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

NewBit

Issue 20 | Special Edition

UNIVERSITY OF WATERLOO | IQC Institute for Quantum Computing

10th anniversary

Quantum Valley Takes the Stage

The science of the incredibly small has taken a giant leap at the University of Waterloo. On Friday, Sept. 21 the **MIKE & OPHELIA LAZARIDIS QUANTUM-NANO CENTRE** officially opened with a ceremony attended by more than 1,200 guests and dignitaries, including Prof. **STEPHEN HAWKING**.

Photos by Jonathan Bielaski

“This is a state-of-the-art research facility where scientists and students from many disciplines will work together toward the next big breakthroughs in science and technology.”

FERIDUN HAMDULLAHPUR,
President, University of Waterloo

“Just as the discoveries and innovations at the Bell Labs led to the companies that created Silicon Valley, so will, I predict, the discoveries and innovations of the Quantum-Nano Centre lead to the creation of companies that will lead to Waterloo Region becoming known as the Quantum Valley.”

MIKE LAZARIDIS,
Entrepreneur and philanthropist

The atrium of the Quantum-Nano Centre, which joins the Institute for Quantum Computing and the Waterloo Institute for Nanotechnology, housed the ribbon cutting ceremony.

Distinguished guests at the ribbon cutting of the Quantum-Nano Centre included Prof. **STEPHEN HAWKING**, MPP **JOHN MILLOY**, and MP **PETER BRAID** (behind).

Political and academic leaders cut the ribbon to officially open the new centre.

IQC Executive Director **RAYMOND LAFLAMME** spoke to the audience of 1,200 at the ribbon cutting.

Visionary philanthropists **DOUG FREGIN** (left), **OPHELIA** and **MIKE LAZARIDIS** with MPP **GLEN MURRAY** (Minister of Training, Colleges and Universities).

IQC doctoral student **DENY HAMEL** (front) was joined by Waterloo Institute for Nanotechnology graduate student **GRAEME WILLIAMS** and Nanotechnology undergraduate **MADELAINE LIDDY** to explain what the new Quantum-Nano Centre will mean to their academic careers.

ON THE COVER

Prof. **STEPHEN HAWKING** joins thousands to celebrate the opening of the Mike & Ophelia Lazaridis Quantum-Nano Centre

Photo by Jonathan Bielaski

On the eve of the official opening

of the Mike & Ophelia Lazaridis Quantum-Nano Centre, scientists, politicians, university leaders and others gathered to celebrate the visionary philanthropy and forward-thinking government support that made the building possible. Among the distinguished speakers were **MIKE LAZARIDIS**, Prof. **STEPHEN HAWKING**, IQC Executive Director **RAYMOND LAFLAMME**, University of Waterloo President **FERIDUN HAMDULLAHPUR** and, via video message, Gov. Gen. **DAVID JOHNSTON**.

1 IQC Executive Director **RAYMOND LAFLAMME** shared his enthusiasm about the opening of the Mike & Ophelia Lazaridis Quantum-Nano Centre with roughly 200 distinguished guests from around the world.

2 Special guest Prof. **STEPHEN HAWKING** with (left to right): WIN Executive Director **ARTHUR CARTY**, IQC Executive Director **RAYMOND LAFLAMME**, philanthropists **DOUG FREGIN**, **MIKE** and **OPHELIA LAZARIDIS**, and University of Waterloo President **FERIDUN HAMDULLAHPUR**.

3 IQC Executive Director **RAYMOND LAFLAMME** and University of Waterloo President **FERIDUN HAMDULLAHPUR** with Prof. **STEPHEN HAWKING**.

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Photo by Jonathan Bielaski

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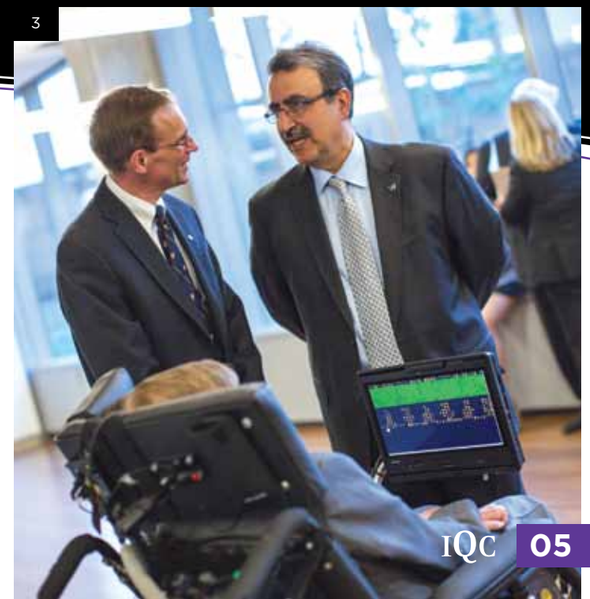

Prof. Stephen Hawking's Speech

Prof. Hawking delivered congratulatory remarks on the opening of the Quantum-Nano Centre during a private dinner reception:

> "I must admit, when I received an invitation to visit the "Quantum-Nano Centre," I was expecting a much, *much* smaller building. It's inspiring to instead come to such a big, beautiful facility devoted to the study of very small things. It is doubly satisfying to know that so many curious, brilliant minds will utilize this place to pursue truly groundbreaking research.
>
> I don't claim to be an expert on quantum computing or nanotechnology, but I do know a few things about the power of big ideas and free scientific exploration. What's happening here in Waterloo is truly special — from theory to experiment and beyond. This dedication to deep, fundamental science will benefit generations to come.
>
> While we don't know exactly where the research that happens here will lead, it will no doubt have impact — and to me, that's the most exciting part.
>
> My thanks to all the visionary supporters and those who had a hand in making this special day happen.
>
> Best of luck on the new voyage that is just beginning."

Open House

On Saturday, Sept. 29, the Institute for Quantum Computing and the Waterloo Institute for Nanotechnology hosted an open house at the Mike & Ophelia Lazaridis Quantum-Nano Centre. Nearly 3,000 visitors explored the state-of-the-art building at the heart of the University of Waterloo's main campus. The event featured interactive exhibits, hands-on demos, lab tours, a panel discussion, and public lectures by science celebrities **JAY INGRAM**, **ROBERT J. SAWYER** and **CHAD ORZEL**.

Thousands of guests toured the laboratories and collaborative spaces at the Quantum-Nano Centre.

Photo by Marco Piani

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> "It was inspiring to see so many people of all ages engaged in cutting-edge science. You could feel the excitement about the new Quantum-Nano Centre, and what it will mean for Waterloo Region, Canada and the world."
>
> **Martin Laforest**,
> Manager of Scientific Outreach, IQC

1 Visitors explored the corridor of underground laboratories at the Quantum-Nano Centre. Labs are buried underground — helping to reduce electromagnetic interference and vibration.

2 The superconducting levitating train was a popular exhibit.

3 Guests got an inside look at quantum cryptography systems.

4 A wide-ranging panel discussion about the future of quantum research featured insights from (left to right) **CHAD ORZEL**, **RAYMOND LAFLAMME**, **MIKE LAZARIDIS**, **TOM BRZUSTOWSKI**, and moderator **IVAN SEMENIUK**.

> "The open house was the first of many events to come at the Quantum-Nano Centre aimed at bringing the science of IQC to the world, and the world to IQC."
>
> **Raymond Laflamme**, IQC Executive Director

Music & Science

The versatility of the Quantum-Nano Centre's seminar room was showcased during the Quantum Symphony concert.

The JAY INGRAM AND THE QUBITS performance featured plenty of audience participation.

Quantum Symphony

On Sunday, Sept. 30, the Kitchener-Waterloo Symphony performed the innovative musical experiment, **"Quantum: Music at the Frontier of Science."** The concert, a multimedia voyage along the surprisingly similar paths followed by physics and music over the past century, included narration, an eclectic musical program and an immersive visual experience. The orchestra performed pieces that helped convey the history and themes of quantum science, by composers as diverse as Mozart and John Cage. The concert's 200 attendees received an exclusive building tour.

Kitchener-Waterloo Symphony Music Director **EDWIN OUTWATER** led the orchestra in a unique musical experiment.

Narrator **ANN BAGGLEY** told the story of how music and science have intersected over the past century, and engaging visuals illustrated key concepts.

Jay Ingram and the Qubits

In a truly one-of-a-kind experience, Canadian science guru **JAY INGRAM** and his rock band, **THE QUBITS**, teamed up with researchers from the Institute for Quantum Computing for an interactive mash-up of music and science. The concert, held on Saturday, Sept. 29, featured classic rock songs with a quantum twist in a fun and immersive evening for the whole family.

JAY INGRAM AND THE QUBITS reworked rock classics with a quantum twist.

JAY INGRAM and IQC's Manager of Scientific Outreach **MARTIN LAFOREST** demonstrated polarization during the Jay Ingram and the Qubits performance. ■

SCIENCE HIGHLIGHTS

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

Quantum teleportation goes the distance

NATURE 489, 05 (2012)

A depiction of the quantum teleportation link created in the Canary Islands by an international research team

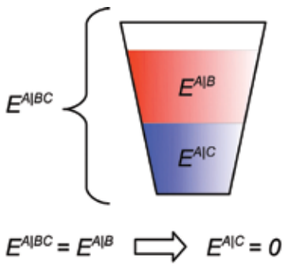
Three IQC scientists were part of an international research team that achieved quantum teleportation over a record-breaking distance in the Canary Islands. Professors **THOMAS JENNEWEIN** and **VADIM MAKAROV**, with PhD student **ELENA ANISIMOVA**, were part of a team that created quantum teleportation over 143 kilometres. Teleportation at such distances is a crucial milestone in this research, since that is roughly the minimum distance between the ground and orbiting satellites. "The experiment paves the way toward teleportation of signals over free space, or even using satellites," said Jennewein.

RANKING WEBSITES WITH A QUANTUM SPEED-UP

PHYS. REV. LETT. 108 (2012)

IQC researcher **SILVANO GARNERONE** co-authored a *Physical Review Letters* paper explaining a quantum speed-up to Google's system for ranking the importance of websites. The team's result represents an important step toward the development of quantum algorithms for quickly and efficiently retrieving useful information in a vast sea of data. The team showed that a quantum adiabatic computation could be superior to the classical approach to estimate the most important part of PageRank. Though the speed-up is not exponential (an advantage some quantum algorithms are known to provide), it is nonetheless a significant result because of its utility in finding useful information amid huge amounts of data.

Exploring Quantum Correlations



PHYS. REV. LETT. 109 (2012)

IQC research assistant professor **MARCO PIANI** recently co-authored a pair of papers in *Physical Review Letters* that explore questions of quantum entanglement and other non-classical correlations. The first paper, published in earlier August, investigates the question of "monogamy" of correlations, i.e. of to what extent quantum correlations obey constraints on how they can be distributed among multipartite systems. The second paper, which appeared in *Physical Review Letters* two weeks later, examines the relationship between quantum entanglement and a more general type of quantum correlations called quantum discord. In particular, this second paper clarifies the role of discord in entanglement distribution. Both papers address fundamental questions that will be crucial to the development of quantum communications and other technologies.

"Entanglement is monogamous. Imagine that Bob and Charlie are both trying to get a date with Alice — for a drink, maybe. If she chooses to go out with Bob, he will be happy and optimistic and will (literally) see the glass full; Charlie will instead be stuck with an empty glass." - Marco Piani

Photo from *Physical Review Letters*

Quantum algorithm a perfect "fit"

PHYS. REV. LETT. 109 (2012)

A team of researchers including IQC postdoctoral fellow **NATHAN WIEBE** demonstrated a powerful new quantum algorithm for data analysis. In collaboration with **SETH LLOYD** (MIT) and **DANIEL BRAUN** (Université de Toulouse), Wiebe described in an August edition of *Physical Review Letters* an algorithm to improve "least-fitting squares" (a data analysis technique) using a quantum computer. "Our work shows that an everyday computational problem can, under certain circumstances, be performed exponentially faster using a quantum computer than using existing classical algorithms," explained Wiebe.

Quantum connections span space — and time

PHYS. REV. LETT. 109 (2012)

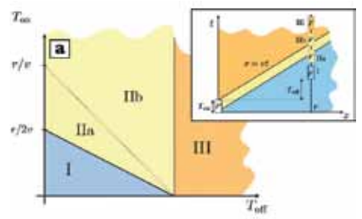


Diagram of the different spacetime regions involved in the experiment. Significant entanglement is extracted from the vacuum to the two qubits "P" and "F" in all the three regions.

A research team including IQC postdoctoral fellow **EDUARDO MARTIN-MARTINEZ** demonstrated quantum entanglement between particles that exist at different points in time. Martin-Martinez and his colleagues demonstrated that entanglement not only exists between quantum particles across space, but can connect particles that exist at different points in time, by making them interact only with the "quantum vacuum." In *Physical Review Letters*, the researchers explained how to use superconducting circuits to confirm something previously only understood in theory — quantum correlations of fluctuations in a vacuum across time and space. ■

IQC Executive Director earns honorary doctorate

For his contributions to scientific research and education, IQC Executive Director **RAYMOND LAFLAMME** received an honorary doctorate from L'Université de Sherbrooke in September. "The award was given to recognize his outstanding scientific accomplishment as a whole, and for his role as a leader in the Canadian quantum information community," said Sherbrooke professor **DAVID POULIN**, who earned his PhD at IQC under Laflamme a decade ago.

RAYMOND LAFLAMME (centre) pictured here with Prof. **SERGE JANDL**, Dean of Science (left) and the head of L'Université de Sherbrooke, Prof. **LUCE SAMOISETTE**

Around the Institute

Welcome

IQC welcomed four new faculty members to its world-leading research team this fall.

Prof. ROBERT KOENIG

Prof. Robert Koenig joined IQC in August following fellowships at the IBM Watson Research Center and the California Institute of Technology. Koenig is a member of the University of Waterloo's Department of Applied Mathematics, and will continue research into developing new quantum error-correcting codes, as well as new cryptographic schemes based on information processing limitations.

Prof. MATTEO MARIANTONI

Prof. Matteo Mariantoni will join IQC this December from the University of California Santa Barbara and the California NanoSystems Institute. He will become a member of the Department of Physics and Astronomy and will continue his research into circuit quantum electrodynamics, with a focus on quantum microwave photonics and quantum computing with superconducting quantum circuits.

Prof. GUO-XING MIAO

Prof. Guo-Xing Miao has been with IQC as a Research Assistant Professor since 2011. In his new position as a faculty member in the Department of Electrical and Computer Engineering, Miao will continue his research into spintronics and topological quantum computing.

Prof. CHRISTOPHER WILSON

Prof. Christopher Wilson joined IQC in October from Chalmers University of Technology in Sweden. Wilson is a member of the Department of Electrical and Computer Engineering, and he will continue his research into superconducting nanocircuits for quantum information.

CREATE GRANTS

Professors **DAVID CORY** and **MICHELE MOSCA** received federal grants worth $1.65 million each to launch cutting-edge training and mentorship programs for young Canadian scientists. The Collaborative Research and Training Experience (CREATE) grants, funded by NSERC, support the training of exceptional students and postdoctoral fellows by encouraging collaboration and teaching professional skills.

Minister of State (Science and Technology) **GARY GOODYEAR** (centre) talks with CREATE funding recipients **MICHELE MOSCA** (left) and **DAVID CORY**.

Quantum Golf Tournament

Winners of IQC's annual Quantum Golf Tournament (left to right): **CHRIS ERVEN**, **CHRIS PUGH**, **MIKE MAZUREK** and **ZAK WEBB**.

Banting Postdoctoral Fellowship

Congratulations to IQC postdoctoral fellow **EDUARDO MARTIN-MARTINEZ,** who has earned the Banting Postdoctoral Fellowship valued at $70,000 per year over two years. The funding will support his work in relativistic quantum information theory and quantum optics.

VANIER CANADA GRADUATE SCHOLARSHIP

IQC graduate student **KENT FISHER** has been awarded the prestigious Vanier Canada Graduate Scholarship worth $50,000 per year over the next three years. The scholarship — one of 156 awarded to exceptional young scientists across Canada — will assist Fisher in his quantum optics research, as well as enable him to travel to international scientific conferences and workshops.

KENT FISHER (centre) explains a quantum optics set-up to students in an IQC summer program.

Documentary screening commemorates Turing anniversary

On June 21, to commemorate the 100th anniversary of Alan Turing's birth, the Institute for Quantum Computing hosted a free public screening of *Codebreaker*, a feature documentary about the father of computer science. The screenings were among the first Canadian showings of the documentary, which was produced for British television last year. Hundreds of visitors came to learn about the computer science genius whose discoveries still underlie much of the research that happens at IQC.



The IQC David Johnston Award for Scientific Outreach

Congratulations to the winners of IQC's Scientific Outreach Award. Up to three awards valued at $2,500 are given annually to graduate students at IQC who have shown an outstanding commitment to scientific outreach and community engagement. This award celebrates Canadian Governor General David Johnston's vital contributions to IQC, his passion for leadership and his enthusiasm for continuous learning, innovation and achievement. David Johnston was president of the University of Waterloo from 1999 to 2010. The award is funded by Industry Canada.

This year's recipients (above, left to right): **FARZAD QASSEMI**, **JAMIE SIKORA** and **EVAN MEYER-SCOTT**.

Arrivals

Faculty
Robert Koenig
Matteo Mariantoni
Guo-Xing Miao
Christopher Wilson

Postdoctoral Fellow
Aharon Brodutch
Audrey Dot
Christopher Haapamaki
Nathaniel Johnston
Keith Lee
Dawei Lu

Staff
Erin Cronin
Robert Crow
Tobi Day-Hamilton
Jen Fung
Ryan Goggin
Chin Lee
Matt Schumacher

Students
Megan Agnew
Vibhu Gupta
Minyang Han
Sarah Kaiser
Shitikanth Kashyap
Lydia Lane-Smith
Maryam Mirkamali
Vincent Russo
Ala Shayeghi
William Stacey
Yongchao Tang
Kyle Willick
Muhammet Yurtalan
Shima Bab Hadiashar
Srinivasan Arunachalam
Stephane Labruyere
Paulina Corona Ugalde
Corey Rae McRae
Jason Boisselle
Alexander Valtchev
Erika Janitz

Long-Term Visitors
Amin Baumeler
Antti Karlsson
Dominique Pouliot
Jonathan Friedman
Laura Piispanen
Mehul Kumar
Melanie Jensenworth
Vikram Sharad Athalye ■

Mike & Ophelia Lazaridis
Quantum-Nano Centre






IQC thanks the many guests, volunteers, staff and supporters who made possible the opening of the Mike & Ophelia Lazaridis Quantum-Nano Centre.

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

Summer at IQC

IQC was buzzing with activity this past summer hosting numerous summer camps, conferences and schools for exceptional students from around the world. Here's just a sampling:

» **9th Canadian Student Conference & 2nd AQuA Student Congress on Quantum Information**

June 18 — 22, 2012

» **Quantum Cryptography School for Young Students 2012**

August 13 — 17, 2012 ■

» **Undergraduate School on Experimental Quantum Information Processing 2012**

May 28 — June 8, 2012

« **12th Annual Canadian Summer School on Quantum Information**

June 11 — 16, 2012

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

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