems. After participating in Physics Olympiads at the international level, she went on to earn her Bachelor of Science in Physics degree at the Autonomous University of Zacatecas (UAZ) in Mexico, her home country.

Now she is a PhD student studying physics and quantum information at IQC with Executive Director **RAYMOND LAFLAMME**, Research Assistant Professor **EDUARDO MARTÍN-MARTÍNEZ** and IQC associate member **ACHIM KEMPF** from the Department of Applied Mathematics. Studying quantum information piqued her interest because she could investigate fundamental problems while creating new technologies at the same time. Although her research is theoretical, the results are at the core of experimental implementation in quantum information processing. "It's exciting to see fundamental discoveries of our universe lead to innovative technologies," says Rodriguez Briones. "It's like a game; you are trying to find out how the universe works and at the same time, you are crafting new technologies. It's fun and it's useful."

Rodriguez Briones is currently developing a purification method for qubits to prepare them for use in a quantum computational device. Controlled preparation of nearly pure quantum states allows the user to initialize the quantum system before doing any kind of quantum computation. Pure qubits are useful for processing quantum information, running algorithms or performing quantum-error correction.

So far, most purification methods involve cooling qubits to a very low temperature or by making measurements. Rodriguez Briones is investigating novel techniques to purify qubits by clever redistribution of entropy at the quantum level. In her current project, she is exploring quantum energy teleportation, a new technique that allows one to transport energy by only sending information and using entanglement. The results go beyond the purification obtained from lowering the temperature with conventional techniques. Furthermore, it can be used for technologies with strong but imperfect measurements.

Rodriguez Briones is collaborating with researchers from different areas, spanning physics and astronomy to applied mathematics. "At IQC, there are many people from different backgrounds. If you have a question for someone in a different area, you can find their office in the same building." She chose IQC at the University of Waterloo to gain deeper insights into physics and quantum information. "IQC is one of the most prestigious institutes for quantum computing in the world, and I'm excited to be part of such a vibrant scientific community – one that brings me closer to the frontiers of current research in quantum information." ■

TOURS/VISITS

TOURING QUANTUM VALLEY

- Senior officials from Innovation, Science and Economic Development Canada (ISED) made a stop at IQC September 17 while attending the Waterloo Innovation Summit to learn more about the developing Quantum Valley in Waterloo Region. Guests included Deputy Minister **JOHN KNUBLEY**, Assistant Deputy Minister **MITCH DAVIES**, Ontario Region Executive Director **MARK LEHMAN** and Director (Finance and Administration) **CHRIS HAMDEN**.

- Delegates from Finance Canada came to IQC during a tour of Waterloo Region on September 30. At IQC, **RICHARD BOTHAM**, Assistant Deputy Minister from the Economic and Fiscal Policy Branch along with representatives from the Microeconomic Policy Analysis Division including **SOREN HALVERSON**, **EVELYN DANCEY** and **EVA AUDY** saw the Quantum NanoFab and toured the labs at RAC II.

- **BILL MANTEL**, Assistant Deputy Minister from the Ontario Ministry of Research and Innovation and his group visited the Quantum NanoFab and the RAC II labs at IQC. ■

Building academic and industrial research collaborations

- A delegation from the University of Strathclyde, including Principal and Vice-Chancellor **SIR JIM McDONALD**, Special Adviser to the Principal and Vice-Chancellor **ANDREW GOUDIE** and Executive Dean, Strathclyde Business School **DAVID HILLIER**, came to IQC on September 10. Their tour was led by University of Waterloo President **FERIDUN HAMDULLAHPUR** and Senior Advisor to the President – Strategic Initiatives **JEAN-JACQUES VAN VLASSELAER**, along with **RAYMOND LAFLAMME** and **TOBI DAY-HAMILTON** from IQC.

- On September 27, a group of Waterloo representatives welcomed President and Vice-Chancellor **PAUL BOYLE** from the University of Leicester, who toured IQC during his visit to campus. **GEORGE DIXON** (University Research), **ERIN SARGEANT GREENWOOD** (Advancement), **ROCCO FONDACARO** (Centre for the Advancement of Co-operative Education), **PAUL SALVINI** (Accelerator Centre) along with IQC's Senior Manager, Scientific Outreach **MARTIN LAFOREST** showed Boyle IQC's research facilities. ■

FROM THE IQC GSA

With a fresh new GSA team, including newcomers **VADIRAJ ANANTHAPADMANABHA RAO**, **MATTHEW BROWN** and **NAYELI AZUCENA RODRIGUEZ BRIONES**, the fall term put the school year off to a great start for social life at IQC. Bowling night returned for a fourth year of x-shaped high fives and tired elbows. Board games and video games nights were held at the Lazaridis Centre once again, including many additions to the IQC board game collection. For Halloween, IQC was decked out in every possible sense: in addition to the always-exceptional costume contest participants, the door-decorating contest put the building in the spirit for the week leading up to October 31st, including contest winner **CHRISTOPHER PUGH** and **AIMEE GUNTHER**'s spook-and-snack den. Additionally, IQC students were invited to tour the facilities of Google in Waterloo. It was a great start to the year, and we look forward to the rest of it.

Written by John Donohue ■

Around
THE INSTITUTE

ANNOUNCEMENTS

Congratulations
to those who defended their thesis in the Fall term:

- **POOMPONG CHAIWONGKHOT**, MSc
- **SEAN WALKER**, MSc
- **JUAN MIGUEL ARRAZOLA**, PhD
- **DAVID LUONG**, MSc
- **ANIRUDH KRISHNA**, MSc
- **JIHYUN PARK**, MSc ■

Illustration for winning story *Ana* © Michael Manomivibul (www.mikemanoart.com and @MikeManoArt)

CONGRATULATIONS TO THE WINNERS OF QUANTUM SHORTS 2015

The Centre for Quantum Technologies' (CQT) at the National University of Singapore annual short story contest is proof that quantum physics really can fire up imagination! IQC partnered with CQT and others to present this year's quantum-inspired flash fiction contest. More than 400 entries were submitted. Congratulations to the winners:

- "Ana" by Liam Hogan, placing first in the open category
- "Don't Die Before You're Dead, Sally Wu" by Andrew Neil Gray, runner up in the open category
- "The Qubits of College Acceptance" by Lily Turaski, named the People's Choice award from 20 shortlisted entries across the open and youth categories
- "Unrequited Signals" by Tara Abrishami, placing first in the youth category

Read the winning entries and the top ten shortlisted in the Open and Youth categories online.

WEB **http://bit.ly/quantum-shorts** ■

IN THE NEWS

Can we get energy from nothing?

New Scientist writer **JOSHUA HOWGEGO** dove into the idea of creating something from nothing, sharing IQC faculty member **CHRISTOPHER WILSON**'s work on the dynamical Casimir effect.

The Casimir effect occurs when two parallel, uncharged conducting plates are placed close to each other in a vacuum and quantum electromagnetic fluctuations create a force that pushes the two plates together. The dynamical Casimir effect uses a moving mirror to produce energy and particles.

Wilson and colleagues performed an experiment testing the dynamical Casimir effect "by using rapidly changing electrical currents to simulate the effect of miniscule mirrors whooshing together at a quarter of the speed of light," *New Scientist* reported. The result: a pair of photons, or energy, appeared in the vacuum. "You can think of it as being like the mirror has knocked the particle into existence," Wilson told *New Scientist*. The article appeared in the first weekly issue of September 2015.

WEB **http://bit.ly/energy-from-nothing** ■

Viewpoint: The end of local realism

"By closing two loopholes at once, three experimental tests of Bell's inequalities remove the last doubts that we should renounce local realism," said **ALAIN ASPECT**, Institut d'Optique, École Polytechnique and CNRS Distinguished Scientist. Aspect's Viewpoint article *Closing the Door on Einstein and Bohr's Quantum Debate* was published in *Physics*. "The results also place several fundamental quantum information schemes, such as device-independent quantum cryptography and quantum networks, on firmer ground."

IQC researchers contributed to one of the three independent experimental tests of Bell's inequalities, closing the loopholes simultaneously, including **EVAN MEYER-SCOTT**, **YANBAO ZHANG**, **THOMAS JENNEWEIN** and alumnus **DENY HAMEL**. IQC alumnus **KRISTER SHALM**, now at the National Institute of Standards and Technologies (NIST), lead a team of researchers who also ruled out classical theories of correlation with remarkably high precision.

WEB **http://bit.ly/physics-viewpoint-aaspect** ■

Canadian, American and Mexican students celebrate physics

IQC PhD student **CHRISTOPHER PUGH** was one of 10 Canadians to travel to Oaxaca, Mexico for the Canada-America-Mexico Graduate Student Conference in Physics (CAM 2015). With over 60 presentations and nine plenary talks, including one celebrating the International Year of Light, attendees shared their research and ideas. Scientific publishing and funding emerged as two common themes throughout the conference, held September 9-12. Highlights included a marching band escort into the banquet tent and a field trip to Monte Albán to see the 2,000-year old ruins of the main city centre. Pugh shared his CAM 2015 experience in *Physics in Canada*.

WEB **http://bit.ly/Pugh-on-CAM2015** ■

AWARDS AND FELLOWSHIPS

Honouring research excellence

Faculty member **DAVID CORY**, Canada Excellence Research Chair (CERC) in Quantum Information Processing, was named a Fellow of the Royal Society of Canada and inducted into the Academy of Science on September 8, 2015. In December, Cory was also appointed Fellow of the American Physical Society for developing one of the first demonstrations of a quantum computer. Cory's work is already being used in a range of applications from the medical field to the oil industry. ■

NEW COURSES IN FALL 2015

QIC 890

Solid State Photonic Devices

QIC 890

Modern Quantum Optics and Nanophotonics ■

Around
THE INSTITUTE

ARRIVALS

Staff

Chloe Lemieux

Students

Arash Ahmadi
Matthew Amy
Eduardo Barrera Ramirez
Matthew Brown
Brandon Buonacorsi
Kristine Boone
Jiahui Chen
Jennifer Fernick
Daniel Grimmer
Jie Lin
Xudong (Michael) Liu
Guofei (Phillip) Long
Benjamin Lovitz
Christian Mastromattei
Connor Paul-Paddock
Helen Percival
Romain Ruhlmann
Dolly Ruiz
Allison Sachs
Dhinakaran Vinayagamurthy
Christopher Warren
Mohd Zeeshan

Visitors

Frederick Strauch
Juan Carlos Garcia Escartin
Aarthi Sundaram
Fred Shultz
Keren Li
Shun Kawakami

Postdoctoral fellows

Franklin Cho
Jason Crann
Dave Touchette
Ben Yager
Katanya Kuntz

IQC FACULTY AWARDS

11 Early Researcher Awards

9 CIFAR Awards

4 Canada Research Chairs

1 John Charles Polanyi Prize

3 Royal Society Fellows

2 American Physical Society Fellows

1 Canada Excellence Research Chair

DOORS OPEN

SEPTEMBER 17, 2016

The Institute for Quantum Computing is opening its doors to the community as part of Doors Open Waterloo Region. Bring the whole family to explore the Mike & Ophelia Lazaridis Quantum-Nano Centre and discover the excitement of quantum mechanics!

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

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

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