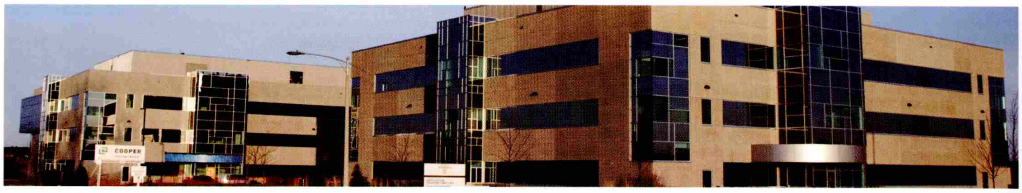

IQC Institute for Quantum Computing

UNIVERSITY OF WATERLOO

ISSUE 14
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2010

THE INSTITUTE FOR QUANTUM COMPUTING

NewBit

Dr. David Cory
Joins IQC as a Canada Excellence Research Chair in Quantum Information Processing

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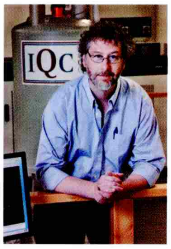


The Boomerang of Life Brings Hawking to IQC

At first glance, a wooden boomerang might seem like a peculiar gift to bestow upon the world's most famous scientist.

But Stephen Hawking immediately understood the significance of the gift he received on June 23 from his former doctoral student, IQC Director Raymond Laflamme.

A couple of decades have passed since Laflamme proved to Hawking — his PhD supervisor at the University of Cambridge — that time behaves more like an arrow than a boomerang in a contracting universe.

But Hawking's visit to IQC demonstrated that the "arrow of time" can sometimes bring longtime friends and colleagues full-circle.

In the 1980s, when Hawking was writing his best-seller *A Brief History of Time*, Laflamme's job was to mathematically demonstrate his mentor's theory about what happens to time in a contracting universe. Trouble was, the math didn't add up. Laflamme instead proved that Hawking's theory — that time reverses direction — could not be true.

Laflamme gave his former mentor the grand tour of IQC's labs, introducing him to the faculty, students, and staff of the institute. IQC personnel mingled with Hawking during a small and memorable reception that followed the laboratory tours.

"A Brief History of Time was the first popular physics book I read in high school, and it was very inspiring for me" said Marius Oltean, an undergraduate research assistant at IQC. "To see Stephen Hawking in person at IQC was itself an inspiration. I appreciated his visit very much."

The boomerang Laflamme presented to Hawking was engraved with an optimistic message for the future: "Come back soon!"

Quantum Grad Program Set to Begin

"The new collaborative graduate program will give students an incredible breadth of study in the field of quantum information, spanning theory and experiment."

- IQC Deputy Director Michele Mosca

For more see page 2

New @ IQC

Visitors

IQC is honoured to have hosted these distinguished guests during the winter term:

- Chris Laumann
- Dmitry Pushin
- Oleg Gittsovich
- Martin Laforest
- Steven Bennett
- Emily Pritchett
- Kent Fisher
- Florian Ong
- Aram Harrow
- Morgan Mitchell
- Patryk Gumann
- Robabeh Rahimi Darabad
- Hendrik Bluhm
- Alberto Marino
- David Touchette
- Colm Ryan
- David Schuster
- Dmitry Matsukevich
- Roderich Tumlka
- Jeff Lundeen
- Catherine Holloway
- Lai Choy Heng
- Kuldip Singh
- Tan Eng Chye
- Artur Ekert
- Chris Fuchs
- Peter Legg
- Vincent Nesme
- Lev Vaidman
- Thomas Jochym-O'Connor
- Tony Leggett
- Artem Kaznatcheev
- Stephen Turnbull
- Ghadir Mohammadkani
- Artem Kaznatcheev

Grad Program Ready to Roll

Classes will commence Sept. 14 in the University of Waterloo's innovative new graduate program in quantum information.

The inaugural class of students will be immersed in every facet of the emerging field. Spanning theoretical and experimental approaches to quantum information processing, the collaborative program aims to give students an unprecedented breadth of study.

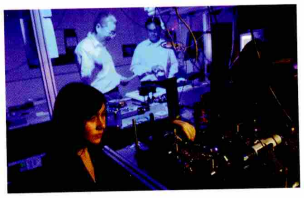
"The breakthroughs in quantum computing will likely happen across different disciplines," said IQC Deputy Director Michele Mosca. "We are sowing the seeds for that to happen. Big ideas tend to come from the cross-pollination of disciplines."

Mosca, who chairs the committee that created the program, hopes the next generation of scientists will make the connections between the various branches of quantum information research, such as computer science, engineering, physics and mathematics.

To this end, the graduate program was created in collaboration with six academic units within three faculties of the University of Waterloo.

Students will be based in their home program and earn a Quantum Information qualification to their degrees; for instance, Master of Mathematics in Computer Science (Quantum Information), or Doctor of Philosophy of Science in Chemistry (Quantum Information).

Students will be required to take two key courses: Quantum Information Processing, and Implementation of Quantum Information Processing.



International Deal Signed for Quantum Collaboration

On March 8, guests from the Centre for Quantum Technologies in Singapore were on hand for the signing of a memorandum of understanding that will foster the exchange of ideas and personnel.

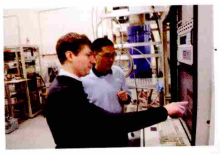
"It's really an honour to take this big step forward in collaborating with the Institute for Quantum Computing," said Tan Eng Chye, provost and deputy president of academic affairs at the National University of Singapore. "Both institutes have a critical mass right now. If we put them together, the chances we will be successful are much higher."

The signing event, held in the nuclear magnetic resonance lab at IQC, drew a number of academics, politicians and dignitaries. University of Waterloo President David Johnston lauded the event as "another big step forward" in the university's history of international cooperation.

IQC now has formalized agreements with IBM, the National Science Council of Taiwan, COM DEV, the Indian Institute of Technology in Kanpur and the National Institute of Informatics in Japan.

Baugh Receives $140K Equipment Grant

IQC faculty member Jonathan Baugh has been awarded a $139,000 grant to purchase state-of-the-art equipment for quantum information research. The one-year Research Tools and Instrumentation grant, awarded by the Natural Sciences and Engineering Research Council of Canada (NSERC), is intended to help top Canadian scientists acquire leading-edge equipment.



The grant will allow Baugh to purchase microwave instrumentation to manipulate single electron spins in quantum dots, which are essentially artificial atoms.

Baugh's team of researchers is investigating ways to use electron spins to encode and manipulate quantum information. This approach, which relies on nanoscale fabrication techniques developed in the semiconductor industry, has the potential for the creation of a system with many quantum bits, through which the full power of quantum computing might be realized.

Fresh Intellect

Dr. David Cory Joins IQC

Dr. David Cory, a pioneer and innovator in quantum computing, joined IQC this spring as Canada Excellence Research Chair (CERC) in Quantum Information Processing.

Cory's appointment as CERC — announced May 17 during a ceremony held inside his new, 10,000-square-foot laboratory at IQC — comes with $10 million in federal funding for his research.

Cory, who joins IQC and the University of Waterloo following a tenure as professor of nuclear engineering at Massachusetts Institute of Technology, is leading new experimental investigations into quantum sensors and actuators — the building blocks of future quantum computers.

He described IQC as a "wonderful environment" in which to pursue his leading-edge research, and lauded the Canadian government for investing in such important work.

"This chair will provide the resources needed to design, fabricate and test a first generation of quantum devices," Cory said. "Over the past decade, the engineering of quantum systems has become a reality. Now we aim to deploy quantum devices."

In total, 19 CERC appointments were announced simultaneously at 13 universities across Canada, in what was lauded as a monumental "brain gain" for the country.

Cory's IQC laboratory in the new Research Advancement Centre 2 (RAC2) is being outfitted with state-of-the-art equipment for conducting experiments using nuclear spin, electron spin, superconducting qubits and quantum optics.

Cory's research is expected to contribute to the world's first generation of practical quantum devices. These new technologies will have immediate and future applications in medicine, communications, biochemistry, physics and nanoscience.

Said IQC Director Raymond Laflamme: "With a scientist the calibre of David Cory as CERC Chair, Canada will be even better positioned to lead the world in the quantum information revolution."

Visitors

- Stephen Turnbull
- Rajat Mittal
- Vladimir Manucharyan
- Scott Foubister
- Samuel Denny
- Michel Devoret
- Sachin Pilot
- Gulshan Rai
- Robert Crow
- Dave Pryce
- Siddhartha Dasgupta
- Dave Dietz
- R Venkatesan
- Preeti Saran
- Amandeep Singh
- David Fransen
- Sasha (Alexander) Korotkov
- Pierre Bury
- Herve Mouren
- André Fougères
- Yuval Sanders
- Helen McDonald
- Martin Leblanc
- David Sevigny
- Mark Saffman
- Matthew Rosato
- Robert Peach
- Chen-Fu Chiang

New Board Member Cosimo Fiorenza

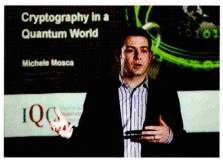
The newest addition to IQC's board of directors is the Vice-President and General Counsel of the Infinite Potential Group.

He is also a director of, and very involved in, a number of public and private non-profit and charitable institutions.

Fiorenza is a member of the Law Society of Upper Canada, the Canadian Bar Association and the Canadian Tax Foundation.

His expertise in Canadian law and business, as well as his enthusiasm for world-class science, make him an incredible asset to IQC's Board of Directors.

Deputy Director Appointed CIFAR Fellow



IQC Deputy Director Michele Mosca has been promoted to the prestigious position of Fellow in the Quantum Information Processing program of the Canadian Institute for Advanced Research (CIFAR).

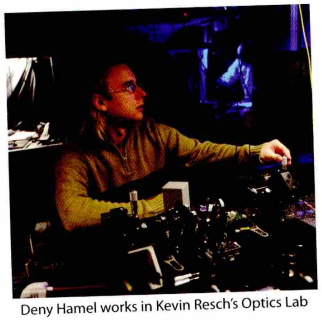
The program is made up of leading Canadian and international theorists and experimentalists from a range of disciplines including chemistry, physics, mathematics and computer science.

Being named a CIFAR Fellow is indicative of Mosca's exceptional contributions to quantum information research and his stature as a leader in the field. The program creates opportunities to share ideas and collaborate with top scientific peers around the world

In The Neighbourhood

Speakers

- Anand Kumar
- William Slofstra
- Krister Shalm
- Andris Ambainis
- Michel Pioro-Ladrière
- Chandrasekhar Ramanathan
- Martin Roetteler
- Howard Barnum
- Edward Farhi
- David Marcos
- Roger Melko
- Maarten van den Nest
- Ion Nechita
- David Poulin
- Pranab Sen
- Spyridon Michalakis
- Todd Brun
- Lieven Vandersypen
- Alipasha Vaziri



Deny Hamel works in Kevin Resch's Optics Lab

Emerson Public Lecture

When a radar trap clocked IQC faculty member Joseph Emerson speeding on a Quebec road, it occurred to him that quantum mechanics might help him get out of paying the fine.

At his March 3 Public Lecture hosted by Perimeter Institute, Emerson recounted how he told the Quebec Ministry of Justice he was innocent according to the fundamental laws of physics. His point was that the rules of quantum mechanics forbid the possibility of measuring the position and velocity of an object, such as an atom, with perfect precision.

However in the everyday world of bigger objects like speeding cars, this effect is negligible. Sensibly, therefore, he never mailed the letter and just paid the fine instead.

His lecture, held at a sold-out Waterloo Collegiate Institute, explored the strange and counterintuitive quantum laws of quantum mechanics and featured clips from the award-winning documentary *The Quantum Tamers*, of which Emerson was a co-author and on-screen personality.

TEDxWaterloo

IQC Director Raymond Laflamme explored the power of curiosity during his talk at the inaugural TEDxWaterloo conference on Feb. 25.

"Curiosity… is a thread that runs through all of us," Laflamme told an audience of roughly 350 at The Gig Theatre in downtown Kitchener.

TEDx is a locally organized offshoot of the TED (Technology, Entertainment, Design) conferences, which feature interesting and inspiring speakers and have become a viral Internet phenomenon.

Laflamme's speech, titled "Sparked By Curiosity: The Quantum Frontier," followed the chain of human discovery from the prehistoric harnessing of fire to the present-day exploration of quantum information technology.

Watch the talk at www.iqc.ca.

IQC Student Wins Prestigious National Scholarship

For his outstanding academic achievements at IQC, Deny Hamel has been awarded the Vanier Graduate Scholarship by the Natural Sciences and Engineering Council of Canada (NSERC).

Valued at $50,000 per year for up to three years, the scholarship is considered NSERC's most prestigious award for doctoral students.

The scholarship will allow Hamel, who has earned near-perfect grades in his Master's degree, to pursue his doctoral studies to the same level of excellence.

"Deny's academic track record is extremely impressive," said his thesis supervisor, IQC faculty member Kevin Resch. "This scholarship is richly deserved."

Hamel's MSc work has focused on the development of new sources of entangled photon pairs using nonlinear materials — a crucial facet of quantum computing research.

"My motivation for doing research has never been winning awards," Hamel said. "Research is just something I want to do. I feel very fortunate to have been rewarded for doing things I love."

Mosca Named to 40 Under 40

IQC Deputy Director Michele Mosca has been named among Waterloo Region's "40 Under 40" for his outstanding contributions to the area's scientific landscape.

The award, announced Feb. 24 in *The Waterloo Region Record*, recognizes 40 young, innovative leaders who have made a difference in the community.

The presence of many remarkable scientists in the region is thanks in large part to Mosca's tireless efforts to recruit the world's top researchers to Waterloo.

For such contributions, the Waterloo Region Record article lauded Mosca as "a pillar and visionary for the region's intellectual community."

Following his undergraduate studies UW, Mosca earned his doctorate in Mathematics at the University of Oxford. When he returned to his Canadian alma mater as a professor, he was determined to help put Waterloo on the map in the emerging field of quantum information research.

"It was a very pleasant surprise and honour to be chosen, knowing how many remarkable people there are in this region," said Mosca.

Hot Off The Press

Broadbent Welcomes Readers to Quantum Country

Anne Broadbent, a postdoctoral fellow at the Institute for Quantum Computing, finds balance between her leading-edge scientific research and her family life on a 10-acre farm nicknamed Windy Poplars.

In a feature published April 17 in The Waterloo Region Record, Broadbent said mathematics has an "elegance" that has always attracted her, not unlike the rustic beauty of her homestead northwest of Waterloo.

Broadbent introduced readers to her husband, Didier Guignard, their seven-month-old son Danny, and the family pet — a Bernese mountain dog named Berny.

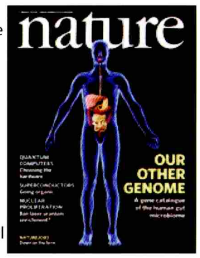
The article is the second installment of a Record series called Young Innovators, in which reporter Rose Simone profiles the next generation of leading-edge thinkers in Waterloo Region.

Nature Article Examines Quantum Computing Possibilities

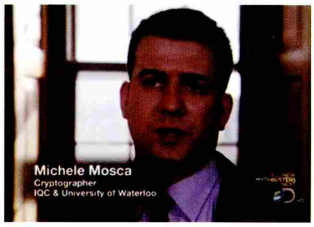
Creating a large-scale quantum computer is an ambitious but achievable goal requiring research in many experimental fields, says a recent article in Nature co-authored by IQC Director Raymond Laflamme.

"As we approach this goal, we will grow accustomed to controlling the counterintuitive properties of quantum mechanics," write Laflamme, Thaddeus Ladd, Fedor Jelezko, Yasunobu Nakamura, Christopher Monroe and Jeremy O'Brien. The article outlines the prevailing experimental techniques for harnessing and controlling quantum bits (qubits), including the use of photons, trapped atoms, nuclear magnetic resonance, quantum dots and dopants in solids, superconductors and other technologies.

"When we have mastered quantum technology enough to scale up a quantum computer," concludes the article, "we will have tamed the quantum world and become inured to a new form of technological reality."



Mosca on Weird or What?



Stay tuned to the History Channel for a new show called "Weird or What," featuring an interview with IQC Deputy Director Michele Mosca. The show examines strange and unsolved mysteries, including the Voynich Manuscript, a centuries-old book written in an unknown language that has never been deciphered.

Mosca lent his expertise on cryptography to the episode, which has already aired several times on the Discovery Channel in the US. Canadian viewers will get their first glimpse of the episode this summer, so keep an eye on iqc.ca for news and airdates.

Major Award!

Congratulations to IQC faculty member John Watrous and doctoral student Sarvagya Upadhyay for winning the prestigious Best Paper Award at the Symposium on Theory of Computing (STOC) for their paper entitled QIP = PSPACE

Director Featured in *Motivated Magazine*

Innate curiosity is the driving force behind all great science, IQC Director Raymond Laflamme writes in the new issue of *Motivated Magazine* — a publication about exceptional leaders.

"Curiosity is the force that drives everything I do," Laflamme writes in the 1,500-word article, "from getting my hands greasy under the hood of my 1979 VW van to manipulating the subatomic particles of the quantum world. And I love to inspire curiosity in others."

Laflamme recounts how curiosity led him from a typical childhood in Quebec to studying physics under the tutelage of Stephen Hawking at Cambridge. Laflamme is in good company within the pages of Motivated Magazine, given that charismatic leaders including Bill Clinton, Starbucks founder Howard Shultz and Apple Computer founder Steve Wozniak have been featured.

To read the story about Laflamme and other exceptional leaders, visit www.motivatedonline.com

Conferences & Workshops

Undergraduate School on Experimental Quantum Information Processing (USEQIP)

May 24 – June 4, 2010

An intensive, hands-on workshop aimed at giving roughly a dozen exceptional undergraduate students real-world experience in quantum computation laboratories. Students described the conference as "challenging," "fascinating" and even a "Willy Wonka's Chocolate Factory of Quantum Information."

Theory and Realization of Practical Quantum Key Distribution

June 14 – 17, 2010

A workshop designed to bring together experimentalists and theoreticians interested in efficient and practical implementations of quantum key distribution. Organizers described the conference as a big success and hope to host it again in 2012.

Quantum Information Processing with Spins and Superconductors (QISS)

May 17 – 19, 2010

A workshop designed to bring leaders in spins and superconductors together to discuss recent progress, unanswered questions, and future directions for building a solid-state quantum information processor.

Cross-Border Workshop

June 3 - 5, 2010

The workshop was intended to foster interaction between students and leading experts in laser science in an informal setting. Graduate and undergraduate students were encouraged to participate in the workshop to be exposed to laser related research outside their usual field.

Upcoming Events

Quantum Cryptography School for Young Students (QCSYS)

July 26 – 30

An exciting, week-long workshop during which a group high school students from across Canada will get hands-on experience working in one of the most cutting-edge topics of science — quantum cryptography.

IQC Open House & Doors Open Waterloo

Saturday, Sept. 18

IQC will offer the general public a rare glimpse into its laboratories and research spaces. As a participating site in the annual Doors Open Waterloo Region, IQC will offer lab tours, demonstrations and a public lecture by Dr. David Cory. More details will be coming soon, so stay tuned.

Upcoming Events for IQC Members

Marineland - July 16, 2010

Annual Golf Tournament - Late Summer

Welcome to IQC Celebrations - Early Fall

QNC Construction

June 2010 Construction

Artist's Rendition

Strength in Numbers

Welcoming the Best & Brightest

New Students

Jean-Philippe Bourgoin
Steven Casagrande
Alessandro Cosentino
Erik Crevier
Christopher Granade
Bassam Helou
Ian Hincks
Tyler Holden
Brad Huiskamp
Sakshi Jain
Virginia Jauregui Villanueva
Kevin Krusulich
Daniel Kumar
Yang Lu
Allison MacDonald
Shazib Mahmood
Ian McMullan
Marius Oltean
Deanna Pineau
Daniel Puzzuoli
Sarah Sheldon
Sujeet Shukla
Denis-Alexandre Trottier
Victor Veitch
Matt Volpini
Caleb Wherry
Xiaodi Wu
Tong Zhao

Social Life @ IQC

Monday Hockey
IQC members gather on Monday afternoons throughout the warm months for a game of pick-up hockey in the RAC parking lot.

Monthly Gatherings
On the first Friday of every month IQC faculty, students and staff get together for a casual social gathering with snacks and refreshments. Family members are always welcome.

New Postdocs

Oleg Gittsovich
Patryk Gumann
Motohisa Fukuda
Dmitry Pushin
Jon Tyson

Visiting Researchers

Seiichiro Tani
Yafei Yu

New Staff

Katharin Harkins
IQC's new Associate Director of Outreach and Communications arrived at the institute in June, following a year in a similar position at the University of Waterloo's Faculty of Engineering. Katharin worked for several years as a communications consultant in the not-for-profit and public sectors, after having served in leadership roles in large corporations including Sun Life Financial.

Martin Laforest
Already a familiar face around IQC, Martin is a PhD graduate who returns to the institute as the new Manager of Scientific Outreach. Before joining the staff at IQC, Martin worked on electron spins and quantum dots in a lab at the Delft University of Technology in the Netherlands. He will now translate his passion for science into outreach and communications activities at IQC.

Steve Weiss
Prior to joining IQC as Manager of Information Technology in May, Steve worked in a similar role at a mid-size manufacturing company. After earning his degree in Computing and Information Science from the University of Guelph, he worked in a number of IT roles, from front-line client support to managerial positions in larger corporations. Interesting quirk: Steve can only write vertically, not horizontally. Ask him why!

Departures

We bid farewell to members who are leaving us and wish them the best of luck in their future endeavours.

Nick Coish
Hannes Huebel
Max Julian
David Luong
Xiongfeng Ma
Alejandra Maldonado
Geir Ove Myhr
Christian Oppenlander
Maria Ortegon Banoy
Christian Oppenlander
Colm Ryan

For questions, comments or general feedback regarding IQC, contact: iqc@iqc.ca

Ray welcoming IQC's guests on April Fools Day

IQC wishes to thank the following individuals and organizations for their generous and continued support:

Mike & Ophelia Lazaridis

- and -

Army Research Office
Bell Family
Bruker Biospin Canada
Canada Foundation for Innovation
Canada Research Chairs
Canada's Economic Action Plan
Canadian Institute for Advanced Research
Canadian Institute for Photonic Innovations
Centre for Applied Cryptographic Research
Centre for Quantum Technologies, Singapore
COM DEV
Communications Security Establishment Canada
Defense Advanced Research Projects Agency
Disruptive Technology Office
Early Researcher Awards
European Research Association
Fields Institute
France Canada Research
Government of Canada
HRDC
IBM
Institut de Ciències Fotòniques
Institute for Computer Research, University of Waterloo
Intelligence Advanced Research Projects Activity
Massachusetts Institute of Technology
Mathematics of Information Technology and Complex Systems
National Science Council of Taiwan
Natural Science and Engineering Research Council
Ontario Centre of Excellence
Ontario Innovation Trust
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Ontario Research Fund
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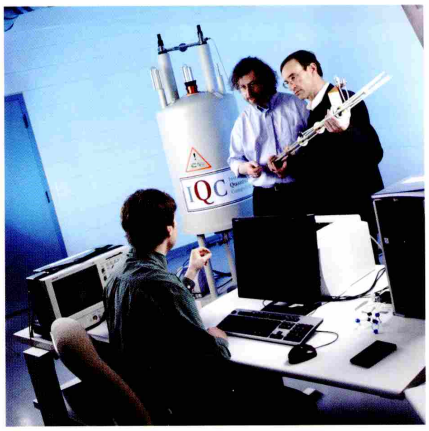
The City of Waterloo



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The NewBit Issue 14

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