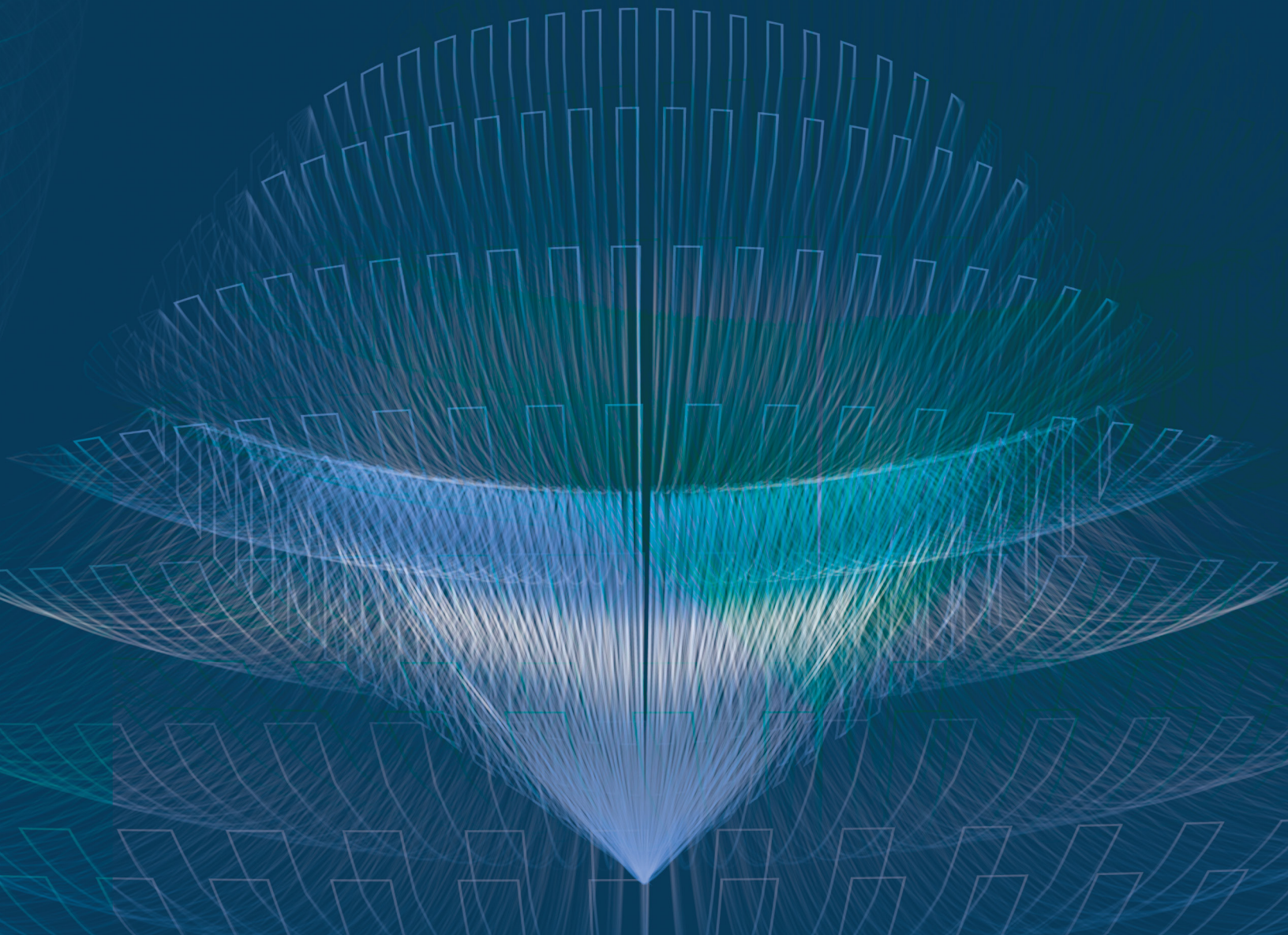
2019-2020

QUANTUM FRONTIERS



UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
Institute for Quantum Science and Technology

Vision

To be a world leader in research and education in pure and applied quantum science and technology.

Mission

To advance quantum science and technology through interdisciplinary research, teaching, and outreach.

Key Facts

18 **postdoctoral fellows**

72 **graduate students**

26 **undergraduate students**

72 **publications in refereed journal and conference proceedings including *Nature* (1), *Physical Review Letters* (2), *Nature Communications* (1), *Physical Review X* (1) and *Optica* (2).**

44 **invited talks at national and international conference/ workshops including three keynotes and two plenary talks**

6.56 **million dollars in research funds**

Contents

Director's Report

The Institute for Quantum Science and Technology hosts 15 research groups and about 130 academic members including professors, research staff and students. The Institute has four research themes: molecular modelling, nanotechnology, quantum information and computing, and quantum optics, across the four departments of Chemistry, Computer Science, Mathematics and Statistics, and Physics and Astronomy. In recent years, the Institute has effectively expanded to the provincial level through the growth of the *Quantum Alberta* initiative, which has three sites: the Universities of Alberta, Calgary and Lethbridge. The Institute for Quantum Science and Technology maintains a strong identity in Calgary but also exists as one of three *Quantum Alberta* branches.

The Institute is pleased to welcome Shabir Barzanjeh and Timothy Friesen as a Faculty member. Shabir moved from the Institute of Science and Technology Austria to the University of Calgary Institute for Quantum Science and Technology in 2020. Shabir's main experimental research directions are exploring quantum coherence and quantum interfaces in electro-and optomechanical systems, and developing superconducting circuit quantum electrodynamics. Tim joins the Institute after having worked at the Antiproton Decelerator facility at the European Organization for Nuclear Research (CERN). Tim's research focuses on trapping particle, microwave techniques, and annihilation detection for high-precision spectroscopy and gravitational mass measurements on antihydrogen.

The Institute for Quantum Science and Technology has enjoyed a successful year of research and training during the 2019/2020 year. Members of the Institute had 72 papers published in refereed journals and proceedings including seven papers appearing in the top-tier journals of *Nature* (1), *Physical Review Letters* (2), *Nature Communications* (1), *Physical Review X* (1), and *Optica* (2). The Institute attracted 21 new students into quantum graduate studies programs in 2019/2020. Seven masters students graduated and five doctoral students completed their degrees. The Institute hosted 19 postdoctoral researchers with four

being recipients of national and provincial postdoctoral fellowship including the *NSERC Postdoctoral Fellowship* (1), *the Alberta Innovates Eyes High Postdoctoral Fellowship* (2) and the *Alexander von Humboldt Feodor Lynen Research Fellowship–Germany* (1).

Success of the Institute is underpinned by support for training and infrastructure with especially notable support from the Natural Sciences and Engineering Research Council (NSERC) Collaborative Research and Training Experience (CREATE) Program called Quanta, which is headquartered at the University of Alberta. This program supports some University of Calgary graduate students. Furthermore, quantum activity is advanced significantly by a Canada Foundation for Innovation (CFI) grant for quantum technology, led by the University of Calgary. The Institute is home to the Alberta Government's Ministry of Job, Economy and Innovation's Major Innovation Fund, which supports quantum science and technology at the Universities of Calgary, Alberta and Lethbridge. This provincial funding supports 24 graduate students and six postdoctoral researchers at the University of Calgary.

The Institute continues to fulfill its mission as a Faculty of Science Institute and deliver outcomes matching Faculty expectations with respect to the quantum aspect of the Faculty's Grand Challenge on "Unlocking Our Digital Future". Furthermore, the Institute has a provincial leadership role through the *Quantum Alberta* initiative, which brings together the province's quantum science and technology researchers under the umbrella of one consortium. As quantum research and development ramps up in Canada and globally, the Institute has a key role to play in ensuring that Calgary continues to be strong on the world stage for quantum science and technology.

Barry Sanders
Director, IQST

Message from the Incoming Chair

Since more than a decade, and currently accelerated because of COVID-19, the world is experiencing industrial revolutions powered by digital and advanced technologies. Social interactions, education, health, and transportation, just to name a few, are all being reshaped and transformed because of advanced technologies. Over the coming decade, how we live, work, and play will continue to rapidly evolve because of multiple technological revolutions.

While others will follow or be shaped by this tsunami of change, the University of Calgary's digital initiative, including the research being done at the Institute for Quantum Science and Technology (IQST), will drive transformations though its transdisciplinary approach to developing advanced technologies in quantum science while growing the province's research and innovation ecosystem.

The high value placed on quantum science and technology is evidenced in the Faculty of Science strategic plan, namely under the Unlocking Our Digital Future Grand Challenge. Furthermore, the new Growth through Focus plan of the University of Calgary has selected "Exploring Digital Worlds" as one of only four focus areas. This Annual Report highlights how the Institute for Quantum Science and Technology is at the forefront of making great strides towards achieving Faculty of Science and University of Calgary goals for a digital future.

The success of the work of IQST is in part evident in funding announcements such as the recent news of Barry Sanders being awarded $3 million through the Major Innovation Fund. This major financial support will help the University of Calgary's *Quantum Alberta* network take advantage of the province's academic strengths and investment opportunities to establish Alberta as a leader in quantum technologies.

The IQST team brings a deep commitment for advancing quantum science applications that improve human existence. Through their continued efforts of developing curiosity, critical thought and disciplinary excellence necessary to solve the challenges of the future, the IQST team is educating our students and alumni to bring positive impact to society. We are proud to have IQST as one of the research leaders in the Faculty of Science and congratulate them to another highly successful year.

Bernhard Mayer
Interim Dean
Chair, Board of Directors

Research Highlights

RESEARCH ACHIEVEMENTS

The Institute for Quantum Science and Technology (IQST) has significant research achievements over the past year. The following exposition of achievements provides a sample of the kinds of activities and breakthroughs seen within IQST.

Nasser Moazzen-Ahmadi's group has produced exciting results on the water-carbon monoxide dimer, including spectra and ab initio calculations, and introducing Coriolis interactions to explain certain anomalous energies, and this result was published in *Physical Chemistry Chemical Physics*. This article is an editor's choice, signifying that the article is one of the journal's outstanding publications.

Gilad Gour's *Physical Review Letters* article on quantifying a dynamical quantum resource showed that generalizing relative entropy of a resource from states to channels has at least six generalizations with fascinating properties and involving a novel smoothing technique for channels that does not apply to states. Gour's definitive review article on quantum resource theories was published in *Reviews of Modern Physics*, which is the top reviews journal in physics.

Gour's leadership in quantum resource theories was acknowledged through giving an invited tutorial at the 2020 Quantum Information Processing Conference, which is the top annual conference for theoretical quantum information.

Christoph Simon is the lead theorist on a collaboration that showed erbium ions, inserted into the best-known host crystal, have better spin coherence in the excited state compared to the ground state, which was published in *Physical Review Letters*, and they propose a type of quantum transduction that exploits this advantage. Simon's collaboration with former *Quantum Alberta* member Alex Lvovsky led to an *Optica* paper reporting entanglement of distinct states of light, each containing over a hundred million photons.

Robert Thompson and Timothy Friesen collaborate with CERN's ALPHA project, which studies spectroscopic properties of anti-Hydrogen, and their *Nature* paper focuses on the Lamb shift, whose 1947 discovery of an energy separation of two fine-structure states of Hydrogen necessitated the theory of quantum electrodynamics.

Here the ALPHA project achieves a precise measurement of the anti-Hydrogen Lamb shift, which is fully consistent with quantum electrodynamics calculations for antimatter.

Paul Barclay's group demonstrated optomechanically amplified wavelength conversion in diamond microcavities, with the results published in *Optica*, and this technique could enable interfacing quantum devices operating at different spectral wavelengths. Notably they report frequency up-conversion with 45% internal conversion efficiency and have successfully incorporated optical amplification.

Barry Sanders provided key theoretical input for two landmark experiments: an experimental demonstration of quantum fully homomorphic encryption published in *Physical Review X* and for emergent momentum-time skyrmions in parity-time-symmetric non-unitary quench dynamics published in *Nature Communications*.

AWARDS

International Awards

Alexander von Humboldt Feodor Lynen Research Fellowship – Germany

Martin Schon

Study Abroad Studentship, Leverhulme Trust - United Kingdom

Adam Powell

National Awards

CAP Herzberg Medal 2019

Paul E. Barclay

MITACS Globalink

Shudipto Kazi Amin
Bo Fu
Rajat Kumar

NSERC Alexander Graham Bell Canada Graduate Scholarship – Doctoral

Stephen Wein

NSERC Alexander Graham Bell Canada Graduate Scholarship – Master

Dante Renato Bencivenga
Janet Leahy

NSERC Postdoctoral Fellowship

Ghazal Haji Salem

NSERC USRA

Xining Chen
Nathan Fischer
Evan Johnson

Nova Chemicals Graduate Scholarship

Rishabh Shukla

Provincial Awards

Alberta Graduate Excellence Scholarship

Katelynn Daly
Alison Fulton
Salini Karuvade
Rishabh Shukla
Zhan Yu

University of Calgary Awards

Alberta Innovates Eyes High Postdoctoral Fellowship

Asha Yadav
Joseph Losby

Alberta Graduate Students Travel Incentive

Archismita Dalal

Canadian Queen Elizabeth II Diamond Jubilee Scholarships (Advanced Scholars)

Nehad AttaElmanan AbdElrahim Mabrouk

Department of Physics and Astronomy Graduate Student Excellence Award

Aaron Barclay

Eyes High International Doctoral Scholarship

Sumit Goswami

Faculty of Graduate Studies Travel Award – International Student

Gaurav Saxena
Parisa Zarkeshian

ii'taa'poh'to'p Graduate Scholarship

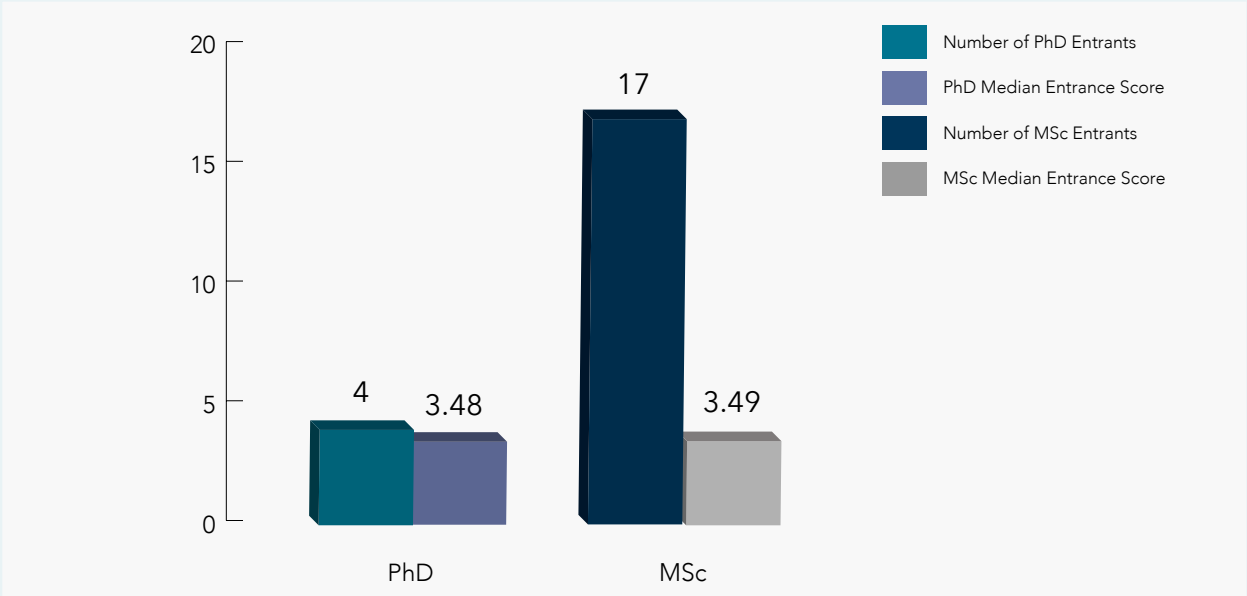
Katelynn Daly

Provost's Doctoral Scholarship

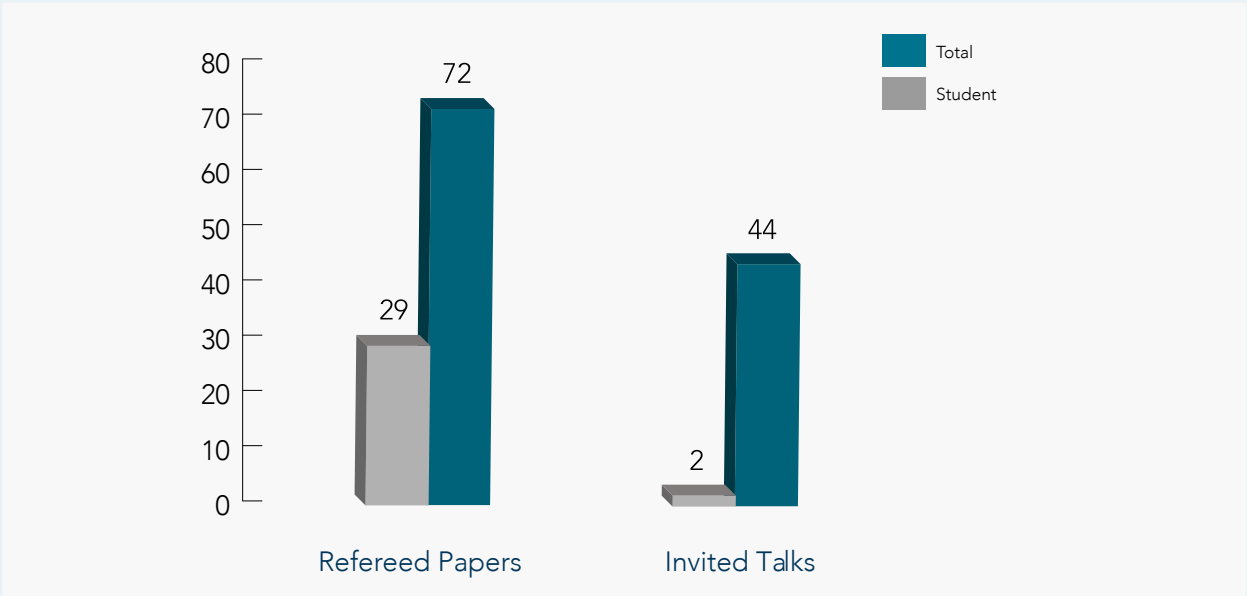
Shudipto Kazi Amin

KEY PERFORMANCE INDICATORS

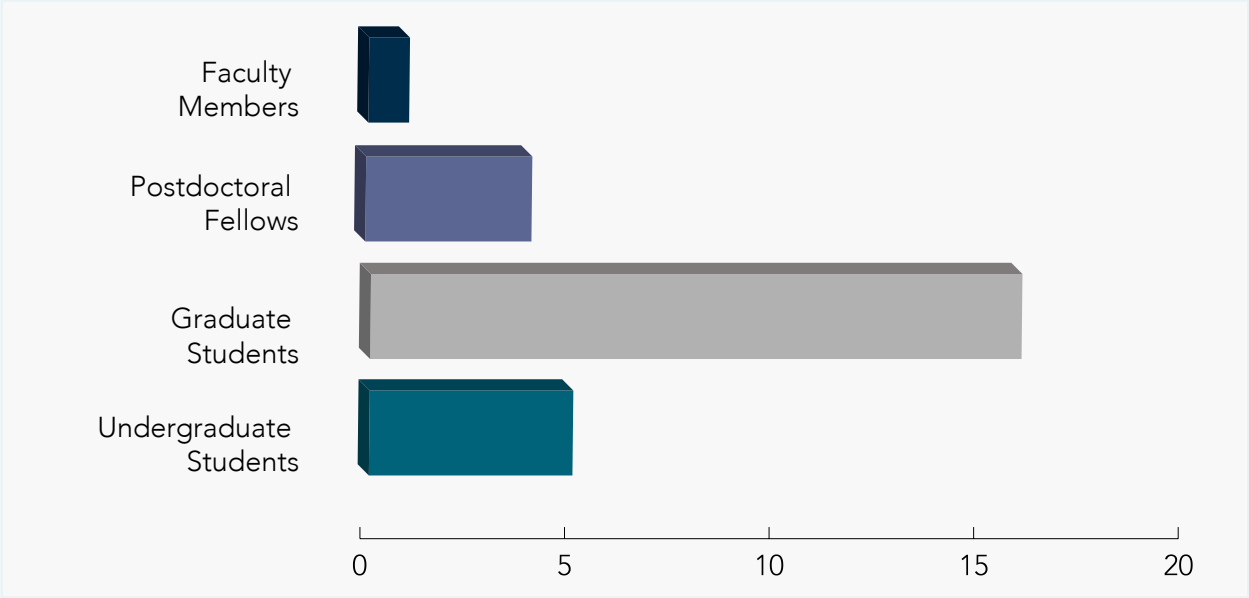
GRADUATE STUDENT ENROLMENT AND QUALITY OF ENTRANTS



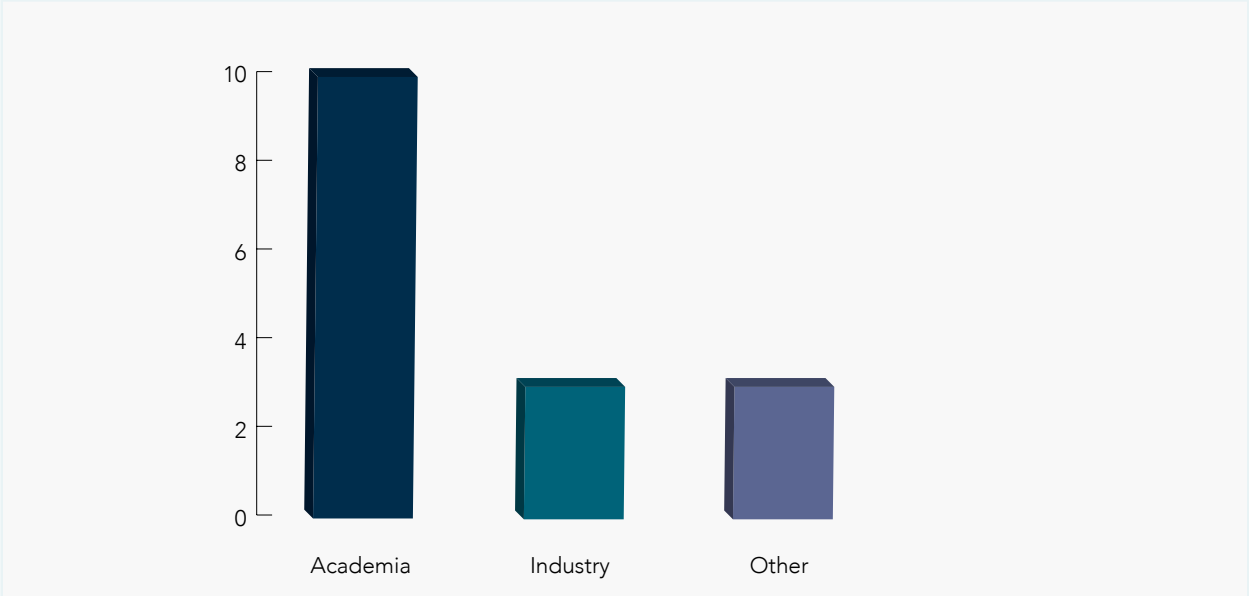
PUBLICATIONS AND PRESENTATIONS



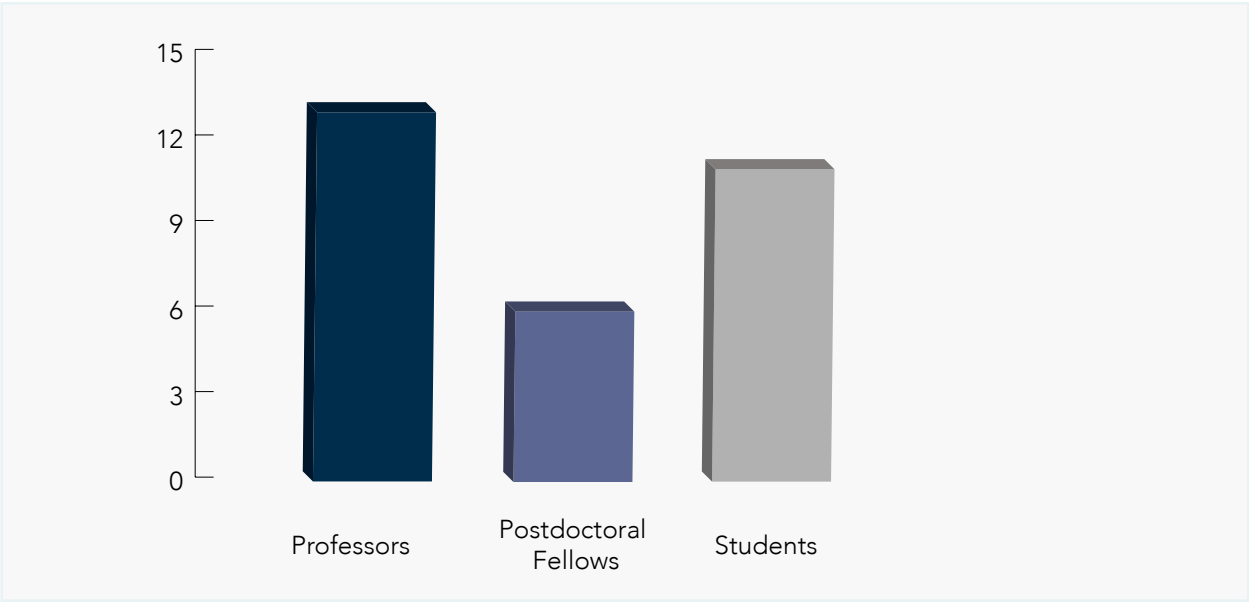
AWARDS (CHAIRS, FELLOWSHIPS AND SCHOLARSHIPS)



TRAINEE DESTINATIONS AFTER IQST



VISTORS

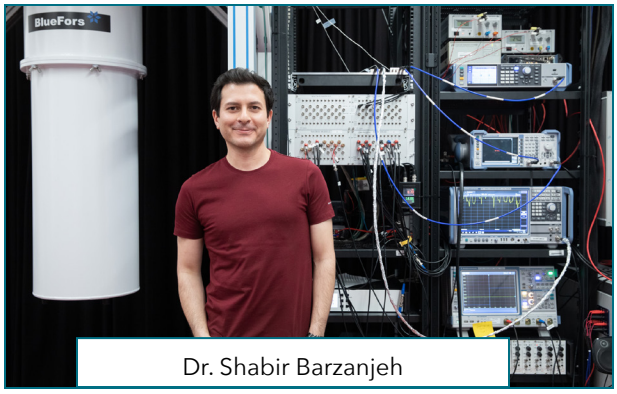


Research Groups

Dr. Paul Barclay

NANOSCALE OPTICS

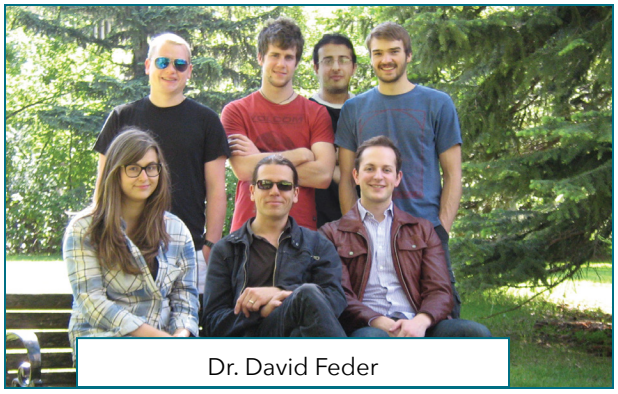
Explores interactions between light and nanoscale systems such as single atoms, electron spins and nanomechanical structures. Employs nanofabrication methods to engineer optical properties of these systems in order to enhance light-matter coupling. The current focus couples single quantum emitters, or “artificial atoms”, to optical nanocavities. The labs are at the University of Calgary and at the NRC National Institute for Nanotechnology in Edmonton, which has advanced nanofabrication tools plus leading quantum optics and nanotechnology researchers.



Dr. Shabir Barzanjeh

INTEGRATED HYBRID QUANTUM CIRCUITS

Focuses on the reversible quantum interface between the superconducting circuits and quantum optical systems. In our lab we develops quantum communication technology that is integrable with superconducting processors for building large-scale quantum networks.



Dr. David Feder

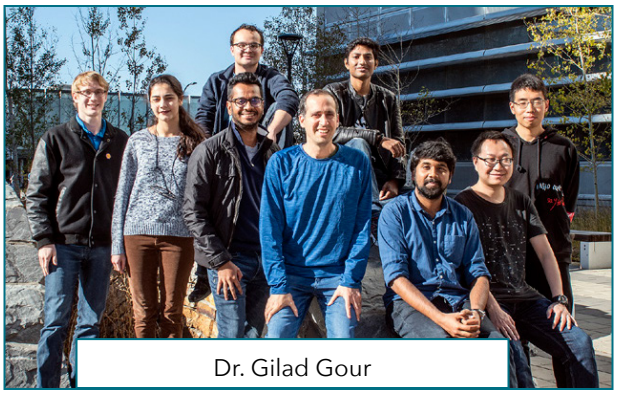
PRACTICAL QUANTUM COMPUTATION

Focuses on understanding intrinsic properties of physical systems, such as ultracold atomic gases or spin lattices, can be employed to construct larger devices able to perform quantum computation. In addition, the group explores alternative models for the implementation of quantum logic, such as one-way quantum computation, quantum walks, and topological quantum computation.

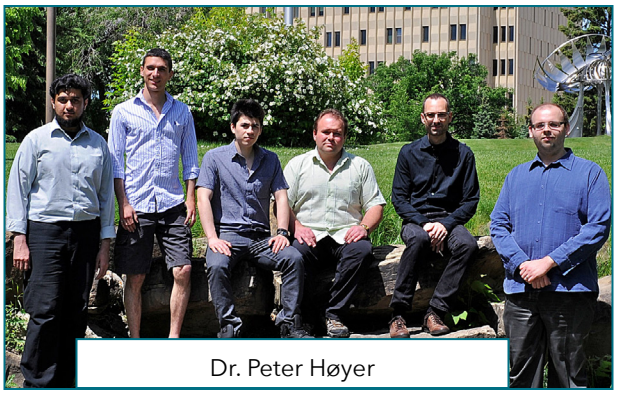
Dr. Timothy Friesen

TESTING OF FUNDAMENTAL SYMMETRIES WITH ANTIMATTER

Experimental testing of symmetries between matter and antimatter primarily through study of (anti)hydrogen in collaboration with the ALPHA (Antihydrogen Laser Physics Apparatus) experiment at CERN. We focus on the development of particle traps, microwave techniques, and annihilation detection for high-precision spectroscopy and gravitational mass measurements on antihydrogen.



Dr. Gilad Gour



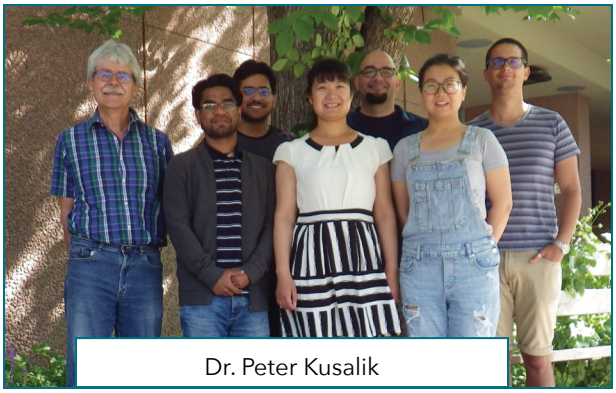
Dr. Peter Høyer

QUANTUM INFORMATION THEORY

Employs sophisticated mathematical methods, such as algebraic geometry, matrix analysis, group theory and C*-algebras, to solve core problems in quantum information science.

QUANTUM COMPUTING

Explores the potential powers of quantum systems to develop quantum algorithms, quantum communication protocols, quantum cryptographic protocols, and quantum computer simulations of quantum mechanical systems. Characterizes the powers and their limitations by studying quantum complexity theory, non-locality, entanglement, and quantum information theory.



Dr. Peter Kusalik

MOLECULAR SIMULATIONS OF LIQUIDS & SOLUTIONS, INTERFACES AND CRYSTALLIZATION

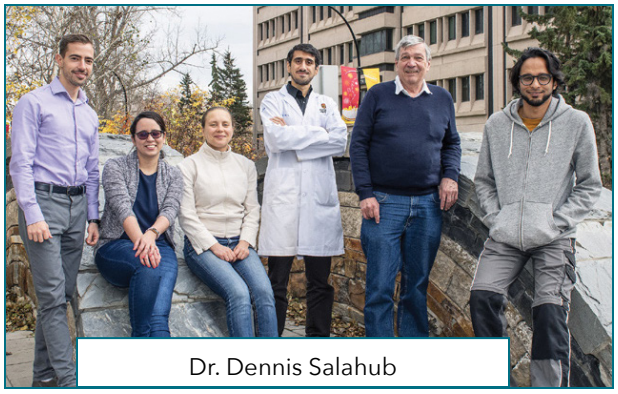
Molecular simulations to examine collections of molecules representing solid or liquid systems. Probes the molecular behaviour to understand properties of liquids and solids and their transformations including nucleation and crystallization. Explores behaviour of the hydroxyl radical in various aqueous environments. Applications range from atmospheric and materials sciences to molecular biology and water treatment.

Dr. Nasser Moazzen-Ahmadi

SPECTROSCOPY OF HYDROCARBONS AND MOLECULAR CLUSTERS AND COMPLEXES

Measures forces responsible for formation of atomic and molecular clusters. Investigates the intermolecular potential in the region of the potential minimum. Explores non-additive effects on the interaction energy and to determine possible condensation pathways. Relevant to a range of applications from atmospheric chemistry to molecular biology.

Dr. Daniel Oblak



Dr. Dennis Salahub

QUANTUM CLOUD LAB

Develops experimental capabilities that will lead to practical implementations of quantum links forming the basis of quantum networks that connect distant quantum devices. Research into quantum-key distribution over fibre and free- space channels, non-classical light sources, and quantum memory based on solid-state materials such as rare-earth ion doped crystals.

MULTISCALE MODELING OF (BIO) CHEMICAL REACTIONS IN COMPLEX ENVIRONMENTS

Investigates mechanisms and rates of chemical reactions occurring in complex environments. Models enzymatic catalysis, electron transfer between proteins and/ or heavy oil upgrading. Employs multiple techniques, from quantum chemistry, to molecular dynamics, to stochastic network analysis, are brought to bear on the problem in the context of high performance computing.

Dr. Barry Sanders

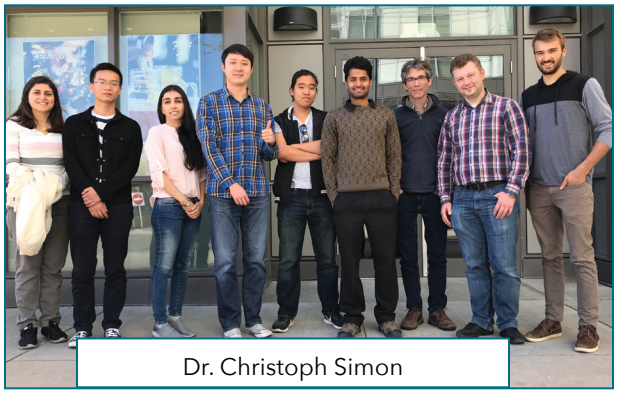
Dr. Yujun Shi

QUANTUM INFORMATION SCIENCE

Develops quantum information technologies that have transformative applications and will be feasible within a decade. The research program is divided into five strands: (i) long-distance secure communication, (ii) simulations of complex systems, (iii) implementations of quantum information tasks, (iv) empirical characterization of quantum states and processes, and (v) determining and quantifying all resources for quantum information processing.

CHEMICAL VAPOR DEPOSITION CHEMISTRY

Focuses on chemical and physical processes underpinning the formation of silicon-containing semiconductor thin film materials using hot-wire chemical vapour deposition. Applies technically demanding laser ionization mass spectrometric and laser spectroscopic techniques to investigate this process at the molecular level. Explores gas-phase reaction chemistry in the formation of silicon carbide and silicon nitride and laser spectroscopy of silicon carbide clusters generated using pulsed discharge and laser ablation methods. Applications include superior-quality films for industrial applications.



Dr. Christoph Simon

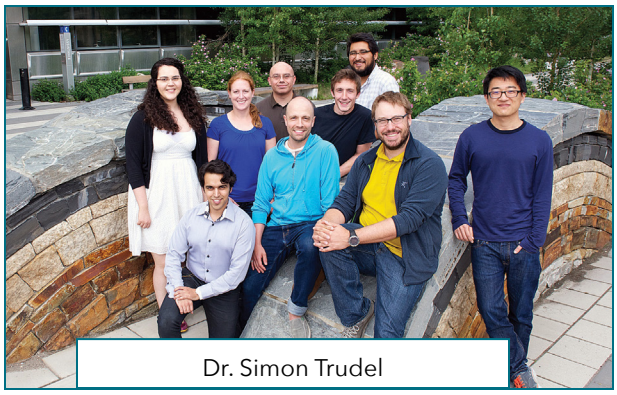
THEORETICAL QUANTUM OPTICS

Applies unique quantum phenomena such as superposition and entanglement (e.g. a future "quantum internet"), to probe whether these phenomena are universal, and to investigate whether they could play a role in biology (e.g. in neuroscience).

Dr. Robert Thompson

TRAPPED ION PHYSICS WITH ATOMS, MOLECULES, AND EXOTIC SPECIES

Develops and measures low-density trapped atoms, molecules and exotic species, especially anti-matter Hydrogen. Collaboration with the Antihydrogen Laser Physics Apparatus (ALPHA) project at CERN involving 40 scientists across 16 institutions. Collaborates with TRIUMF's Ion Trap for Atomic and Nuclear (TITAN) Science, particularly on sympathetic and evaporative cooling.



Dr. Simon Trudel

NANOSCALE MATERIAL

Investigates the synthesis, characterization, and structure-property relationships in inorganic solid-state nanomaterial, such as metal-oxide thin films and multimetallic nanoparticles. Develops high-performance materials in technologically and commercially relevant focus areas such as clean-energy conversion and spin-based electronics. Characterizes materials using state- of-the-art methods, such as electrochemical testing, electron microscopy, x-ray diffraction, and magnetometry based on superconducting quantum interference devices. Properties are analyzed to provide feedback for synthetic approaches for improvement.

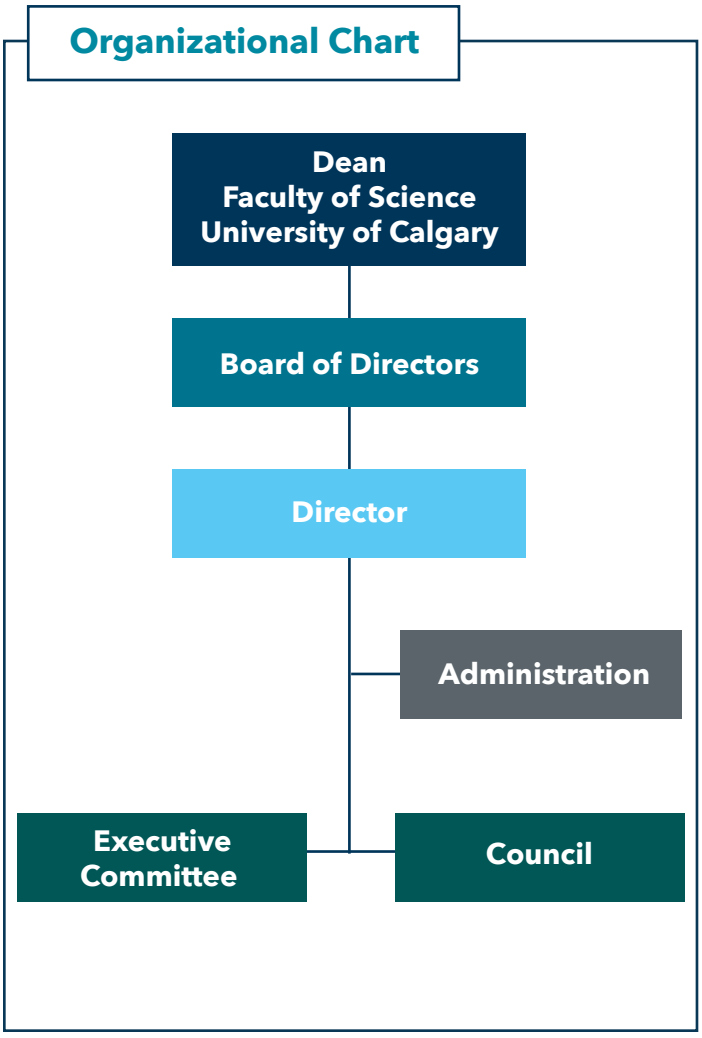
Management & Membership

INSTITUTE STRUCTURE

The Institute is managed on a day-to-day level by the Institute Director and the Institute Administrator. The Director reports to the Board of Directors and is ex officio a member of this Board. The Board reports to the Dean of Faculty of Science who chairs the Board.

The Director and the Administrator of the Institute work on day-to-day matters of the Institute. The Institute Executive comprises the Director, Administrator and five faculty members other than the Director. The Executive meets monthly to discuss and make decisions on executive matters. The Executive receives advice and guidance from the IQST Council, which comprises all full and affiliate faculty members of the Institute and meets three times annually.

All of the Institute's research, teaching, service and outreach activities are conducted by faculty members and their research groups.



GOVERNANCE

BOARD OF DIRECTORS

Lesley Rigg
Dean, Faculty of Science, University of Calgary

Marie D'Iorio
Senior Strategy Advisor, University of Ottawa

Chip Elliott
Chief Scientist, Raytheon BBN Technology

Sir Peter Knight
Principal, The Kavli Royal Society International Centre

Barry C. Sanders
Professor, Department of Physics and Astronomy, University of Calgary

Carl Williams
Deputy Director, Physical Measurement Laboratory (PML), National Institute of Standards and Technology (NIST)

EXECUTIVE COMMITTEE

Paul E. Barclay
Associate Professor, Department of Physics and Astronomy, University of Calgary

Peter Kusalik
Professor, Department of Chemistry, University of Calgary

Daniel Oblak
Assistant Professor, Department of Physics and Astronomy, University of Calgary

Barry C. Sanders
Professor, Department of Physics and Astronomy, University of Calgary

COUNCIL

Faculty Members

Paul Barclay
Associate Professor, Department of Physics and Astronomy, University of Calgary

Shabir Barzanjeh
(joined January 2020)
Assistant Professor
Department of Physics and Astronomy, University of Calgary

David Feder
Associate Professor, Department of Physics and Astronomy, University of Calgary

Timothy Friesen
(joined February 2020)
Assistant Professor
Department of Physics and Astronomy, University of Calgary

Gilad Gour
Professor, Department of Mathematics and Statistics, University of Calgary

Peter Høyer
Associate Professor, Department of Computer Science, University of Calgary

Peter Kusalik
Professor, Department of Chemistry, University of Calgary

Nasser Moazzen-Ahmadi
Professor, Department of Physics and Astronomy, University of Calgary

Daniel Oblak
Assistant Professor
Department of Physics and Astronomy, University of Calgary

Dennis Salahub
Professor Emeritus, Department of Chemistry, University of Calgary

Barry C. Sanders
Professor, Department of Physics and Astronomy, University of Calgary

Yujun Shi
Professor, Department of Chemistry, University of Calgary

Christoph Simon
Professor, Department of Physics and Astronomy, University of Calgary

Robert I. Thompson
Professor, Department of Physics and Astronomy, University of Calgary

Simon Trudel
Associate Professor, Department of Chemistry, University of Calgary

Affiliate Members

Robin Cockett
Professor, Department of Computer Science, University of Calgary

David Hobill
Associate Professor, Department of Physics and Astronomy, University of Calgary

Sergei Noskov
Professor, Department of Biological Sciences, University of Calgary

Reginald Paul
Professor, Department of Chemistry, University of Calgary

Rei Safavi-Naini
Professor, Department of Computer Science, University of Calgary

Renate Scheidler
Professor, Department of Mathematics and Statistics, University of Calgary

Peter Tieleman
Professor, Department of Biological Sciences, University of Calgary

Daniel Trad
Associate Professor, Department of Geoscience, University of Calgary

Richard Zach
Professor, Department of Philosophy, University of Calgary

Postdoctoral Fellows

Abhijeet Alase
Morteza Amirani
Rogelio Delgado Venegas
Jiri Hostas
Vinaya Kumar Kavatamane Rathnakara
David Lake
Gustavo de Oliveira Luiz (completed June 2019→researcher, nanoFAB)
Joseph Losby
Matthew Mitchell (resigned March 2020→postdoc, University of British Columbia)
Nicholas Randell
Ghazal Haji Salem
Carlo Maria Scandolo
Martin Schon
Denis Sukachev
Maryam Taheri
Yunlong Xiao (completed August 2019→postdoc, Nanyang Technological University)
Asha Yadav
Jun Zhang (resigned September 2019→postdoc, University of New South Wales)
Wei Zhang (completed March 2020)

Research Associates/Coordinators/ Engineers

Roohollah Ghobadi (Research Associate)

Graduate Students (PhD Program)

Shudipto Kazi Amin
Mohsen Bagherimehrab
Aaron Barclay
Bishnupada Behera
Stephanie Bovincini
Oliver Calderon
Archismita Dalal
Katelynn Daly
Balarama Sridhar Dwadasi
Carlos Enriquez-Victorero
Andrew Evans
Alison Fulton
Sumit Goswami
Masoud Habibi Davijani
Chris Healey (graduated August 2019)
Lizandra Barrios Herrera
Jiawei Ji
Hamidreza Kaviani
Faezeh Kimiaee Asadi
Sourabh Kumar
Prasoon Kumar Shandilya
Salini Karuvade
David Lake (graduated December 2019 →postdoc, University of Calgary)
Pascal Lefebvre
Nehad AttaElmanan AbdElrahim Mabrouk

Matthew Mitchell (graduated November 2019→postdoc, University of Calgary)
Eugene Moiseev
James Moncreiff
Mahmood Noweir
Eduardo Paez
Gaurav Saxena
Shahrzad Taherizadegan
Arina Tashchilina (graduated November 2019→postdoc, University of Alberta)
Seyed Shakib Vedaie
Lei Wang
Stephen Wein
Pooja Woosaree
Yadong Wu (graduated November 2019→postdoc, the University of Hong Kong)
Hadi Zadeh Haghighi
Parisa Zarkeshian

Graduate Students (MSc Program)

Omid Aligholamioskooee
Eric Ampong (graduated August 2019)
Dante Renato Bencivenga
Alex Cameron (graduated December 2019)
Anustup Das
Jake Flowerdew (graduated September 2019→PhD, University of Oxford)
Jianing Geng
Masoud Habibi Davijani (graduated August 2019→PhD, University of Calgary)
Mojtaba Komeili
Murali Krishna
Prasoon Kumar Shandilya (transferred September 2019→PhD, University of Calgary)
Janet Leahy
Shang Li (graduated December 2019)
Pengcheng Liao
Zhuohao (Ray) Liu
Xinyuan Ma
Blaine Jeffrey McLaughlin
Robert Riley Nerem
Joan Ngure
Yasser Novo-Fernández
Kimberley Ann Owen
Adam Powell
Hamza Qureshi (graduated December 2019→ quantum applications scientist, Agnostiq Labs)
Kuntal Sengupta
Sara Shafiei Alavijeh
Rishabh Shukla
Deepesh Singh (transferred March 2020→PhD, University of Queensland)
Prathwiraj Umesh (graduated October 2019→PhD, Institute for Quantum Optics and Quantum Information Austria)
Taozhe (Evan) Wu
Yufeng Wu
Yanjuan Xiong
Zhan Yu

Undergraduate Students

Benjamin Appleyard (PHYS598)
Hemanto Bairagi (PHYS598)
Karabee Batta (Summer Internship)
Xining Chen (NSERC USRA)
Kyle Ostrander (CHEM502)
Travis Gartner (PHYS599)
Ben Godwin (CHEM502)
Elliot Evans (CPSC502)
Nathan Fischer (NSERC USRA)
Bo Fu (MITACS Globalink)
Alex Hickey (NSERC USRA & PHYS598)
Evan Johnson (NSERC USRA)
Victoria Johnson (PHYS598)
Rajat Kumar (MITACS Globalink)
Janet Leahy (CPSC502)
Linh Ly (PURE Award)
Kyle Ostrander (Research Assistant)
Rana Pratap Simh Mukthavaram (Summer Internship)
Kenneth Sharman (Summer Student & PHYS599)
Jordan Smith (PHYS 598)
Antoine Stellio (Research Internship)
Zach Thomson (CHEM402)
Ruchir Tullu (Summer Undergraduate Student)
Camila Suarez Viltres (Summer Undergraduate student)
Yuxuan Wang (CHEM402)
Rana Zibakhshshabgahi (PHYS598)

Administration

Xining Chen (Part-time Webmaster)
Jing (Nancy) Lu (Administrator)

Publications

REFEREED JOURNAL PUBLICATIONS (PUBLISHED)

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STUDENT THESES

E. Ampong, "Decomposition of hexamethyldisilazane on hot metal filaments and its gas-phase chemistry in a hot-wire chemical vapor deposition reactor" (MSc thesis), September 2019.

A. C. Cameron, "Quantum phase characterization via entanglement scaling in fermionic quantum wires" (MSc thesis), October 2019.

J. Flowerdew, "Optimising ion transport in a thermal ionisation mass spectrometer and plasma ion source using Monte Carlo simulations" (MSc thesis), September 2019.

M. Habibi Davijani, "Continuous-variable ramp quantum secret sharing with Gaussian states and operations" (MSc thesis), April 2019.

C. Healey, "Nanophotonic devices for nonlinear optomechanics" (PhD thesis), May 2019.

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INTELLECTUAL PROPERTY

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INVITED PRESENTATIONS AT WORKSHOPS/ CONFERENCES

1 May 2019, D. R. Salahub, "50 years of trying to understand natural and life sciences – learning from giants and from my students and postdocs", The 15th International Symposium on Computational Methods in Science and Engineering (ICCMSE 2019) (Symposium in honour of Dennis R. Salahub), Rhodes, Greece, 1–5 May 2019.

1 May 2019, D. R. Salahub, "Multiscale Modelling: from clusters to nanoparticles in complex environments – insight into mechanisms for heavy oil upgrading", The 15th International Symposium on Computational Methods in Science and Engineering (ICCMSE 2019), Rhodes, Greece, 1–5 May 2019.

2 May 2019, Y. J. Shi, "Fabrication of Au, Pt, and AuPt nanoparticles by pulsed laser-induced dewetting and their characterization", 6th Annual Alberta NanoSymposium, Edmonton, Canada, 2–3 May 2019.

10 May 2019, B. C. Sanders, "Machine learning for quantum control" (plenary), Machine Learning for Quantum Technology, Max Planck Institute for the Science of Light, Erlangen, Germany, 8–10 May 2019.

13 May 2019, T. Friesen, "Status and prospects for CPT tests with the ALPHA experiment", 8th Meeting on CPT and Lorentz Symmetry (CPT'19), Bloomington, United States of America, 12–16 May 2019.

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21 May 2019, C. Simon, "Entanglement from the quantum internet to quantum neuroscience", Photonics North 2019, Quebec City, Canada, 21–23 May 2019.

21 May 2019, P. E. Barclay, "Diamond optomechanics and quantum nanophotonics" (keynote), Symposium Latsis 2019 on Diamond Photonics (LATSIS2019), Lausanne, Switzerland, 19–22 May 2019.

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3 June, 2019, T. Friesen, "Tests of fundamental physics with trapped antihydrogen", 2019 Canadian Association of Physicists (CAP) Congress, Burnaby, Canada, 3–7 June 2019.

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8 June 2019, G. Gour, "Mathematical structures and features of quantum resource theories", Canadian Mathematical Society (CMS) Summer Meeting, Regina, Canada, 7–10 June 2019.

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23 June 2019, P. E. Barclay, "Coherent optomechanical light manipulation in diamond", The 10th International Conference on Metamaterials, Photonic Crystals and Plasmonics, Lisbon, Portugal, 23–26 June 2019.

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12 July 2019, F. Kimiaee Asadi, "Rare-earth ions quantum networks", SQUARE Summer School, Karlsruhe, Germany, 10–12 July 2019.

23 July 2019, P. E. Barclay and M. J. Mitchell, "Diamond nano-optomechanical devices", The 10th International Conference on Metamaterials, Photonic Crystals and Plasmonics (META2019), Lisbon, Portugal, 23–26 July 2019.

24 July 2019, N. Sang-Nourpour, S. Asgarnezhad-Zorgabad and B. C. Sanders, "Generation and propagation of surface-plasmon polaritons at lossy interfaces", The 10th International Conference on Metamaterials, Photonic Crystals and Plasmonics (META2019), Lisbon, Portugal, 23–26 July 2019.

30 July 2019, C. Simon, "Quantum optics approaches to fundamental questions", Quantum Alberta Workshop 2019, Edmonton, Canada, 30 July 2019.

1 August 2019, B. C. Sanders, "Treasure hunt for computational problems that can be solved faster by quantum annealing", 2019 Joint Statistical Meetings (JSM 2019), Denver, United States of America, 27 July–1 August 2019.

25 August 2019, D. R. Salahub, "Dynamique électronique dans des environnements polarisables", Congrès de Chimistes Théoriciens d'Expression Latine (CHITEL2019), Montreal, Canada, 25–30 August 2019.

2 September 2019, B. C. Sanders, "Treasure hunt for computational problems that can be solved faster by quantum annealing", Quantum Africa V, Protea Hotel Stellenbosch, South Africa, 2–6 September 2019.

6 September 2019, B. C. Sanders, "Machine learning for quantum control", Quantum Machine Learning and Data Analytics Workshop, Purdue University, United States of America, 5–6 September 2019.

16 September 2019, P. E. Barclay, "Diamond and spin nano-optomechanics", Frontiers in Optics (OSA Annual General Meeting), Washington DC, United States of America, 15–19 September 2019.

16 September 2019, B. C. Sanders, "How to build a quantum computer", Summer School: New Advances in Quantum Information and Quantum Technology, Ulug'bek Madrasah, Samarkand, Uzbekistan, 10–18 September 2019.

19 September 2019, P. E. Barclay, "Diamond and spin nano-optomechanics", Frontiers in Optics 2019, Washington DC, United States of America, 15–19 September 2019.

20 September 2019, B. C. Sanders, "Machine learning for quantum control", International Conference on Emerging Quantum Technologies, Hefei, People's Republic of China, 16–20 September 2019.

21 September 2019, B. C. Sanders, "Treasure hunt for computational problems that can be solved faster by quantum annealing", Quantum Technology Workshop: Academia Meets Industry, Shanghai, People's Republic of China, 21–22 September 2019.

11 October 2019, C. Simon, "Entanglement from the quantum internet to quantum neuroscience", Chicago Quantum Exchange Quantum Networking Workshop, Chicago, United States of America, 11 October 2019.

5 November 2019, B. C. Sanders, "Advanced manufacturing and quantum technologies" (keynote), CMC & NanoCanada Workshop on Advanced Manufacturing Technologies for Health, Edmonton, Canada, 5 November 2019.

2 December 2019, B. C. Sanders, "How to use a quantum computer II" (tutorial), International Workshop on Quantum Computing, Information Processing and Machine Learning, National Taiwan University, Taiwan, 2–4 December 2019.

2 December 2019, B. C. Sanders, "How to use a quantum computer I" (tutorial), International Workshop on Quantum Computing, Information Processing and Machine Learning, National Taiwan University, Taiwan, 2–4 December 2019.

3 December 2019, B. C. Sanders, "Learning for quantum control" (keynote), International Workshop on Quantum Computing, Information Processing and Machine Learning, National Taiwan University, Taiwan, 2–4 December 2019.

17 December 2019, D. Oblak, "Light-matter interfaces in rare-earth ion doped solids", PhotonIcs & Electromagnetics Research Symposium (PIERS), Xiamen, People's Republic of China, 17–20 December 2019.

5 January 2020, B. C. Sanders, "Qudit benchmarking", 2020 International Workshop on Quantum Information, Quantum Computing and Quantum Control, Shanghai University, People's Republic of China, 2–5 January 2020.

4 February 2020, P. E. Barclay, "Diamond optomechanics for coherent manipulation of light", SPIE Photonics West, San Francisco, United States of America, 4–6 Feburary 2020.

Linkage

COLLABORATIONS

International Institutions

Aarhus University, Denmark
Ben-Gurion University of the Negev, Israel
California Institute of Technology, United States of America
Centre national de la recherche scientifique, France
Centro de Investigación y de Estudios Avanzados (CINVESTAV), Mexico
Cockcroft Institute, United Kingdom
Colorado School of Mines, United States of America
Eastern Illinois University, United States of America
European Organization for Nuclear Research (CERN), Switzerland
Federal University of Rio De Janeiro, Brazil
Foshan University, People's Republic of China
Grand Accélérateur National d'Ions Lourds, France
GSI Helmholtz Centre for Heavy Ion Research, Germany
Henan University of Technology, People's Republic of China
Indian Institute of Technology – Roorkee, India
Korean Institute of Science and Technology, South Korea
Louisiana State University, United States of America
Marquette University, United States of America
Max Planck Institute for Nuclear Physics, Germany
Missouri University of Science and Technology, United States of America
Montana State University, United States of America
Nanyang Technological University, Singapore
Politecnico di Milano, Italy
Purdue University, United States of America
Qingdao Institute of Marine Geology, People's Republic of China
Radboud University, the Netherlands
Raman Research Institute, India
Shandong University, People's Republic of China
Sharif University of Technology, Iran
Soreq Nuclear Research Centre, Israel
Stockholm University, Sweden
Swansea University, United Kingdom
Tata Research Development and Design Centre, India

Technische Universität Dresden, Germany
Technische Universität München, Germany
The Russian Quantum Center, Russia
Università Ca' Foscari Venezia, Italy
Université catholique de Louvain, Belgium
Université Paris Sciences et Lettres, France
Université Paris-Saclay, France
Université Paris-Sud, France
Université Paul Sabatier, France
University College Dublin, Ireland
University of California at Berkeley, United States of America
University of Electronic Science and Technology China, People's Republic of China
University of Giessen, Germany
University of Groningen, Germany
University of Heidelberg, Germany
University of Oxford, United Kingdom
University of Science and Technology of China, People's Republic of China
University of Science and Technology, South Korea
University of Technology Sydney, Australia
University of York, United Kingdom

National Institutions

Lakehead University
Queen's University
TRIUMF
Simon Fraser University
University of Alberta
University of British Columbia
University of Manitoba
University of Victoria
University of Waterloo
York University

Industrial & Government

1QBit
City of Calgary
Hewlett-Packard
National Research Council of Canada (Ottawa)

VISITORS

NAME	INSTITUTION
Alán Aspuru-Guzik	University of Toronto
Karabee Batta	Birla Institute of Technology and Science (BITS Pilani)
Aritra Das	Indian Institute of Techonolgy, Kanpur
Niel de Beaudrap	University of Oxford
Hubert de Guise	Lakehead University
André Fougères	National Optics Institute
Bo Fu	Shandong University
Xianxin Guo	Hong Kong University of Science and Technology
Karol Horodecki	University of Gdańsk
Mahnaz Jafarzadeh	Urmia University
Kyle Jordan	University of Victoria
Sejeong Kim	University of Technology Sydney
Na Lin	Shandong University
Alberto Marino	University of Oklahoma
Hridya Meppully Sasidharan	S. V. National Institute of Technology
Varun Narasimhachar	Nanyang Technological University
Yi Peng	Institute of Physics, Chinese Academy of Sciences

NAME	INSTITUTION
Haleema Sadia Qureshi	COMSATS University Islamabad
Jocelyn Read	California State University, Fullerton
Joe Salfi	University of British Columbia
Yuval Sanders	Macquarie University
Yi Shen	Beihang University
Barak Shoshany	Perimeter Institute for Theoretical Physics
Antoine Stellio	Institut national des sciences appliquées de Rouen
Shakir Ullah	COMSATS University Islamabad
Ming-Ming Wang	Xi'an Polytechnic University
Marcelo Wu	National Institute of Standards and Technology & University of Maryland
Jianwei Xu	Northwest A&F University
Siren Yang	Dalian University of Technology
Jeff Young	University of British Columbia

Graduate Courses

COURSE NAME	INSTRUCTOR	DESCRIPTION
CPSC601 Special Topics in Computer Science: Boolean Functions	P. Høyer	Measures including influence, sensitivity, degree, and certificate. Models including deterministic, probabilistic, quantum, and communication. Objectives including exact, one-sided, bounded-error, property testing, and learning. Spectral properties including frequencies, correlations, and moments. Classes of functions including monotone, unate, symmetric, balanced, junta, and linear. Methods including norms, concentrations, counting, and combinatorial.
CPSC619 Quantum Computing	P. Høyer	Introduction to quantum computing. Quantum algorithms, quantum search, quantum fourier transforms, quantum error correcting codes, quantum cryptography, nonlocality and quantum communication complexity, and quantum computational complexity.
PHYS617 Relativistic Quantum Mechanics	B. C. Sanders	Klein-Gordon and Dirac equations; Dirac spinor and the adjoint spinor; charge (C), parity (P) and (T) transformations and CPT symmetry; relativistic corrections to atomic spectra.
CHEM 619.09 Advanced Mass Spectrometric Techniques	Y. J. Shi	Theoretical and practical aspects of mass spectrometric techniques; instrumentation design, method development, instrument maintenance and troubleshooting aspects; operation of different types of instruments and hands-on experience in mass spectra acquisition; analysis and Interpretation of experimental data; applications in identification of unknown chemical compounds; recent developments in the field of mass spectrometry instrumentation including hyphenated techniques and their applications in multi disciplinary fields.

Services and Outreach

CONFERENCES/WORKSHOPS

MEMBERS	COMMITTEE	CONFERENCE/WORKSHOP	LOCATION	DATES
P. E. Barclay	Co-chair	CLEO Special Symposium on Coupling Artificial Atoms to Nano- and Opto-mechanical Systems	San Jose, United States of America	5–10 May 2019
B. C. Sanders	Organizer	BIRS Workshop on New Developments in Quantum Machine Learning	Banff, Canada	12–17 Jul 2020

PROFESSIONAL SERVICES

NAME	ROLE	JOURNAL/SOCIETY/INSTITUTION
P. E. Barclay	Associate Editor	*Optics Letters*
D. L. Feder	Member, Editorial Board	*PLoS One*
P. G. Kusalik	Member, Advisory Board, US Department of Energy Frontier Research Centre "Fluid Interface Reactions, Structures and Transport (FIRST)"	Oakridge National Laboratory
N. Moazzen-Ahmadi	Guest Editor, Special Issue "Spectroscopic Characterization of Noncovalent Interactions"	*Journal of Molecular Spectroscopy*
N. Moazzen-Ahmadi	Member, Editorial Board	*Journal of Molecular Spectroscopy*
D. R. Salahub	Member, Editorial Board	*Advances in Quantum Chemistry*

NAME	ROLE	JOURNAL/SOCIETY/INSTITUTION
D. R. Salahub	College of Reviewers	Canadian Institutes of Health Research
D. R. Salahub	Member, Editorial Board	*Computation*
D. R. Salahub	Vice Chair, Editorial Board	*Interdisciplinary Science: Computational Life Sciences*
D. R. Salahub	Member, Editorial Board	*Journal of Computational Chemistry*
D. R. Salahub	Member, Academic Editorial Board	*PLoS One*
B. C. Sanders	Chief Scientist	Creative Destruction Lab (CDL) Toronto
B. C. Sanders	Lab Scientist	Creative Destruction Lab (CDL) Rockies
B. C. Sanders	Member, Editorial Board	IOP ebooks™
B. C. Sanders	Chair, Steering Committee	Quantum Africa Conference Series
B. C. Sanders	Editor-in-Chief	*New Journal of Physics*
Y. J. Shi	Associate Editor	*Canadian Journal of Chemistry*
Y. J. Shi	Guest Editor, Special Issue "HWCVD10"	*Thin Solid films*
C. Simon	Member, Physics Advisory Committee	Fermi National Accelerator Laboratory
S. Trudel	Director	Click Materials Corp.
S. Trudel	Chair, Materials Division	Chemical Institute of Canada
S. Trudel	Members, Scholarships and Fellowships Selection Committee for Chemical, Biomedical and Materials Science Engineering	Natural Sciences and Engineering Research Council of Canada

QUANTUM PUBLIC LECTURE

The Quantum Public Lecture serves to convey leading breakthroughs in quantum science and technology to the general public. The public appetite is indeed high for learning the latest advances in the quantum world. Professor Alán Aspuru-Guzik from University of Toronto delivered a public lecture titled "Quantum algorithms for near-term quantum computers" to about 180 persons on 22 October 2019, and this event was supported by the Faculty of Science Alumni Relations team as a joint outreach effort. This public lecture was simulcasted at the Universities of Alberta and Lethbridge.

OUTREACH LECTURES

4 May 2019, B. C. Sanders, "Quantum computing and health", The Alberta Epigenetics Network Annual Summit, Canmore, Canada, 3–5 May 2019.

13 May 2019, B. C. Sanders, "Hybrid quantum-classical reinforcement learning in controlled quantum networks", Workshop: CIRI (Critical Infrastructure Resilience Institute Center of Excellence) at CISA (Cyberstructure and Infrastructure Security Agency, Department of Homeland Security), Arlington, United States of America.

7 July 2019, B. C. Sanders, "Science through the lens of Imam Jafar al-Sadiq (as)", 17th Annual Universal Muslim Association of America Conference (UMAA), Washington DC, United States of America, 5–7July 2019.

17 July 2019, B. C. Sanders, "What quantum computers do (lecture 1)", Institute of Business Administration, Karachi, Pakistan.

18 July 2019, B. C. Sanders, "What quantum computers do (lecture 2)", Institute of Business Administration, Karachi, Pakistan.

19 July 2019, B. C. Sanders, "What quantum computers do (lecture 3)", Institute of Business Administration, Karachi, Pakistan.

27 August 2019, B. C. Sanders, "Our quantum century", Emerging Innovation Summit, RMIT Capitol Theatre, Melbourne, Australia, 26–28 August 2019.

20 September 2019, T. Friesen, "Measuring the colour and weight of antimatter at CERN", Beakerhead at the Rothney Astrophysical Observatory (RAO), Calgary, Canada.

18 October 2019, P. Umesh, K. Owen, and D. Oblak, "Keeping secrets in a quantum world", Security Researchers and Industry Experts Talks 2019 (SecRETs), Calgary, Canada.

12 November 2019, B. C. Sanders, "The global race for quantum supremacy" (Public Lecture), Deutsch-Amerikanisches Institut, International Science Festival, Heidelberg, Germany.

19 January 2020, B. C. Sanders, "On moving forward: Sudan science and technology", Canada-Sudan: Knowledge Transfer and Sustainable Development Workshop, Coral Hotel, Khartoum, Sudan.

21 January 2020, B. C. Sanders, "Our quantum century" (dinner speech), Creative Destruction Lab (CDL) Rockies, Calgary, Canada.

MEDIA COVERAGE

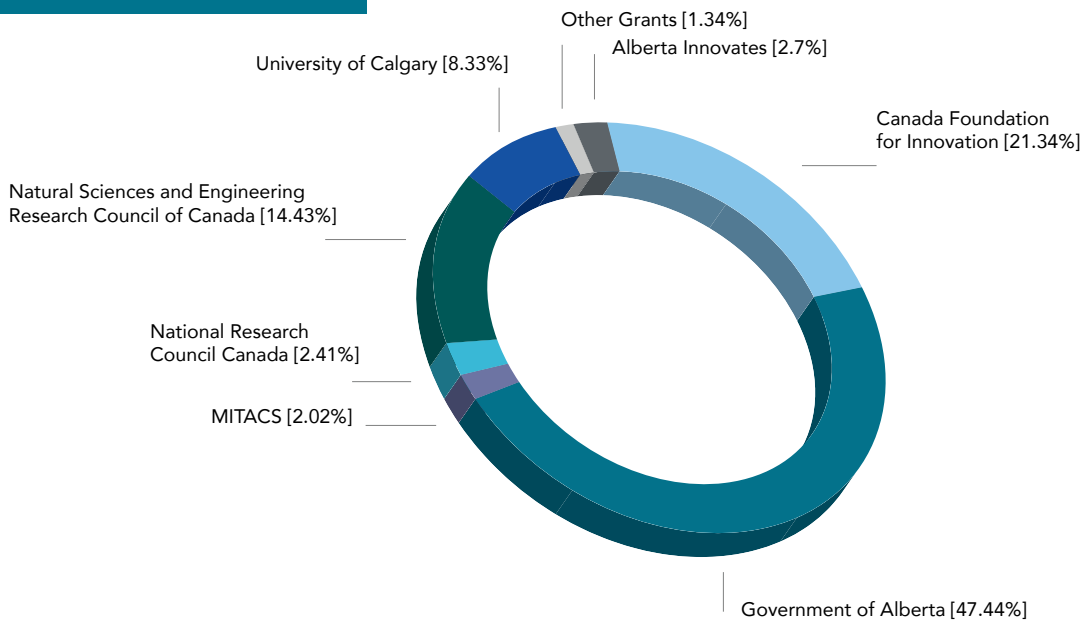
SOURCE	TITLE OF ARTICLE	DATE
Illinois.edu	CIRI physicists harness quantum computing to safeguard critical infrastructure: Barry C. Sanders	8 May 2019
CAP.ca	The 2019 CAP Herzberg Medal is awarded to Paul Barclay: Paul E. Barclay	8 May 2019
CCIDCOM.com	ITU Workshop on Quantum Information Technology (QIT) for Networks is Held in Shanghai: University of Calgary	5 Jun 2019
Edaily.co.kr	International Conference on Quantum Computing in Seoul from 11 to 12 July 2019: Barry C. Sanders	11 Jul 2019
The Science Monitor	International Conference on Quantum Computing in Seoul from 11 to 12 July 2019: Barry C. Sanders	12 Jul 2019
Geo Pakistan	Quantum Information Summer School (QISS) 2019 at Institute of Business Administration (IBA) Karachi (TV interview 1:16:10 - 1:21:54): Barry C. Sanders	18 Jul 2019
The Washington Post	The quantum revolution is coming, and Chinese scientists are at the forefront: Barry C. Sanders	18 Aug 2019
3CCorp.net	The quantum revolution is coming, and Chinese scientists are at the forefront: Barry C. Sanders	19 Aug 2019
NDTV	The quantum revolution is coming, and Chinese scientists are at the forefront: Barry C. Sanders	19 Aug 2019
Independent.co.uk	Trump administration nervous after China takes major step forward in quantum technology: Barry C. Sanders	19 Aug 2019
The Washington Post	China's top quantum scientist has ties to the country's defense companies: Barry C. Sanders	26 Dec 2019
Sudanese News Agency (SUNA)	A prominent Canadian physicist lecturing at Sudanese universities: Barry C. Sanders	14 Jan 2020
Wired	Physicists take their closest look yet at an antimatter atom: Timothy Friesen and Robert I. Thompson	19 Feb 2020
Physicsworld.com	Honeywell says it will soon release 'the most powerful quantum computer yet': Barry C. Sanders	20 Mar 2020

Research Grants

(UNAUDITED)

By funding agency

Total Revenue: $6.56M



By origin

Total Revenue: $6.56M

Objectives for Next Year

Paul E. Barclay

- Demonstrate a tunable optomechanical memory based on "reservoir engineering" principle
- Measure spin-optomechanical coupling in diamond micodisk devices
- Develop diamond photonic crystal optomechanical devices

Shabir Barzanjeh

- Install Bluefors dilution refrigerators, microwave and optical components
- Write automation software for experiments with cavities, qubits and mechanical oscillators
- Design and fabricate silicon-on-insulator electro-optomechanical systems
- Measure the optomechanical resonator
- Complete sideband cooling of the mechanical resonator to its ground state

David L. Feder

- Determine the computational complexity of preparing and detecting topological states in qubits
- Investigate matrix product states characterized by degenerate singular values as universal resources for measurement-based quantum computation
- Explore the influence and power of particle interactions for characterizing and inducing topology in many body quantum systems
- Employ techniques in algebraic graph theory to determine the ground state and excitations of hard-core bosons on lattices

Timothy Friesen

- Improve in-situ magnetometry techniques for spectroscopy and gravity measurements on antihydrogen
- Complete upgrade and commission ALPHA-g apparatus at CERN
- Install and calibrate Time Projection Chamber annihilation detector in the ALPHA-g apparatus
- Develop a novel stripline resonator for excitation of anti-proton spin flip transitions in antihydrogen
- Develop new cylindrical Penning trap designs for antihydrogen formation and spectroscopy

Gilad Gour

- Determine necessary and sufficient conditions for converting one state to another under symmetric operations
- Derive necessary and sufficient conditions for converting an incoherent athermal state to an athermal state with coherence in the energy basis
- Find an explicit example for non-additivity of the Holevo capacity of a quantum channel
- Generalize the uncertainty principle from a lone system to a system entangled with quantum memory with applications to quantum cryptography

Peter Høyer

- Develop quantum algorithms and prove bounds on sampling distributions
- Prove bounds on quantum walks for transitive graphs

Peter G. Kusalik

- Examine the factors important in the stability and mechanism of formation of aqueous nanobubbles
- Further develop and validate effective interaction potentials for hydroxide radical in water that faithfully reproduces the structural features observed from ab initio simulations
- Determine the stability and reactivity of hemi-bonded complexes of hydroxide radical with chloride or bromide anions
- Develop and test empirical and coarse grain potential models appropriate for simulations studies of self-assembly processes in zinc-/carboxylate metal-organic framework
- Use machine learning approaches to characterize formation of order during metal-organic framework self-assembly
- Develop Markov State models based on key structural events and their transitions during the nucleation processes of ice and gas clathrate hydrates
- Use novel molecular simulation approaches to identify nucleation pathways in mixed gas hydrates

Nasser Moazzen-Ahmadi

- Develop sensitive, compact, potable, and low-cost sensors for monitoring green-house gas emission
- Develop accurate global potential energy surfaces for molecular complexes
- Spectroscopic studies of microsolvation of carbon monoxide and carbon dioxide in water
- Develop quantum mechanical models of infrared band systems of ethane for remote sensing of terrestrial and planetary atmospheres

Daniel Oblak

- Commission quantum satellite ground station and establish quantum communication link to satellite
- Demonstrate novel quantum memory protocol using thulium-doped crystal
- Demonstrate two-photon interference with the aim of implementing measurement device-independent quantum key distribution using single photons from quantum dots
- Detect and characterize ultra-weak bio-photon emission from tadpole brain-tissue

Dennis R. Salahub

- Implement the combined method of density functional theory and Hubbard dynamics into deMon2k for strongly correlated systems
- Extend oil-sands upgrading simulations to molybdenum disulfide as the nanocatlyst
- Design new nanocatalysts
- Employ machine learning to identify collective-variable reaction coordinates for free-energy calculations
- Initiate collaborative research with NRC-Ottawa within their AI4D (Artificial intelligence for Design) program on design of new nanocatalysts

Barry C. Sanders

- Formulate framework for intelligent search of computational problems showing a quantum speed up
- Devise a quantum algorithm for preparing the a free-field ground state with quasilinear scaling with respect to the number of modes
- Propose fast low-power pulse sequences for two-qubit gates for atomic quantum computing
- Assess potential benefits of quantum algorithms to surmount computational problems in metabolomics
- Develop a comprehensive framework for devising and assessing a quantum internet
- Install a functional quantum-satellite ground station in Calgary with Oblak
- Develop verification and validation protocols for quantum tasks
- Formulate quantum measurement as dual to quantum-state generation

Yujun Shi

- Investigate chemical kinetics of nitrogen-containing organosilicon precursors in the chemical vapor deposition process
- Develop method of using chemical vapor deposition for the growth of gallium trioxide nanostructures
- Explain the process of pulsed laser dewetting for the formation of bimetallic nanoparticles on patterned and unpatterned substrates

Christoph Simon

- Explain the role of communication complexity and the potential for quantum communication complexity advantage in the brain
- Develop a transducer protocol based on opto-mechanical arrays
- Explain the potential for backpropagation of synaptic weight information through photonic channels in the brain
- Develop a proposal for quantum simulation with Rydberg excitons
- Develop a proposal for quantum repeaters with spins in quantum dots
- Develop a proposal for room-temperature quantum networks with nitrogen-vacancy centers in diamond
- Explain the radical pair mechanism as an explanation for electron spin resonance and isotope effects in Xenon-induced anesthesia
- Explain cavity-enhanced quantum memories in rare-earth ion doped crystals, including the atomic frequency comb and controllable dipole memories
- Explain optically active defects in hexagonal boron nitride as potential nodes for room-temperature quantum networks

Robert I. Thompson

- Complete upgrade and commission ALPHA-g apparatus at CERN
- Resolve atomic structures of antihydrogen
- Explore novel ion source options for TITAN

Simon Trudel

- Develop machine learning for the design of thin-film charge transport layers
- In operando investigation of catalysts using synchrotron methods
- Develop ferroelectric-nanomaterials bonds on a silicon surface

IQST adds value to the University of Calgary in the following ways

Enables multidisciplinary research through finanacial and logistical support

Builds a quantum science and technology community through visitor, seminar, and colloquium programs

Assists new faculty members to becoming productive researchers rapidly

Publishes reports and web pages that showcase the Institute as a leader in quantum information science

Supports recruitment of outstanding faculty, researchers,and graduate students

Sponsors and supports leading conferences held locally

Partners with other quantum institutes

Enhances the University's reputation by delivering outstanding research results

Benefits the wider community by contributing new knowledge in a strategic area

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