NEWSBIT

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

ISSUE 29 | SPRING 2016

Digital quantum matters

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UNIVERSITY OF WATERLOO | IQC Institute for Quantum Computing

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Cover Photo by: IQC

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FROM THE EDITOR

It seemed as though everyone was talking about quantum in April. Prime Minister Justin Trudeau started a global conversation after he told a journalist some basic concepts of quantum mechanics at a funding announcement at Perimeter Institute and those comments quickly went viral. Media outlets around the world shared the news about our self-described "geek" Prime Minister talking about quantum mechanics.

We want to continue that conversation and help teach Canadians more about quantum information science and technology. It's why we've teamed up with Canadian partners as part of Innovation150 – a year-long, nationwide celebration of our innovative past and present, and our exciting future. You can read more about the announcement by the Honourable Minister of Canadian Heritage **MÉLANIE JOLY** and the Institute for Quantum Computing's exciting project *QUANTUM: The Exhibition*.

While we have been busy preparing the exhibition, the research groups continue to innovate. One group, the Laboratory for Digital Quantum Matter, is developing technologies for extensible quantum computing architectures based on superconducting qubits. We feature faculty member **MATTEO MARIANTONI** and his lab in this issue.

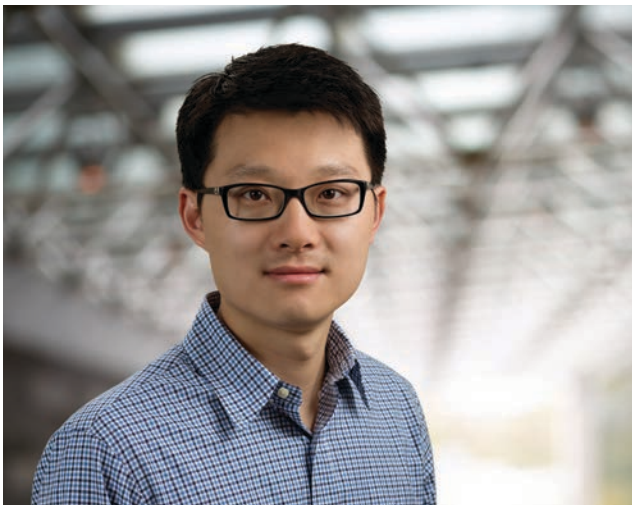
Other researchers we feature this month have found ways to make steps in developing quantum applications by learning new control methods. In one paper, a research team describes a new technique that ensures they don't lose the 'quantumness' of a state, while another team changed the colour of a single photon in a diamond quantum memory.

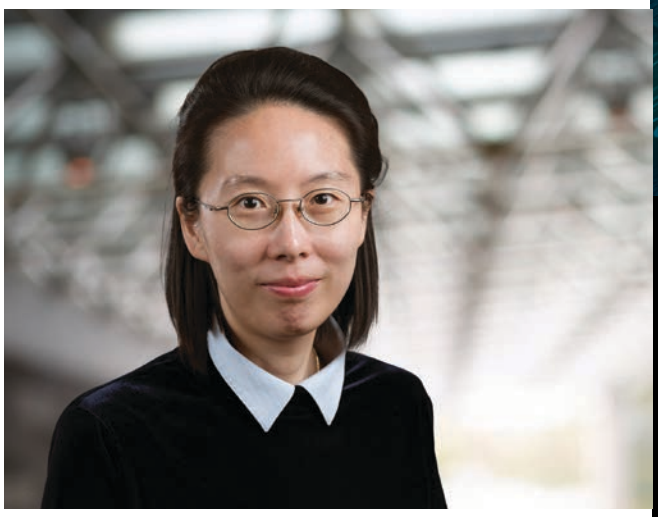
We want to keep sharing quantum with the world. You'll see in this issue that we keep touring the globe attending conferences to talk about quantum and invite visitors to IQC to take a peek in our labs. Next year, through *QUANTUM: The Exhibition*, we'll travel from coast to coast to coast to give more Canadians the opportunity to explore and learn about quantum information science and technology. We hope to see you on one of our stops!

JODI SZIMANSKI, *Senior Communications Manager*

New hires at IQC

We welcome two new professors to IQC





WEI TSEN

Professor **WEI TSEN**'s research explores atomically thin quantum materials. Using the unique structural, optical and electronic properties of low-dimensional quantum materials, Tsen is working to develop novel quantum devices.

Prior to joining IQC and the Department of Chemistry at Waterloo, Tsen completed a BS in Electrical Engineering and Computer Sciences, as well as a BS in Engineering Physics at the University of California, Berkeley. He then completed his PhD in Applied Physics at Cornell University and went on to a postdoctoral associate position at Columbia University.

NA YOUNG KIM

NA YOUNG KIM joins IQC and the Department of Electrical and Computer Engineering at the University of Waterloo as lead of the Quantum Innovation (QuIN) laboratory. Her research aims to build large-scale quantum processors based on novel materials and advanced technologies.

Kim received a BS in Physics from Seoul National University and then completed her graduate studies in the Department of Applied Physics at Stanford University. After her postgraduate work at Stanford, Kim then worked on the development of small display products at Apple. ■

Celebrating Canada's sesquicentennial with INNOVATION150

IQC will share quantum information science and technology from coast to coast to coast

Minister of Canadian Heritage, the Honourable **MÉLANIE JOLY** unveiled Innovation150 and $5,875,000 in funding from the Government of Canada at the Discovery Centre in Halifax, Nova Scotia on Tuesday, March 15. An interactive, year-long celebration of Canadian innovation, the program will offer opportunities for youth, families and communities across the country to experience innovation first-hand.

Innovation150 will bring exhibitions and programming including major city-wide festivals, guest speakers, a touring MakerMobile and dynamic online experiences to Canadian communities over the next year. Innovation150 partners include: IQC, Perimeter Institute for Theoretical Physics, Actua, the Canada Science & Technology Museums Corporation and the Canadian Association of Science Centres.

IQC will launch *QUANTUM: The Exhibition* October 13, 2016 at THEMUSEUM in Waterloo Region. Visitors will be immersed in the intriguing world of quantum physics through this interactive, bilingual traveling exhibit, experience the core concept of quantum mechanics and learn how it is already revolutionizing technologies. The exhibit will travel across Canada next year including stops in Vancouver, Calgary, Saskatoon, Ottawa and Halifax.

» **MÉLANIE JOLY**, Minister of Canadian Heritage, announces Innovation150 and almost $6 million in funding from the Government of Canada in Halifax.

Official ambassador for Innovation150, **ARTHUR McDONALD** speaks at the announcement.

The crowd gathered to celebrate the announcement also had the chance to see how a superconducting train works in a demonstration by Senior Manager, Scientific Outreach **MARTIN LAFOREST**. Also on hand were **TOBI DAY-HAMILTON**, **ADELE NEWTON** and **ANGELA OLANO**, along with Canadian astrophysicist and winner of the 2015 Nobel Prize in Physics, **ARTHUR McDONALD**, the official ambassador for the Innovation150 project.

"Canada's 150th anniversary is an ideal time to celebrate great Canadian science and bring quantum science to Canadians across the country," said Day-Hamilton, Associate Director, Communications and Strategic Initiatives. "The research that is happening at IQC and at other institutes across the country is too important to stay in the labs. We want everyone to have an understanding of how quantum technologies will change their lives." ■

Senior Manager, Outreach, **MARTIN LAFOREST** conducts a demonstration of the superconducting train using liquid nitrogen.

Piecing it together.

THE PUZZLE OF PROTOTYPING QUANTUM COMPUTING TECHNOLOGY

It is believed that implementing a quantum computer may represent a major step forward for research and society; however, the full potential of a quantum computer is still uncertain. Promising possibilities may include running simulations of quantum systems, providing quantum security or processing quantum data for tasks such as machine learning and artificial intelligence. Researchers continue to piece the puzzle together to realize a quantum computer.

The Laboratory for Digital Quantum Matter led by **MATTEO MARIANTONI** is focusing on a specific piece of the quantum computing puzzle: developing technologies for extensible quantum computing architectures based on superconducting devices. The main component of such architectures is the physical quantum bit (qubit). A superconducting qubit is similar to the electronic circuits currently found in a classical computer and is characterized by two states, 0 and 1. Quantum mechanics makes it possible to prepare the qubit in superposition states so that the qubit can simultaneously be in both states 0 and 1. Pairs of qubits can be prepared in "superimposed" two-qubit states. These are two crucial requirements for building a quantum computer.

Major progress has been made towards controlling and measuring physical qubits over the past 15 years, however physical qubits are characterized by inherent natural errors that cause them to lose quantum information. The error rate of the state-of-the-art physical qubit is approximately 10^{-2}, compared to the error rate in classical computing of 10^{-15}, a difference of 13 orders of magnitude. "The physical qubit errors right now are much worse than the transistor in a classical computer," said Mariantoni. "We are working towards bridging the gap between classical and quantum computing. To implement a universal quantum computer, we need to cure and mitigate those errors."

TAKING THE LOGICAL ROUTE

The next step in achieving this goal is to make a logical qubit, a new level of encoding where a cluster of 100 to 1,000 physical qubits behaves as a single logical qubit. "A logical qubit will reduce the effects of the errors of individual physical qubits, aligning the error rate more closely to that of a classical computer," said Mariantoni. "This will bring us a step closer to realizing a quantum computer."

This effort is one that Mariantoni is passionate about. After finishing a postdoctoral fellowship at the University of California, Santa Barbara under the supervision of **JOHN M. MARTINIS**, now at Google, he joined IQC to contribute to the development of quantum computing technology. Now, with a state-of-the-art equipped lab and a strong research team of five PhD students including **JEREMY BEJANIN**, **CAROLYN EARNEST**, **THOMAS McCONKEY**, **COREY RAE McRAE**, and **JOHN RINEHART**, Mariantoni is leading the Laboratory for Digital Quantum Matter on the path to developing extensible quantum computing technologies.

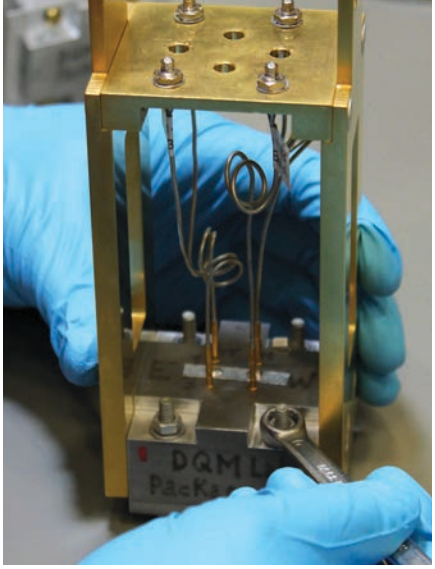
MATTEO MARIANTONI inspects one the dilution refrigerators in the Laboratory for Digital Quantum Matter.

KEEPING IT COOL IN THE LAB

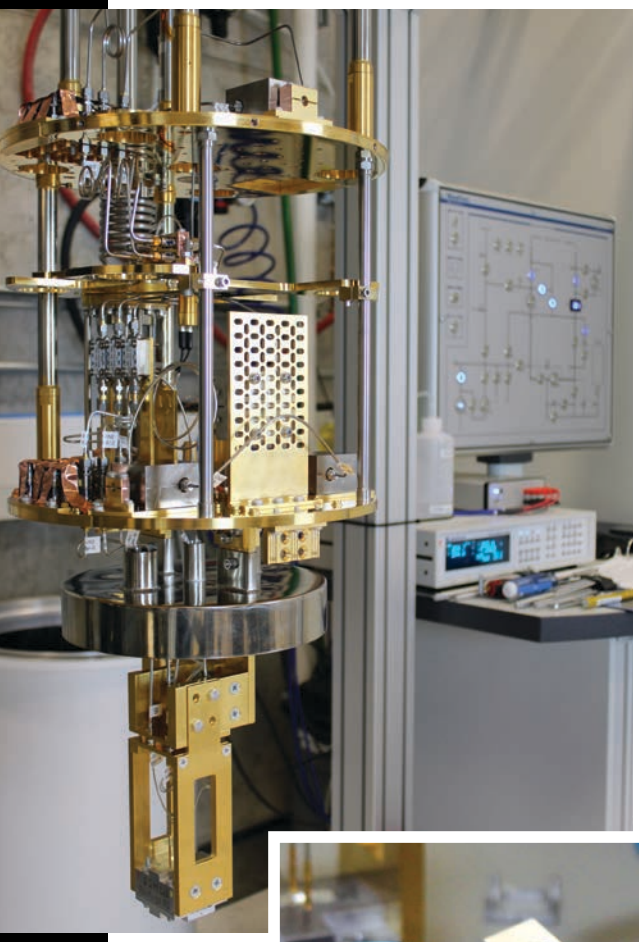
Starting in the Quantum NanoFab, the team fabricates superconducting devices from scratch and spends time developing "recipes" for devices that are grown from very thin nanofilms of metal and then patterned by lithography.

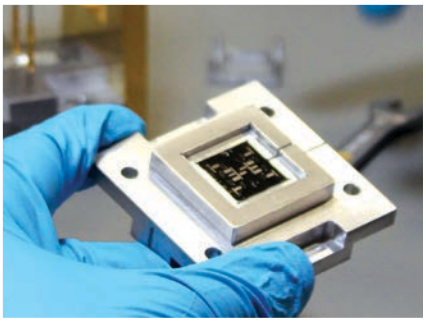
The devices are brought into the lab where two dilution refrigerators, a special type of cryostat, keep the circuits close to absolute zero temperature, at approximately -273 degrees Celsius. Qubits in different states – 0 and 1 – are separated by an energy gap. The cold temperature is required to initialize the qubits in the 0 state at the beginning of an experiment.

The energy gap between the 0 and 1 states can also be expressed in terms of frequency of hertz (Hz). This frequency is about 5 GHz for typical superconducting devices, the same frequency currently used for telecommunications. The Laboratory for Digital Quantum Matter uses microwave pulses centered at this frequency to control and measure the qubit states. The pulses are sent from dedicated sources and pulse generators through a network of cables connecting the qubit in the cryostat's cold environment to the room temperature electronics. Readout signals finally make it possible to verify whether the qubit was in state 0 or 1 at the end of a set of control pulses.



« PhD student **JEREMY BEJANIN** opens the quantum socket to change the chip inside.





» The chip inside the quantum socket is cooled at 10 mK, close to absolute zero, inside a dilution refrigerator to become superconducting. Superconducting resonators on the chip are made from aluminum.

WIRING IN 3D

The network of cables required to access the qubits in the cryostat is a complex infrastructure. Setting it up is considered a "true art", as Mariantoni puts it. Earlier this year, his research group presented a novel wiring technique called the quantum socket at the American Physical Society (APS) meeting in March.

Developed by Mariantoni's group, the quantum socket is a new wiring method that uses three-dimensional wires based on spring-loaded pins to address individual qubits. The quantum socket, which is a necessity to wire up logical qubits, connects classical electronics with quantum circuits and has already experimentally demonstrated control of superconducting devices. The research group's main focus was to develop a highly reproducible technology, while fulfilling all the stringent requirements for manipulating superconducting qubits. "The quantum socket is extendable from one to hundreds of qubits," said Mariantoni. "This new wiring method is one of the many critical steps necessary for the development of extensible quantum computing technologies."

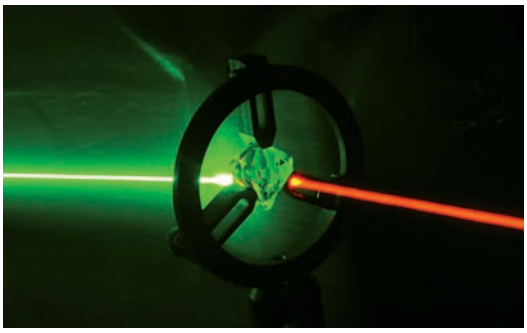
COMMUNITY EFFORT

Mariantoni recognizes the need for a collaborative effort in the quest to build a superconducting quantum computer, not only between academic institutions, but also with industry partners. "This will be a community effort. Our team is specializing in making one or a few pieces of an actual quantum computer. Eventually, these technologies will be used by industry partners to build a truly scalable quantum processor," he said. Together, the research community will complete the quantum computing puzzle.

WEB **http://bit.ly/TheQuantumSocket** ■

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.



Changing the colour of a single photon in a diamond quantum memory

NATURE COMMUNICATIONS 7, 11200 (2016)

PhD students **KENT FISHER** and **JEAN-PHILIPPE MacLEAN** and faculty member **KEVIN RESCH**, Canada Research Chair in Optical Quantum Technologies, along with researchers from the National Research Council of Canada (NRC) have, for the first time, converted the colour and bandwidth of ultrafast single photons using a room-temperature quantum memory in diamond. The results were published in *Nature Communications* in April.

The diamond quantum memory works by converting the photon into a particular vibration of the carbon atoms in the diamond, called a phonon. This conversion works for many different colours of light allowing for the manipulation of a broad spectrum of light. The energy structure of diamond allows for this to occur at room temperature with very low noise. Researchers used strong laser pulses to store and retrieve the photon. By controlling the colours of these laser pulses, researchers controlled the colour of the retrieved photon.

Quantum networks are made of components with different ideal frequencies and bandwidths, and the ability to shift the colour of a photon between them enables higher performance. Smaller frequency shifts can also be used for wavelength division multiplexing, a transmission method where large amounts of information are broken down into small packets of slightly varying frequencies so they can be reconstructed upon delivery.

WEB **http://bit.ly/DiamondQuantumMemory** ■

Breaking time-reversal symmetry with chiral quantum walks

PHYSICAL REVIEW A 93, 042302 (2016)

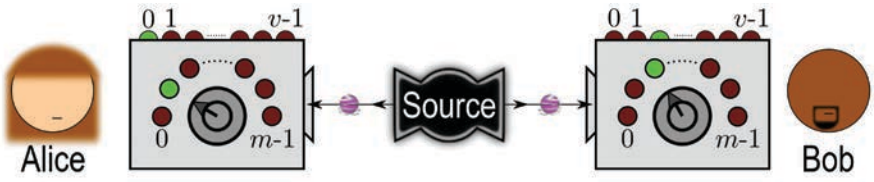
An international collaboration, including six IQC researchers, broke time-reversal symmetry in quantum walks for the first time. This is a key step toward controlling state transfer probability without losing the 'quantumness' of the state due to errors that arise using other methods. Controlling the evolution of quantum states is one of the main challenges in developing quantum applications, such as quantum computers.

The researchers identified the most basic time asymmetric process that allows symmetry breaking and experimentally realized it using room-temperature liquid-state nuclear magnetic resonance (NMR) on a three-qubit system. This allowed them to simulate a chiral quantum walk to break time-reversal symmetry. This method allows control without biased distribution of initial states with limited system access and achieves state transfer probabilities approaching unity.

The paper, *Chiral Quantum Walks*, by IQC Postdoctoral Fellow **DAWEI LU**, faculty members **RAYMOND LAFLAMME** and **JONATHAN BAUGH**, visitors **JUN LI** and **HANG LI** and IQC Affiliate **JACOB BIAMONTE**, in collaboration with researchers from around the world, was published in *Physical Review A* April 1.

WEB **bit.ly/BreakingTimeReversal** ■

SCIENCE
HIGHLIGHTS



DEFINING NONCONVEXITY IN QUANTUM CORRELATIONS

PHYSICAL REVIEW A 92, 062120 (2015)

IQC PhD student **JOHN DONOHUE** and **ELIE WOLFE** of Perimeter Institute have determined the required complexity of a quantum system and how many bits of shared classical information are needed between two parties to generate a general probability distribution with a known set of quantum correlations.

In a simple case where Alice and Bob can each choose one of two inputs and reveal one of two possible outputs, Donohue and Wolfe found that at most three bits of shared randomness are required to reach the full set of achievable quantum correlations with a two-qubit system. Without this shared randomness, the range of possible quantum correlations is nonconvex, meaning that even if two types of correlations are possible to build, their average may not be. This is the first time that nonconvexity has been shown for complete regions of quantum correlations.

Their results, *Identifying nonconvexity in the sets of limited-dimension quantum correlations* published in *Physics Review A* in January, may be useful for entanglement verification and opens the door to further research in this area. "Many questions remain," says Donohue, "including the consideration of more complex scenarios with additional qubits."

WEB **http://bit.ly/DefiningNonconvexity** ■

Growing nanowires takes a new direction

NANO LETTERS 2016, 16 (5)

Researchers collaborating with IQC faculty member **MICHAEL REIMER** found a new method to grow high-quality, defect-free material for nanowire p-n junctions. This results in better electrical contacts for quantum light-emitting diode (LED) devices.

The electrical contact has been in issue for a decade. Now that this is solved, the results are a step towards developing quantum devices. According to Reimer, "From here we can scale up to a devices that transfers entanglement. Ultimately the goal is to build a quantum device that interfaces stationary and flying qubits."

The research published in *Nano Letters* in April, *High Yield Growth and Characterization of <100> InP p-n Diode Nanowires*, also has implications for quantum detectors, solar cells and other energy conversion applications.

WEB **http://bit.ly/GrowingNanowires** ■

IQC OUTREACH

TALKS & TOURS

LAFLAMME SHARES HIS PREDICTIONS FOR QUANTUM COMPUTERS

The annual Andrew Chamblin Memorial Lecture was given by Executive Director **RAYMOND LAFLAMME** at the largest ever Cambridge Science Festival. Laflamme spoke about recent developments in quantum technology and the obstacles researchers must overcome to take it even further. He also shared some predictions about the future of quantum computing, including the production of a 100-qubit processor within five years and a new, quantum equivalent to Moore's law once this feat is achieved. The two-week festival, March 7-20, focused on interaction between humans and technology, including artificial intelligence. ■

CONVERSING ABOUT QUANTUM AT CALTECH

RAYMOND LAFLAMME participated in *A Conversation on the Future of Quantum Computers* at the Caltech Quantum Summit January 27, 2016. The discussion panel was moderated by Senior Science Editor Jennifer Ouellette of Gizmodo.com, and other participants came from top computing companies such as HP Laboratories, IBM, Microsoft, Intel and Google. A publicity video for the Summit featuring Stephen Hawking and Paul Rudd playing quantum chess went viral with nearly 2 million views.

WEB **http://bit.ly/QuantumChess-RuddHawking** ■

CONFERENCES

Sharing the latest theoretical quantum information research

Researchers investigating the theoretical aspects of quantum computing, quantum cryptography and quantum information met at the Banff Centre in Alberta for the 19th annual Quantum Information Processing (QIP) conference, January 10-16. Among the research presented was *An experimental test of noncontextuality without unwarranted idealizations* by IQC researchers **MIKE MAZUREK**, **MATT PUSEY**, **KEVIN RESCH** and **ROB SPEKKENS**. Faculty member **JOHN WATROUS** presented *Quantum Interactive Proofs and Semidefinite Programs* during the tutorial sessions at the University of Calgary prior to the conference.

WEB See the tutorial notes: **http://bit.ly/QIP-2016** ■

UPCOMING CONFERENCES

QCrypt

September 12-16, 2016
Washington, DC

WEB **http://2016.qcrypt.net/**

4th ETSI/IQC Workshop on Quantum-Safe Cryptography

September 19-21, 2016
Toronto, Ontario

WEB **http://bit.ly/ETSI-2016** ■

MARCH MEETING IN MARYLAND

The APS March Meeting brought nearly 10,000 researchers, scientists and students to Baltimore, Maryland from March 14-18. More than 30 abstracts presented at the conference were co-authored by IQC researchers:

DMITRY PUSHIN: *Twisting Neutron Waves*

JOEL WALLMAN, YUVAL SANDERS and BARRY SANDERS: *Bounding quantum gate error rate based on reported average fidelity*

ADAM WEI TSEN: *Weakly Bound and Strongly Interacting: $NbSe^2$ and 1T-TaS^2 in the 2D Limit*

Wallman: *Estimating the coherence of noise*

THOMAS McCONKEY, JEREMY BEJANIN, JOHN RINEHART, COREY RAE MCRAE, CAROLYN EARNEST and MATTEO MARIANTONI: *The Quantum Socket: Wiring for Superconducting Qubits*

KAVEH GHARAVI and JONATHAN BAUGH: *Optimization of metamorphic buffers for molecular epitaxial growth of high quality AlInSb/InSb quantum structures*

GUO-XING MIAO, DELER LANGENBERG and Mariantoni: *Growth of single-crystal Al layers on GaAs and Si substrates for microwave superconducting resonators*

DARRYL HOVING, Gharavi and Baugh: *Readout scheme for Majorana parity states using a quantum dot*

POL FORN-DIAZ: *Broken selection rule in the quantum Rabi model*

CHRISTOPHER HERDMAN: *A numerical study of the energy gap of the quantum dimer-pentamer model and Engineering autonomous error correction in stabilizer codes at finite temperature*

ROGER MELKO: *Entanglement Entropy and Topological Order in Resonating Valence-Bond Quantum Spin Liquids, Machine learning phases of matter and The learnability of critical distributions*

PATRICK COLES, ERIC METODIEV and NORBERT LÜTKENHAUS: *Unstructured quantum key distribution*

SANGIL KWON: *Cr^{3+} NMR for Multiferroic Chromium spinel $ZnCr_2Se_4$*

DAVID LAYDEN, EDUARDO MARTÍN-MARTÍNEZ and ACHIM KEMPF: *A universal scheme for indirect quantum control*

Herdman, PIERRE-NICHOLAS ROY and Melko: *Entanglement entropy of the ground state of the Lieb-Liniger model*

Gharavi, GREGORY HOLLOWAY and Baugh: *Proximity semiconducting nanowire junctions from Josephson to quantum dot regimes*

CHUNQING DENG, JEAN-LUC ORGIAZZI, FEIRUO SHEN and ADRIAN LUPASCU: *Analysis of qubit dynamics under strong resonant pulses using Floquet theory*

CHRISTOPHER CHAMBERLAND, TOMAS JOCHYM-O'CONNOR and RAYMOND LAFLAMME: *Quantum fault-tolerant thresholds for universal concatenated schemes*

Holloway and Baugh: *Electrical characterization of surface passivation in III-V nanowires*

Melko and GIACOMO TORLAI: *Exploring many-body physics with deep networks*

CHUNG WAI SANDBO CHANG, VADIRAJ ANANTHAPADMANABHA RAO and CHRISTOPHER WILSON: *Multimode Entanglement Generation in a Parametric Superconducting Cavity*

KYLE WILLICK and Baugh: *Continuous Wave Noise Spectroscopy Beyond the Weak Coupling Limit*

Martín-Martínez: *Relativistic Quantum Communication and the Structure of Spacetime*

GUILLAUME VERDON-AKZAM, Martín-Martínez and Kempf: *Asymptotically Limitless Quantum Energy Teleportation via Qudit Probes*

HOLGER HAAS: *Dipolar Decoupling in Magnetic Resonance Force Microscopy using Optimal Control Pulses*

YANBAO ZHANG and Lütkenhaus: *Entanglement verification with detection efficiency mismatch*

GUANRU FENG, FRANKLIN CHO, ROBABEH RAHIMI, DANIEL (KYUNGDEOCK) PARK, BRANDON BUONACORSI, Baugh and Laflamme: *Benchmarking of Quantum Control in ESR*

DAWEI LU, AHARON BRODUTCH, visitors H. LI and J. LI, DENIS-ALEXANDRE TROTTIER, GUILU LONG, Baugh and Laflamme: *Experimental Estimation of Average Fidelity of a Clifford Gate on a 7-qubit Quantum Processor*

Ananthapadmanabha Rao, Sandbo Chang, Forn-Diaz and Wilson: *Quantum optics with nonlinearly coupled superconducting resonators*

Forn-Diaz, JEAN-LUC ORGIAZZI, MUHAMMET (ALI) YURTALAN, MARTIN OTTO, Wilson and Lupascu: *Ultrastrong coupling in a flux qubit-transmission line system*

TAISIYA MINEEVA, DAVID CORY, JOACHIM NSOFINI, DUSAN SARENAC and Pushin: *Neutron interferometry with cold stage*

DUSAN SARENAC, Wood, Mineeva, Cory and Pushin: *Neutron interferometry for precise characterization of quantum systems* ■

Around the INSTITUTE

student PROFILE: KENT FISHER

Reddit: A new platform for engaging with researchers

It's not an everyday occurrence that a scientific author has the opportunity to share research, answer questions and engage with readers through a two-way conversation. PhD student **KENT FISHER** had just that experience after the press release about his recent publication organically appeared on Reddit.

A friend sent Fisher a text alerting him that the release about his paper, *Frequency and bandwidth conversion of single photons in a room-temperature diamond quantum memory*, was posted to the front page of Reddit. Fisher wasn't a Reddit user, but hopped onto the site to see the post – this was the first time information about his research had been posted. The post received 2,849 upvotes – an indication of how many readers found the post to be interesting or a good topic for conversation.

Users already generated discussion and were looking for further explanation. "It felt very humbling to see that people were interested in the paper," Fisher said. "It was really neat to be able to have a real-time conversation with the readers. It doesn't happen very often that readers have a platform to connect with the author of a scientific paper like that."

Fisher's quantum optics research focuses on using single photons for quantum information and quantum computing applications. For the last few years, one of his projects has been the implementation of a quantum memory. Using a single photon to carry a qubit or piece of quantum information, Fisher has been investigating ways to store this information and retrieve it on demand.

The paper published in *Nature Communications* showed that once a photon was driven into the diamond for storage by a laser, retrieving the photon using a second laser tuned to a different frequency changed the photon's colour and bandwidth.

"Changing the colour of a stored photon is useful for frequency or wavelength multiplexing, a technique that is used in communications today," said Fisher. "We can change the frequency of the photon to match a specific wavelength, such as that of a fibre optic cable, which could increase data rates."

Fisher, a Toronto native, completed his Bachelor of Science at the University of Guelph before pursuing his Master's of Physics (Quantum Information) at Waterloo. Following his PhD in Physics under the supervision of Canada Research Chair in Quantum Optics **KEVIN RESCH**, Fisher has plans to return to Toronto for a postdoctoral fellowship at the University of Toronto with **AEPHRAIM STEINBERG** next year.

WEB **http://bit.ly/FisheronReddit** ■

FROM THE IQC GSA

It was a warm winter, but that didn't stop IQC from holding some chilly events to kick off 2016. More than 30 IQC students and postdocs went curling at the Westmount Golf and Country Club in February, where we were given a quick lesson and time to play a few ends of friendly competition. After many slips and falls getting started, we emerged as curling pros, or at least with the ability to put a rock or two in the house. In March, IQC held its second Chili Cookoff, where more than 10 chilis made by students, faculty and staff members competed for the title of Chili Champion. In the end, the winner by popular vote tied between Professor Kevin Resch's meaty chili, The Carne Cycle, and MSc student Matthew Brown's sweet chili, Bean Pot, while MSc Student Chris Warren's Thermal State walked away with the title of Spiciest Chili.

For the third year, the IQC GSA held an April social, where more than 50 students, postdocs and staff members descended upon uptown Waterloo in matching purple garb for an evening of refreshments, dancing and, most importantly, karaoke. We look forward to enjoying the summer sun at the IQC for the next four months.

Written by John Donohue ■

TOURS/VISITS

TOURING QUANTUM VALLEY

On January 17, members of the federal government met with IQC members and were given a tour of the facilities. The delegation included the Honourable **NAVDEEP BAINS**, Minister of Innovation, Science and Economic Development, the Honourable **BARDISH CHAGGER**, Minister of Small Business and Tourism, and MPs **RAJ SAINI** and **MARWAN TABBARA** of Kitchener Centre and Kitchener South-Hespeler respectively.

March 2, the Honourable **KIRSTY DUNCAN**, Minister of Science and members of the department of Innovation, Science and Economic Development (ISED) Canada visited the Quantum NanoFab and researcher **KEVIN RESCH**'s lab to learn about the research done at IQC.

The Honourable **REZA MORIDI**, Minister of Research and Innovation and Minister of Training, Colleges, and Universities, visited IQC January 25 to become acquainted with the researchers and their work.

JOHN TORY, Mayor of Toronto, **DAVE JAWORSKY**, Mayor of Waterloo, and **BERRY VRBANOVIC**, Mayor of Kitchener toured the labs in the Mike & Ophelia Lazaridis Quantum-Nano Centre on March 23. The visit was part of a larger effort to promote the area from Waterloo region to Toronto as an 'innovation corridor'.

Fifteen students from the Laurentian Science Communication Graduate program received a short communication workshop with **JODI SZIMANSKI** and **KATHRYN FEDY** on February 23. This was followed by a tour that included the Quantum NanoFab and three labs where they heard from students **CHRIS WARREN**, **CHRIS PUGH** and **CHRIS HAAPAMAKI**. ■

TEAM SPIN ICE PLAYS A PERFECT SEASON

Faculty member **MICHAEL REIMER** and 12 other IQC members played UW Campus Rec hockey during the Winter term. After an undefeated season, they beat out 25 teams to become the champions of the semi-competitive division. ■

Backstage with Neil deGrasse Tyson

IQC Master's students **MATTHEW BROWN** and **CHRIS WARREN** were backstage in Toronto on February 24 for "An Evening with Neil deGrasse Tyson," a travelling lecture series. Tyson spoke on a wide variety of topics, from recent developments in astrophysical science to the importance of science and scientific thinking permeating culture. After the talk, Brown and Warren had a chance for a brief photo op with the popular science purveyor and gave him a Quantum Cats t-shirt. ■

International Women's Day Dinner

Members of the IQC Equity & Inclusivity Committee joined nearly 300 other staff, faculty and students for the University of Waterloo's 11th annual International Women's Day Dinner on March 4. Distinguished guest speaker **JEAN ANDREY**, Dean of the Faculty of Environment, gave a talk about women, the environment and sustainable development. ■

IN THE NEWS

Funding for Innovation150

On March 15, the Government of Canada announced the Innovation150 initiative, the science-focused element of the Canada 150 celebrations, in Halifax, Nova Scotia. The Honourable **MÉLANIE JOLY**, Minister of Canadian Heritage, introduced the Innovation150 participants: Perimeter Institute, IQC, Actua, the Canadian Association of Science Centres and the Canada Science and Technology Museums Corporation. Through interactive events, more than 80 communities across Canada will learn about Canada's innovative past and the opportunities offered by science. In coverage of the announcement, *Metro* featured a photo of **MARTIN LAFOREST**, IQC Senior Manager of Scientific Outreach, guiding young children through a science experiment at Halifax's Discovery Centre as part of the federal announcement.

WEB Government news release: **http://bit.ly/Innovation150PressRelease**
Metro article: **http://bit.ly/Innovation150MetroArticle** ■

Around
THE INSTITUTE

Trudeau talks quantum computing

Executive Director **RAYMOND LAFLAMME** got the chance to talk quantum with Prime Minister Justin Trudeau during a tour of Perimeter Institute for Theoretical Physics on April 15. Their conversation went on to seed a social media sensation that garnered headlines around the world.

The Prime Minister's answer to a reporter's comment in jest, "I was going to ask you about quantum computing, but..." went viral not only in Canada, but around the globe. Garnering over 5 million views, the answer was covered by all the major Canadian news outlets along with *Popular Science*, *TIME* and *The New York Times*.

In the article *Justin Trudeau's quantum leap, Maclean's* reported that Laflamme was impressed by Trudeau's understanding of the basics of quantum computing. And though Laflamme — and the rest of the world — was pleasantly surprised, he insisted in his *Maclean's* interview that "Quantum physics is easy. Running a country, that's complex."

WEB **http://bit.ly/TrudeauTalkingQuantum** ■

THESIS DEFENCE

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

EVAN MEYER-SCOTT, PhD
YUVAL SANDERS, PhD ■

AWARDS AND FELLOWSHIPS

Graduate Scholarship awarded to PhD Student

SEAN WALKER was awarded the Alexander Graham Bell Canada Graduate Scholarship by the Natural Sciences and Engineering Committee (NSERC) for the third time. Earlier awards were for his Master's, while the 2016 award is for his PhD. The Canada Graduate Scholarship is given to deserving scholars in natural science or engineering graduate programs so they can concentrate on their studies and work with the best research mentors in their field. ■

RESEARCHER RECEIVES CSA CONTRACT

The Canada Space Agency (CSA) awarded faculty member **THOMAS JENNEWEIN** a $500,000 contract to advance the Detector Assembly subsystem of a Quantum Key Distribution (QKD) payload for the proposed Quantum Encryption and Science Satellite (QEYSSat) mission. Together with Neptec Design Group of Ottawa and other industry partners, Jennewein and his group will improve the design of the Detector Assembly, fabricate and integrate the hardware, and test the prototype in space-like conditions, including thermal-vacuum and radiation. ■

Laflamme's CRC renewed

Executive Director **RAYMOND LAFLAMME**'s Canada Research Chair (CRC) was renewed in February for $1.4 million over seven years. "The CRC renewal provides me with perhaps the most precious resource – time – which is essential to continue our progress in the complex and constantly evolving quantum world," said Laflamme. He will focus on developing methods to better control how quantum systems evolve. ■

First time a group wins equity award

The University of Waterloo Status of Women & Equity Committee (SWEC) awarded FemPhys founders **EMMA MCKAY**, **JENNIFER REID** and **SARAH KAISER** the SWEC Equity & Inclusivity Award. The award is given to those who have had a demonstrable, positive impact on equity, inclusivity and diversity on campus. FemPhys is an organization that meets these criteria by working toward a welcoming and supportive environment for female students studying physics. One of the group's first lectures was a catalyst for the creation of IQC's own Equity and Inclusivity Committee. ■

IQC ENTRANCE AWARDS

Both **NAYELI AZUCENA RODRIGUEZ BRIONES** and **CLIFFORD PIESHA** were given the $5,000 IQC Entrance Award this Winter for academic excellence and potential for research in quantum information science as determined by grades, research statements and reference letters. ■

Growing nanowire arrays for aerospace applications

Faculty member **JONATHAN BAUGH**, in collaboration with **RAY LAPIERRE** at McMaster University, is growing III-V nanowires to create sensitive infrared photodetector arrays with possible applications in the aerospace industry. With a grant awarded by Lockheed Martin and the partnership of the Ontario Centres of Excellence (OCE), their work involves growing nanowires perpendicular to a silicon oxide mask. Baugh and collaborators have chosen the material in their nanowires to detect infrared light, which is more robust for sensing in inclement weather, for example, than visible light. ■

PhD student receives Mike & Ophelia Lazaridis Fellowship

PhD student **SUMIT SIJHER** was awarded the 2016 Mike & Ophelia Lazaridis Fellowship, valued at up to $20,000 a year, renewable for up to four years, in complement with a University of Waterloo Award to cover tuition. Fellowships are given to international students who show promise for excellence in research in the field of Quantum Information Science. ■

PhD STUDENT AWARDED DAVID R. CHERITON GRADUATE SCHOLARSHIP

The David R. Cheriton Graduate Scholarship, awarded for academic excellence and demonstrated interest in research related to designing and implementing efficient computing systems, was given to PhD student **DHINAKARAN VINAYAGAMURTHY**. The scholarship is valued at $10,000 and is typically awarded for two years. ■

Around
THE INSTITUTE

ARRIVALS

Faculty

Na Young Kim
Adam Wei Tsen

Staff

Jeannie Bairos
Xinhua Ling
Michele Roche

Graduate students

Shahab Akmal
David Jepson
Clifford Plesha

Long-term visitors

Cheng Guo
Viv Kendon
Zhengfang Liu
Xiaodong Ma
Qingping Wu ■

On April 15, 2016, Prime Minister Justin Trudeau took a minute to explain what makes quantum computing so exciting. The rest is history.

Normal computers work either there's power going through a wire or not, it's one o… binary systems. What quantum states allow … is … more complex information to be encoded into a … bit. … gular computer bit is either a one or a zero … or … quantum state can be much more complex than that because … as we know things can be both … at the … time and the uncertainty … allows quantum states … to encode more information into a much smaller computer. So that's

99 words

QUOTED IN

84 publications

APPEARED IN THE NEWS IN

समाचार 新聞 أخبار വാർത്ത

11 countries

YOUTUBE

Over

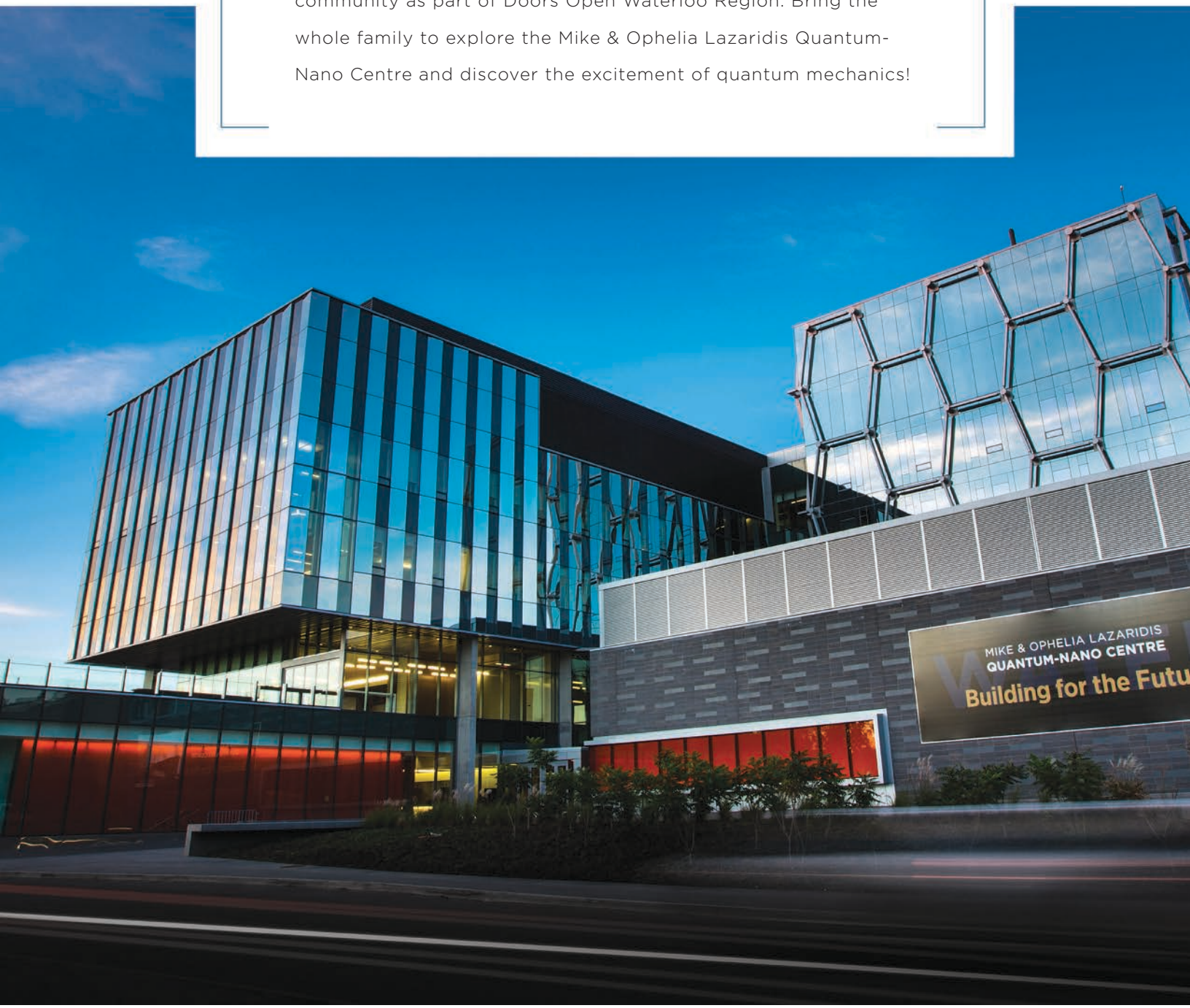
2,413,639

views

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

QUANTUM: THE EXHIBITION

#SUPERPOSITION

Watch for the cross-country tour beginning this fall at THEMUSEUM in downtown Kitchener!

INNOVATION150

PERIMETER INSTITUTE · actua · UNIVERSITY OF WATERLOO · IQC · CANADA 150 · Canada

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

UNIVERSITY OF WATERLOO | IQC Institute for Quantum Computing

Ontario

Canada