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

30 postdoctoral fellows
100 graduate students
31 undergraduate students
35 invited talks at conferences/workshops including one plenary talk
10 million dollars in research funds

94 publications in refereed journal and conference proceedings including Nature Communications (1), PRX Quantum (2), ACS Applied Materials and Interfaces (1), Physical Review Letters (3), Optica (1), ACS Energy Letters (1) and Nature Photonics (1)
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The Institute for Quantum Science and Technology hosts 21 research groups and about 170 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. University of Calgary researchers collaborate closely with counterparts at the Universities of Alberta and Lethbridge, and Quantum Alberta is the umbrella organisation for quantum activity in the Province with the Institute functioning as the Calgary branch.

The Institute is pleased to welcome new members Leonid Belostotski, Samira Siahrostami and Milana Trifkovic as Faculty members. Dr Belostotski is a Professor and Tier II Canada Research Chair in the Department of Electrical and Software Engineering. His research focuses on radio-frequency and millimetre-wave circuits and systems, including low noise amplifiers, digital-to-analogue converters, and unique beamforming solutions. Dr Siahrostami has been an Associate Professor in the Department of Chemistry since 2018, initially joining the Global Research Initiative in Sustainable Low Carbon Unconventional Resources funded by a Canada First Research Excellence Fund (CFREF). She received the John Jeyes Award from the Royal Society of Chemistry in 2021, and the Tom Ziegler Award of the Chemical Institute of Canada in 2023. Her research focuses on theoretical and computational material design relating to electrocatalysis for sustainable energy and environmental protection applications. Dr Trifkovic is an Associate Professor in the Department of Chemical and Petroleum Engineering and works on quantum dots, in particular designing processes to convert asphaltene into graphene quantum dots. Milana is an expert in optimally designing, operating and controlling complex, non-linear engineering systems.

The Institute for Quantum Science and Technology has enjoyed a successful year of research and training during the 2022/2023 year. Members of the Institute had 94 papers published in refereed journals and proceedings including 10 papers appearing in the top-tier journals of Nature Communications (1), PRX Quantum (2), ACS Applied Materials and Interfaces (1), Physical Review Letters (3), Optica (1), ACS Energy Letters (1) and Nature Photonics (1). The Institute attracted 18 new students into quantum graduate studies.
programs in 2022/2023. Eleven master’s students graduated and five doctoral students completed their degrees. The Institute hosted 30 postdoctoral researchers with five being recipients of international, national and provincial postdoctoral fellowships including Swiss National Science Foundation Fellowship, e2i Fellowship, PiMS Postdoctoral Fellowship, Eyes High Postdoctoral Fellowship, Killam Postdoctoral Fellowship and MITACS Accelerate Entrepreneur Funds.

The Institute is home to the Alberta Government’s Ministry of Technology and Innovation, whose predecessor the Ministry of Job, Economy and Innovation. The Ministry oversees the Major Innovation Fund allocation supporting quantum science and technology at the Universities of Calgary, Alberta and Lethbridge. The Institute continues to fulfill its mission as a Faculty of Science Institute and deliver outcomes matching Faculty expectations with respect to the Grand Challenge of “Unlocking Our Digital Future”. 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.

In 2022, Quantum City, a partnership of the University of Calgary, Government of Alberta and a leading information technology company Mphasis, was established with over $100 million in private and public investments. The Quantum City’s mission is to capture the benefits of quantum technology by creating adoption pathways. Quantum City is merging as a global knowledge translation hub, bringing together researchers, quantum companies and early adopters of quantum technologies and services. IQST continues to represent the academics at the University of Calgary engaged in quantum science and technology and its adjacent areas, with Quantum City focused on creating a “quantum” ecosystem in Calgary. To realize the vision of being the place where quantum technology becomes quantum solutions, Quantum City is investing in multiple synergistic areas. One of these investments is qLab, which is a quantum fabrication and characterization facility. Another investment is qHub, which is an incubation and ideas collision space. Other investments and support include training and upskilling programs and supporting the University of Calgary initiative to appoint new quantum faculty members as well as establishing the University of Calgary’s Professional Master’s in Quantum Computing program. Quantum City is led by Steering Committee Chair Dr Robert Thompson, Associate Vice-President (Research) and Executive Director of Research Services at the University of Calgary, Scientific Director Dr Barry Sanders, and Managing Director Dr Megan Lee, and is supported by a dynamic board of Steering Committee members representing research, academia, industry and community engagement.

Dr. Barry C. Sanders
Director
Message from
the Chair

There is no doubt about it: Calgary is emerging as an international high-tech hub. Increasingly, quantum science is a thread woven throughout our tech sector, bolstered by our robust infrastructure, talented workforce, and entrepreneurial spirit. From nanotechnology to biomedical engineering, the future of quantum in our city is bright.

In June 2022, the establishment of Quantum City—Calgary’s new quantum innovation hub—solidified that this type of technology is driving Alberta into the future. Quantum City is a collaboration between the University of Calgary, the Government of Alberta and Mphasis, a multinational IT solutions provider. The hub allows our city’s innovative minds to come together and find groundbreaking solutions to some of the world’s most complex problems. At IQST, we are honoured to be part of such a revolutionary initiative.

Some highlights from this year include:

- The establishment of Quantum City with over $100 million in private and public investments, including $23 million from the Government of Alberta. The hub is led by Steering Committee Chair Dr. Robert Thompson, Scientific Director Dr. Barry Sanders and Managing Director Dr. Megan Lee.

- In June, Quantum City partner Mphasis opened its Calgary headquarters. The global IT solutions provider specializes in cloud and cognitive services and has a strong emphasis on hiring local talent and students.

- Professor Peter Zoller from University of Innsbruck in Austria delivered a public lecture titled “A taste of quantum: A quantum leap in quantum information” at the TELUS Spark Science Centre in October. The lecture was part of the 2022 Quantum Summit organized by Quantum City, the Government of Alberta’s Quantum Technologies Major Innovation Project and Quantum Alberta.

This year has been truly exceptional when it comes to developing quantum technology in our city. Our success lies in strong partnerships, visionary minds, and a fearless approach to innovation. The future looks bright. I look forward to seeing it unfold.

Dr. Kristin Baetz
Chair, IQST Board of Directors
Dean, Faculty of Science
University of Calgary
Research Highlights

RESEARCH ACHIEVEMENTS

The Institute for Quantum Science and Technology (IQST) has made 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.

Christoph Simon and his group are making great strides in exploring quantum phenomena in biology. They presented the case that many of the weak magnetic-field effects observed in biological systems could be due to a radical-pair mechanism, which has a quantum origin. Their highly cited work appeared in the *Journal of the Royal Society Interface*. Simon’s collaboration with a group in France yielded a breakthrough on photon-number entanglement generated by sequential excitation of a two-level atom, published in *Nature Photonics*.

Samira Siahrostami advocated a rechargeable metal-hydrogen peroxide battery as a solution to improve metal-air battery performance, which was published in *ACS Energy Letters*. Her other discovery, in a collaborative effort, establishes that lanthanum aluminate is an efficient catalyst for two-electron water electrolysis. This discovery advances the goal of producing hydrogen peroxide is important especially because hydrogen peroxide is an environmentally benign and powerful chemical oxidizer. This latter work was published in *Nature Communications*.

Paul Barclay and his group demonstrated high-frequency torsional motion transduction using optomechanical coupled oscillators, reported in a paper published in *Optica*. Erhan Saglamyurek collaborated on a University of Alberta experiment demonstrating superradiance-mediated photon storage for a broadband quantum memory, reported in *Physical Review Letters*. Barry Sanders collaborated on an experimental demonstration of topological spin texture of chiral edge states in photonic two-dimensional quantum walks, reported in *Physical Review Letters*.

Postdocs Saubhik Sarkar and Abhijeet Alase collaborated on a project concerning exploitation of second-order quantum phase transitions for sensing at criticality. Specifically, they investigate phase transitions in free-fermionic topological systems that exhibit neither symmetry-breaking nor long-range entanglement and argue that gap closing is the main candidate for the ultimate source of
quantum enhanced sensing, paving the way for topological quantum sensors that are expected to be robust against local perturbations. The article was published in Physical Review Letters.

In the past year, Peter Kusalik and his collaborators explored molecular insights into the impacts of calcite nanoparticles on methane hydrate formation, published in ACS Sustainable Chemistry. Milana Trifkovic’s group reported coupling particle ordering and spherulitic growth for long-term performance of nano cellulose/poly(ethyleneoxide) electrolutes, reported in ACS Applied Materials and Interfaces.

AWARDS

International Awards

SWISS NATIONAL SCIENCE FOUNDATION FELLOWSHIP
Sigurd Flågan

National Awards

CANADIAN INSTITUTE OF NUCLEAR PHYSICS FELLOWSHIP
Adam Powell

MITACS ACCELERATE ENTREPRENEUR
Sourabh Kumar

MITACS-ACCELERATE GRADUATE RESEARCH INTERNSHIP PROGRAM
Seyed Shakib Vedaei
Robert Riley Nerem

NSERC CANADA GRADUATE SCHOLARSHIPS – MASTER’S PROGRAM
Elijah Adams
Abby Swadling

NSERC POSTGRADUATE SCHOLARSHIPS – DOCTORAL PROGRAM
Linh Ly

NSERC USRA
Mir Humayun
Hai Le
Mira Rupert
Abby Swadling

PIMS POSTDOCTORAL FELLOWSHIP
Thomas Theurer

TOM ZIEGLER AWARD OF THE CHEMICAL INSTITUTE OF CANADA
Samira Siahrostami

Provincial Awards

ALBERTA GRADUATE EXCELLENCE SCHOLARSHIP (AGES)
Katelynn Daly
Al-Waleed El-Sayed
Pirouz Kiani
Peyman Parsa
Anuj Sethia
Jordan Smith
Pooja Woosaree

University of Calgary Awards

e²i FELLOWSHIP
Sourabh Kumar

EYES HIGH POSTDOCTORAL FELLOWSHIP
Majid Taghavi Dehaghani
Thomas Theurer

CANADIAN QUEEN ELIZABETH II DIAMOND JUBILEE SCHOLARSHIPS (ADVANCED SCHOLARS)
Nehad AttaElmanan AbdEbrahim Mabrouk

EMERGING LEADERS IN THE AMERICAS SCHOLARSHIP
Dorcas Addo

EYES HIGH INTERNATIONAL DOCTORAL SCHOLARSHIP
Bishnupada Behera

FACULTY OF GRADUATE STUDIES DOCTORAL SCHOLARSHIP
Pragati Gupta

FACULTY OF SCIENCE AWARD OF EXCELLENCE
Simon Trudel

FACULTY OF SCIENCE GLOBAL OPEN DOCTORAL FELLOWSHIP
Pooja Woosaree
FACULTY OF GRADUATE STUDIES INTRODUCTION TO ENTREPRENEURSHIP – HUNTER CENTRE
Pragati Gupta

KILLAM POSTDOCTORAL SCHOLARS
Abhijeet Alase

NOVA CHEMICAL GRADUATE SCHOLARSHIP
Santiago Jimenez Villegas
Oliver Calderon

PURE AWARD
Lucas Brown
Shabaz Dhaliwal
Dareen Hallak
Simon Hu
Mobina Jamali
Marcus Kasdorf
Anthony Klevsky
Sean Wilson

SCHULICH SCHOOL OF ENGINEERING
DEPARTMENTAL RESEARCH EXCELLENCE AWARD (DEPARTMENT OF CHEMICAL AND PETROLEUM ENGINEERING)
Milana Trifkovic
Key Performance Indicators

GRADUATE STUDENTS ENROLMENT AND QUALITY OF ENTRANTS

- **PhD**
  - Number of PhD Entrants: 6
  - PhD Median Entrance Score: 3.43

- **MSc**
  - Number of MSc Entrants: 12
  - MSc Median Entrance Score: 3.43
PUBLICATIONS AND PRESENTATIONS

Refereed Papers: 94
Invited Talks: 35
AWARDS
(CHAIRS, FELLOWSHIPS AND SCHOLARSHIPS)

- Postdoctoral Fellows: 7
- Graduate Students: 23
- Undergraduate Students: 12
- Faculty Members: 3

VISITORS

- Academia: 23
- Industry: 2
- Government: 2
TRAINEE DESTINATIONS AFTER IQST

- Academia: 9
- Industry: 12
- Other: 7
Research Groups

NANOSCALE OPTICS

Explore interactions between light and nanoscale systems such as single atoms, electron spins and nanomechanical structures. Employ 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 Nanotechnology Research Centre in Edmonton, which has advanced nanofabrication tools plus leading quantum optics and nanotechnology researchers.

INTEGRATED HYBRID QUANTUM CIRCUITS

Focus on the reversible quantum interface between the superconducting circuits and quantum optical systems. Develop quantum communication technology that is integrable with superconducting processors for building large-scale quantum networks.
PRACTICAL QUANTUM COMPUTATION
Explore intrinsic properties of physical systems, such as ultracold atomic gases or spin lattices, which can be employed to construct larger devices able to perform quantum computation. Also explore alternative models for the implementation of quantum logic, such as one-way quantum computation, quantum walks, and topological quantum computation.

RADIO-FREQUENCY AND MIXED-SIGNAL CIRCUITS
Develop integrated circuits and systems for application in wireless systems, radio astronomy, and quantum computing, aiming to realize ultra-low-noise receiver systems in commercial bipolar complementary metal-oxide-semiconductor technologies.
TESTING 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. Focus on the development of particle traps, microwave techniques, and annihilation detection for high-precision spectroscopy and gravitational mass measurements on antihydrogen.

QUANTUM INFORMATION THEORY
Employ sophisticated mathematical methods, such as algebraic geometry, matrix analysis, group theory and C*-algebra, to solve core problems in quantum information science.
QUANTUM COMPUTING
Explore the potential of quantum systems to develop quantum algorithms, quantum communication protocols, quantum cryptographic protocols, and quantum computer simulations of quantum mechanical systems. Characterize the powers and their limitations by studying quantum complexity theory, non-locality, entanglement, and quantum information theory.

MOLECULAR AND MATERIALS ELECTRONIC STRUCTURE
Explore the relationship between electronic structure of molecules and materials and their broader chemical properties and study the use of such interactions in molecular electronics and other applications. X-ray spectroscopies are the major tools for our exploration of electronic structure.
MOLECULAR SIMULATIONS OF LIQUIDS & SOLUTIONS, INTERFACES AND CRYSTALLIZATION

Perform molecular simulations to examine collections of molecules representing solid or liquid systems. Probe the molecular behaviour to understand properties of liquids and solids and their transformations including nucleation and crystallization. Explore behaviour of aqueous nanobubbles and the origins of their stability and mobility. Applications range from atmospheric and materials sciences to molecular biology and water treatment.

SPECTROSCOPY OF HYDROCARBONS AND MOLECULAR CLUSTERS AND COMPLEXES

Measure forces responsible for formation of atomic and molecular clusters. Investigate the intermolecular potential in the region of the potential minimum. Explore non-additive effects on the interaction energy and to determine possible condensation pathways.
QUANTUM CLOUD LAB
Develop experimental capabilities that will lead to practical implementations of quantum links forming the basis of quantum networks that connect distant quantum devices. Conduct research into quantum-key distribution over fibre and freespace channels, non-classical light sources, and quantum memory based on solid-state materials such as rare-earth ion doped crystals.

COMPLEX NANO MATERIALS
Computational description and modelling of nanoscale materials for applications to neuromorphic computing, transparent conductors, and sensing. Explore phenomena that emerge when matter is “packed” at the nanoscale at which quantum effects are present.
MULTISCALE MODELLING OF (BIO) CHEMICAL REACTIONS IN COMPLEX ENVIRONMENTS

Investigate mechanisms and rates of chemical reactions occurring in complex environments. Model enzymatic catalysis, electron transfer between proteins and/or heavy oil upgrading. Employ 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.

QUANTUM INFORMATION SCIENCE

Develop quantum information technologies that have transformative applications and will be feasible 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.
QUANTUM INFORMATION AND FOUNDATIONS

Use mathematical tools, such as matrix and convex analysis, to quantify quantum resources and optimize their use in information-theoretic protocols. Apply informational methods to foundational problems in quantum theory, especially using the framework of general probabilistic theories, which combine convex analysis with categorical methods.

CHEMICAL VAPOUR DEPOSITION CHEMISTRY

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

Undertake computational catalyst material design for applications to clean-energy technologies such as fuel cells, electrolysers and batteries. Design catalysts from first principles by modelling reactions in silico for a range of electrochemical reaction.

THEORETICAL QUANTUM OPTICS

Apply 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).
TRAPPED ION PHYSICS WITH ATOMS, MOLECULES, AND EXOTIC SPECIES

Develop and measure 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. Collaborate with TRIUMF’s Ion Trap for Atomic and Nuclear (TITAN) Science, particularly on sympathetic and evaporative cooling.

ADVANCED MATERIAL DESIGN

Design and characterize novel materials with applications in the energy sector including polymer nanocomposites, nanoparticle stabilized emulsions, bicontinuous interfacially jammed emulsion gels and newly developed bicontinuous intraphase emulsion gels.
NANOSCALE MATERIAL

Investigate synthesis, characterization, and structure-property relationships in inorganic solid-state nanomaterial, such as metal-oxide thin films and multimetallic nanoparticles. Develop high-performance materials in technologically and commercially relevant focus areas such as clean-energy conversion and spin-based electronics. Characterize materials using state-of-the-art methods, such as electrochemical testing, electron microscopy, X-ray diffraction, and magnetometry based on superconducting quantum interference devices.
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 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

Kristin Baetz
Dean, Faculty of Science, University of Calgary

Marie D’Iorio
Chief Operating Officer, University of Ottawa

Chip Elliott

Sir Peter Knight
Senior Fellow in Residence, The Kavli Royal Society International Centre

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

Carl Williams
President and Chief Executive Officer, CJW Quantum Consulting

EXECUTIVE COMMITTEE

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

Shabir Barzanjeh
Assistant Professor, Department of Physics and Astronomy, University of Calgary

Leonid Belostotski
Professor, Department of Electrical and Software Engineering, University of Calgary

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

Timothy Friesen
Assistant Professor, Department of Physics and Astronomy, University of Calgary

Claudia Gomes da Rocha
Assistant Professor, Department of Physics and Astronomy, University of Calgary

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

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Professor, Department of Chemistry, University of Calgary

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Samira Siahrostami
Associate 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

**Milana Trifkovic**  
Associate Professor, Department of Chemistry, University of Calgary

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

**Affiliate Members**

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

**Hubert de Guise**  
Professor, Department of Physics, Lakehead University

**Khabat Heshami**  
Research Officer, National Research Council Canada

**David Hobill**  
Professor Emeritus, Department of Physics and Astronomy, University of Calgary

**Reginald Paul**  
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**Rei Safavi-Naini**  
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**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
Shirin Afzal (completed September 2022)
Ozioma Akakuru
Abhijeet Alase (resigned July 2022 → postdoctoral fellow, University of Sydney)
Aaron Barclay
Natalia do Carmo Carvalho
Hanen Chenini
Sigurd Flågan
Arash Hejazi
Sabade Gul
Jiri Hostas
Faezeh Kimiae Asadi
Youssef Kora
Sourabh Kumar
Renaud Miclette-Lamarche (completed December 2022 → research associate, Concordia University)
Mosayeb Naseri
Trong Huynh Buu Ngo (completed December 2022 → engineer, Norcada)
Mahmood Noweir (completed April 2022, electromagnetic compatibility engineer, MDA)
Nicholas Randell (completed July 2022 → research scientist, Ionic Solutions Ltd.)
Habib Rastegar
Vinaya Kumar Kavatamane Rathnakara
Saubhik Sarkar
Ashutosh Singh
Martin Schon (completed July 2022)
Sunaina Sunaina
Majid Taghavi Dehaghani
Tatek Temesgen Terfasa
Thomas Theurer
Deeksha Verma
Hadi Zadeh Haghighi
Parisa Zarkeshian (completed January 2023)

Research Associates/Assistant
Morteza Chehel Amirani (research associate, completed September 2022 → computational research scientist, Svante)
Stephanie Bonvicini (research assistant)
Roohollah Ghobadi (research associate, completed October 2022 → researcher, QC Design)
Taras Hrushevskyi (research associate)
Qasim Khan
Joseph Losby (research associate, completed February 2023 → operations manager, qLab of Quantum City)
Erhan Saglamyurek (senior research associate, completed August 2022 → project scientist, Lawrence Berkeley National Laboratory)
Vahid Salari (research associate)
James Stevenson (research assistant)

Graduate Students (PhD Program)
David Amaro Alcalá
Shudipto Kazi Amin
Aaron Barclay (graduated June 2022 → postdoc, University of Calgary)
Bishnupada Behera
Stephanie Bonvicini (graduated December 2022 → co-founder, Matter3D)
Oliver Calderon
Archismita Dalal
Katelynn Daly
Danial Davoudi
Sagnik Dutta
Balarama Sridhar Dwadasi
Al-Waleed El-Sayed
Leili Esmaeilifar
Koorosh Esteki
Ujjwal Gautam
Sankha Ghosh
Nasser Gohari Kamel
Pragati Gupta
Lizandra Barrios Herrera (graduated February 2023)
Jiawei Ji
Zahra Kabirkhoo
Mahsa Karimi
Salini Karuvade
Thisara Kulatunga
Prasoon Kumar Shandilya
Linh Ly
Nehad AttaElmanan AbdElrahim Mabrouk
Anindya Mitra
Eduardo Páez Barrios
Adam Powell
Mohammad Radpour
Farhad Rasekh
Mahdi Rizvandi
Rishabh
Gaurav Saxena
Vishnu Seshan
Seyed Shakib Vedaei
Hatef Shahmohamadi
Alex Sheldon (graduated May 2022 → high-speed analog design engineer, NXP Semiconductors)
Rishabh Shukla
Shahrzad Tahezadehgan
Lei Wang
Pooja Woosaree
Hao Xie
Hadi Zadeh Haghighi (graduated June 2022 → postdoc, University of Calgary)
Elia Zanoni
Elham Zohari
Joseph Zsombor-Pindera

Graduate Students (MSc Program)
Maryam Abarashi (graduated April 2022)
Parinaz Abbasi
Elijah Adams
Snehasis Addy
Ishra Afroze
Omid Aligholamioskoee (graduated May 2022 → PhD, California Institute of Technology)
A. K. D Kavini K. Amarasinghe
Jeas Grejoy Andrews
Aradhana Anil
Ashkan Bayat
Parisa Behjat Khatouni
Mahdi Bornadel
Ziheng Chang
Kavini A. K. Don Kaluarachchige
Asma Farhat
Travis Gartner
Sye Ghebretnsae
Mayte Li Gomez
Fariba Hosseinyinjed Khaledy
Thomas Hujon
Joe Itoh
Santiago Jimenez Villegas (graduated November 2022 → research scientist, Travertine)
Pirouz Kiani
Mark Lai (graduated September 2022 → RF designer, Kepler Communications)
Janet Leahy
Zhuohao(Ray) Liu
Xinyuan Ma (graduated January 2023)
Ismail Majed
Zachary Manson
Eduardo Miguel Martinez Garcia
Abdul Mohamed
Robert Riley Nerem (graduated April 2022 → PhD, University of California, San Diego)
Joan Ngure (graduated August 2022)
Yasser Novo-Fernández
Julian Palandri
Peyman Parsa
Marwa Safa
Mahkame Salimi Moghadam
Nihari Sathsarani Pathirannehelage (graduated March 2023 → research associate, Katal Energy Inc.)
Anuj Sethia
Mehreen Shabbir
Sara Shafiei Alavijeh (graduated August 2022)
Amit Shalev
Kenneth Sharman (graduated December 2023 → head of product, Quantized Technologies Inc.)
Jordan Smith (graduated January 2023 → chief executive officer, Quantized Technologies Inc.)
Amirhossein Sotoodehfar
James Stevenson (graduated August 2022 → sessional instructor, University of Calgary)
Jay Suh
Armin Tabesh
Praveen Wakwella
Greg Wong
Tyler Zegray
Undergraduate Students
Luis Daniel Abalo-Sangervasi (PHYS 598)
Amir Ahadi (research assistant)
Shayaan Ahmad (undergraduate research)
Lucas Brown (PURE & PHYS 598)
Lachlan Cuskelly (undergraduate research)
Joshua Daniel Felce Gonzalez (PHYS 598)
Shabaz Dhaliwal (PURE)
Emily Frede (PHYS 598)
Gabby Galinas (PHYS 598)
Sye Ghebretnsae (PHYS 598)
Dareen Hallak (PURE award)
Mir Humayun (NSERC USRA)
Simon Hu (PURE award)
Mobina Jamali (PURE award)
Emma Johnson (PHYS 598)
Eugene Kalionau (PHYS 599)
Marcus Kasdorf (PURE & PHYS 598)
Anthony Klevsky (PURE award)
Nick Kuzmin (research assistant)
Hai Le (NSERC USRA)
Abdullah Maqsood (Coop internship)
Quinn Mira Rupert (PHYS 598 & NSERC USRA)
John Ngo (PHYS 598)
Lucke Praught (research assistant)
Raj Rakha (PHYS 599)
Harris Saleem (CHEM 502)
Salma Salhi (PHYS 598)
Peter Shmerko (undergraduate research)
Reece Stefanyszyn (PHYS 598)
Abby Swadling (PHYS 598 & NSERC USRA)
Sean Wilson (PURE award)

Administration
Jing (Nancy) Lu (Administrator)
Sonali Keshava Murthy Naik (Part-time Webmaster)
Publications

REFEREED JOURNAL PUBLICATIONS


A. J. Barclay, A. R. W. McKellar and N. Moazzen-Ahmadi, “Infrared spectra of (CO_2)_2-Rg trimers, Rg=Ne, Ar, Kr, and Xe”, *Journal of Molecular Spectroscopy* **387**: 111673 (5 pp.), July 2022.

L. Belostotski, A. T. Sutinjo, R. Subrahmanyan, S. Mandal and A. Madanayake, “General framework for array noise analysis and


M. Naseri, D. R. Salahub, S. Amirian and M. A. Rashid, “Computational investigation of Ba2ZrTiO6 double perovskite for optoelectronic and thermoelectric applications”, Journal of


**REFEREE CONFERENCE PROCEEDINGS**


BOOKS AND CHAPTERS


STUDENT TESSES

M. Abarashi, “Electronic properties of tailored 2D materials for chemical sensor applications” (MSc Thesis), April 2022.

O. Aligholamioskooee, “Applying group theory to the study of a carbon trimer defect in hexagonal boron nitride” (MSc Thesis), June 2022.


S. Jimenez Villegas, “Metal oxide-mediated transformations of small molecules for chemical synthesis and energy storage” (MSc Thesis), November 2022.

M. Lai, “300-1500 MHz broadband LNA for the Canadian hydrogen observatory and radio-transient detector” (MSc Thesis), September 2022.


N. S. P. Pathirannehelage, “Molecular dynamics simulations of bulk nanobubbles: Investigation of factors important to their stability” (MSc Thesis), September 2022.

S. Shafiei Alavijeh, “Hole burning spectroscopy of Erbium-doped optical fibre for applications in quantum networks” (MSc Thesis), September 2022.


J. M. Stevenson, “Theoretical and experimental studies of the gas-phase decomposition chemistry of organosilicon compounds containing silicon-nitrogen bonds via hot-wire chemical vapor deposition” (MSc Thesis), August 2022.


**INTELLECTUAL PROPERTY**


**INVITED PRESENTATIONS AT WORKSHOPS/CONFERENCES**

1 April 2022, C. Simon, “Could quantum entanglement play a role in the brain?”, US Army Research Office Workshop on Quantum Biology (virtual), 1 April 2022.


18 July 2022, M. Trifkovic, “Hierarchically structured porous monoliths enabled by moving away from equilibrium in tricontinuous polymer blend nanocomposites”, the 49th World Polymer Congress (MACRO 2022), 17–21 July 2022, Winnipeg, Canada.


4 August 2022, C. Simon, “Could quantum entanglement play a role in the brain?”, Templeton Foundation Workshop on Quantum Effects in Microtubules, Banff, Canada, 4 August 2022.

11 August 2022, D. L. Feder, “A graph approach to the matrix permanent and determinant”, Workshop on Graph Theory, Algebraic Combinatorics and Mathematical Physics, Montreal, Canada, 25 July–19 August 2022.


12 October 2022, L. Belostotski, “A path to fully integrated QPUs” (plenary), Alberta Quantum Summit 2022, Calgary, Canada, 11–13 October 2022.


ACADEMIC COLLABORATIONS

International Institutions
Aarhus University, Denmark
Beihang University, People’s Republic of China
Ben-Gurion University of the Negev, Israel
California Institute of Technology, United States of America
Centro de Investigación y de Estudios Avanzados (CINVESTAV), Mexico
Cockcroft Institute, United Kingdom
Cornell University, United States of America
European Organization for Nuclear Research (CERN), Switzerland
Florida International University, United States of America
Indian Statistical Institute, India
Institute for Quantum Computing, Baidu Research, People’s Republic of China
Jet Propulsion Laboratory, United States of America
Jiangnan University, People’s Republic of China
National Institute of Standards and Technology, United States of America
National Institute for Nuclear Physics – Pisa (INFN), Italy
National University of Singapore, Singapore
Purdue University, United States of America
Qingdao Institute of Marine Geology, People’s Republic of China
RWTH Aachen University, Germany
Soreq Nuclear Research Centre, Israel
Stockholm University, Sweden
Swansea University, United Kingdom
Trinity College Dublin, Ireland
Università Ca’ Foscari Venezia, Italy
Università degli Studi di Cagliari, Italy
Università di Pavia, Italy
Università Ulm, Germany
Université catholique de Louvain, Belgium
Université Paris-Saclay, France
Universidade Federal do Espírito Santo, Brazil
Universidade Federal do Rio de Janeiro, Brazil
University of Cambridge, United Kingdom
University College Dublin, Ireland
University of Brescia, Italy
University of California at Berkeley, United States of America
University of California at Los Angeles, United States of America
University of Hong Kong, People’s Republic of China
University of Liverpool, United Kingdom
University of Manchester, United Kingdom
University of Oxford, United Kingdom
University of Science and Technology of China, People’s Republic of China
University of Sydney, Australia
University of Technology Sydney, Australia
University of Tokyo, Japan
University of Warsaw, Poland

National Institutions
British Columbia Institute of Technology
Simon Fraser University
University of Alberta
University of British Columbia
University of Manitoba
University of Ottawa
University of Victoria
University of Waterloo
York University
<table>
<thead>
<tr>
<th>Collaborative Entity</th>
<th>Name</th>
<th>Role</th>
<th>Nature</th>
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<tr>
<td>1QBit</td>
<td>Seyed Shakib Vedaie</td>
<td>Collaborator (scientific)</td>
<td></td>
<td>Quantum machine learning</td>
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<td>MITACS graduate internship</td>
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<tr>
<td>ApexQubit</td>
<td>Barry C. Sanders</td>
<td>Scientific Advisory Board Member</td>
<td></td>
<td>Quantum Computing</td>
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<tr>
<td>Clariant Specialty Chemical</td>
<td>Pierre Kennepohl</td>
<td>Collaborator</td>
<td></td>
<td>Catalyst optimization through AI-enabled spectroscopic analysis</td>
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<td>CMC Microsystems</td>
<td>Shabir Barzanjeh</td>
<td></td>
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<td>Defence Research and Development Canada</td>
<td>Paul E. Barclay</td>
<td>Collaborator</td>
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<td>Quantum sensor</td>
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<td>Katal Energy Inc.</td>
<td>Peter Kusalik</td>
<td>NSERC Alliance Grant</td>
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<td>Nanobubbles in nanoemulsion fuels</td>
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<tr>
<td>National Research Council Canada</td>
<td>Leonid Belostotski</td>
<td>Principal Investigator</td>
<td></td>
<td>High-speed digitization</td>
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<tr>
<td>National Research Council Canada</td>
<td>Daniel Oblak</td>
<td>Collaborator</td>
<td></td>
<td>Quantum dots for MDI-QKD, integrated quantum dot circuits for quantum communication, and ultraweak photon detection from biological samples</td>
</tr>
<tr>
<td>National Research Council Canada</td>
<td>Christoph Simon</td>
<td>Collaborator</td>
<td></td>
<td>Quantum sensing with biophotons, quantum simulation, quantum networks and quantum neuromorphic computing</td>
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<tr>
<td>National Research Council Canada</td>
<td>Nasser Moazzen-Ahmadi</td>
<td>Collaborator</td>
<td></td>
<td>Molecular clusters &amp; gas sensors</td>
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<tr>
<td>SBQuantum</td>
<td>Barry C. Sanders</td>
<td>Advisor</td>
<td></td>
<td>Quantum sensing</td>
</tr>
<tr>
<td>TRIUMF</td>
<td>Robert I. Thompson &amp; Timothy Friesen</td>
<td>Collaborator</td>
<td></td>
<td>ALPHA project</td>
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<tr>
<td>Zapata Computing</td>
<td>Archismanita Dalal</td>
<td>Collaborator</td>
<td></td>
<td>Noise tailoring for robust amplitude estimation</td>
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### VISITORS

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Dorcas Addo</td>
<td>Kwame Nkrumah University of Science and Technology</td>
</tr>
<tr>
<td>Javier Aizpurua</td>
<td>Center for Materials Physics in San Sebastian (CSIC-UPV/ehu)</td>
</tr>
<tr>
<td>Ismail Akkouche</td>
<td>University Frères Mentouri Constantine 1</td>
</tr>
<tr>
<td>Patrizia Calaminici</td>
<td>Centro de Investigación y de Estudios Avanzados (CINVESTAV), Mexico</td>
</tr>
<tr>
<td>Shane Eaton</td>
<td>Politecnico di Milano</td>
</tr>
<tr>
<td>Mile Gu</td>
<td>Nanyang Technology University/National University of Singapore</td>
</tr>
<tr>
<td>Zheng-Cheng Gu</td>
<td>Chinese University of Hong Kong</td>
</tr>
<tr>
<td>Hubert de Guise</td>
<td>Lakehead University</td>
</tr>
<tr>
<td>Aurélien de la Lande</td>
<td>Centre national de la recherche scientifique (CNRS), Orsay</td>
</tr>
<tr>
<td>Sanjib Dey</td>
<td>Indian Institute of Science Education and Research, Mohali</td>
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<tr>
<td>Ania Jayich</td>
<td>University of California, Santa Barbara</td>
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<tr>
<td>Phil Kaye</td>
<td>National Research Council Canada</td>
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<tr>
<td>Andreas Koster</td>
<td>Centro de Investigación y de Estudios Avanzados (CINVESTAV), Mexico</td>
</tr>
<tr>
<td>Asif Iqbal</td>
<td>Natural Resources Canada (NRCan)</td>
</tr>
<tr>
<td>Nana Liu</td>
<td>Institute of Natural Sciences, University of Michigan and Shanghai Jiao Tong University Joint Institute</td>
</tr>
<tr>
<td>Min Namkung</td>
<td>Kyung Hee University</td>
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<tr>
<td>Mosayeb Naseri</td>
<td>Islamic Azad University, Kermanshah Branch</td>
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<tr>
<td>Russ Renzas</td>
<td>Oxford Instruments</td>
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<tr>
<td>Kora-at Petchrat</td>
<td>Prince of Songkla University</td>
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<tr>
<td>Jeong San Kim</td>
<td>Kyung Hee University</td>
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<tr>
<td>Javad Shabani</td>
<td>New York University</td>
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<tr>
<td>Atharva Shukla</td>
<td>Indian Institute of Technology, Roorkee</td>
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<tr>
<td>Namrata Shukla</td>
<td>Banaras Hindu University</td>
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<tr>
<td>Enrique Solano</td>
<td>Kipu Quantum</td>
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<tr>
<td>Thomas Sowinski</td>
<td>Polish Academy of Sciences</td>
</tr>
<tr>
<td>Qiping Su</td>
<td>Hangzhou Normal University</td>
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<tr>
<td>Peter Zoller</td>
<td>Universität Innsbruck</td>
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## Graduate Courses

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Instructor</th>
<th>Description</th>
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<tbody>
<tr>
<td>CHEM689.3 Selected Topics in Physical Chemistry (Advanced Materials Characterization Methods)</td>
<td>S. Trudel</td>
<td>Courses covers metrics characterization methods such as electron microscopy, X-ray absorption spectroscopy, X-ray diffraction, X-ray photo electron spectroscopy, and conductivity measurements.</td>
</tr>
<tr>
<td>CHEM619.09 Advanced Mass Spectrometric Techniques</td>
<td>Y. J. Shi</td>
<td>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 multidisciplinary fields.</td>
</tr>
<tr>
<td>ENGG 601 Professional Development I</td>
<td>M. Trifkovic</td>
<td>Topics include: health and safety, communication styles, supervisory relationships and respect in the lab, presentation skills including presentation planning and voice projection, reference gathering and management, awareness of plagiarism, and writing abstracts.</td>
</tr>
<tr>
<td>ENGG 603 Professional Development II</td>
<td>M. Trifkovic</td>
<td>Topics include: presentation skills, skills for writing scientific manuscripts, peer review process, defence and candidacy, engineering design, intellectual property, and networking basics.</td>
</tr>
<tr>
<td>MATH653.2 Topics in Pure Mathematics: Representation Theory</td>
<td>C. M. Scandolo</td>
<td>The course is an introductory graduate course to group representation theory, with some reference to actual quantum research. Topics will be chosen according to the interest of the instructors and students.</td>
</tr>
<tr>
<td>PHYS677 Implementation of Quantum Information</td>
<td>B. C. Sanders</td>
<td>Proposals and realizations of quantum information tasks including quantum computation, quantum communication, and quantum cryptography in optical, atomic, molecular, and solid state systems.</td>
</tr>
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</table>
## Services and Outreach

### CONFERENCES/WORKSHOPS

<table>
<thead>
<tr>
<th>Name</th>
<th>Committee</th>
<th>Conference/Workshop</th>
<th>Location</th>
<th>Dates</th>
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</thead>
<tbody>
<tr>
<td>P. E. Barclay</td>
<td>Chair, Quantum and Nonlinear Optics Committee</td>
<td>Advanced Photonics Congress</td>
<td>Maastricht, the Netherlands</td>
<td>24–28 July 2022</td>
</tr>
<tr>
<td>P. E. Barclay</td>
<td>Co-Chair</td>
<td>NanoCanada International Conference: From Earth to Space</td>
<td>Edmonton, Canada</td>
<td>8–10 June 2022</td>
</tr>
<tr>
<td>D. Salahub</td>
<td>Chair, Organizing Committee</td>
<td>21st deMon Developers Workshop</td>
<td>Kananaskis, Canada</td>
<td>13–17 October 2022</td>
</tr>
<tr>
<td>B. C. Sanders</td>
<td>Chair, Program Committee</td>
<td>International Conference on Quantum Communication, Measurement and Computing</td>
<td>Lisbon, Portugal</td>
<td>11–15 July 2022</td>
</tr>
<tr>
<td>S. Trudel</td>
<td>Co-organizer</td>
<td>North American Solid State Chemistry Conference</td>
<td>Calgary, Canada</td>
<td>2–4 August 2023</td>
</tr>
</tbody>
</table>

### PROFESSIONAL SERVICES

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
<th>Journal/Society/Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. E. Barclay</td>
<td>Member, Selection Committee</td>
<td>Banting Postdoctoral Fellowship Program, Government of Canada</td>
</tr>
<tr>
<td>P. E. Barclay</td>
<td>Member, Alliance Quantum Evaluation Committee</td>
<td>National Sciences and Engineering Research Council (NSERC)</td>
</tr>
<tr>
<td>P. E. Barclay</td>
<td>Project Leader, Quantum Sensing</td>
<td>National Research Council Canada</td>
</tr>
<tr>
<td>P. E. Barclay</td>
<td>Project Leader, NanoInitiative Project</td>
<td>National Research Council Nano</td>
</tr>
<tr>
<td>P. E. Barclay</td>
<td>Associate Editor</td>
<td>Optics Express</td>
</tr>
<tr>
<td>P. E. Barclay</td>
<td>qLab Scientific Lead</td>
<td>Quantum City, Calgary</td>
</tr>
<tr>
<td>S. Barzanjeh</td>
<td>Reviewer</td>
<td>Nature Physics</td>
</tr>
<tr>
<td>L. Belostotski</td>
<td>Editor-in-Chief</td>
<td>IEEE Journal of Solid-State Circuits</td>
</tr>
<tr>
<td>Name</td>
<td>Role</td>
<td>Journal/Society/Institution</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>L. Belostotski</td>
<td>Chair, SCC/CAS Chapter</td>
<td>Institute of Electrical and Electronics Engineer (IEEE)</td>
</tr>
<tr>
<td>D. L. Feder</td>
<td>Member, Editorial Board</td>
<td>PLOS ONE</td>
</tr>
<tr>
<td>D. Oblak</td>
<td>Member, Expert Group on Quantum Technology</td>
<td>Canadian Photonic Industry Consortium (CPIC)</td>
</tr>
<tr>
<td>D. R. Salahub</td>
<td>Member, Editorial Board</td>
<td>Advances in Quantum Chemistry</td>
</tr>
<tr>
<td>D. R. Salahub</td>
<td>College of Reviewers</td>
<td>Canadian Institutes of Health Research</td>
</tr>
<tr>
<td>D. R. Salahub</td>
<td>Member, Editorial Board</td>
<td>Computation</td>
</tr>
<tr>
<td>D. R. Salahub</td>
<td>Vice Chair, Editorial Board</td>
<td>Interdisciplinary Science: Computational Life Sciences</td>
</tr>
<tr>
<td>D. R. Salahub</td>
<td>Member, Editorial Board</td>
<td>Journal of Computational Chemistry</td>
</tr>
<tr>
<td>D. R. Salahub</td>
<td>Member, Academic Editorial Board</td>
<td>PLOS ONE</td>
</tr>
<tr>
<td>B. C. Sanders</td>
<td>Scientist</td>
<td>Creative Destruction Lab—Rockies</td>
</tr>
<tr>
<td>B. C. Sanders</td>
<td>Scientist</td>
<td>Creative Destruction Lab—Toronto</td>
</tr>
<tr>
<td>B. C. Sanders</td>
<td>Member, Core Task Force, Open Quantum Initiative</td>
<td>GESDA–Geneva Science and Diplomacy Anticipator</td>
</tr>
<tr>
<td>B. C. Sanders</td>
<td>Member, Editorial Board</td>
<td>IOP ebooks™</td>
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<tr>
<td>B. C. Sanders</td>
<td>Chair, Board of Directors</td>
<td>Deep Tech Canada</td>
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<tr>
<td>B. C. Sanders</td>
<td>Member, Advisory Committee, Applied Quantum Computing</td>
<td>National Research Council Canada</td>
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<td>B. C. Sanders</td>
<td>Challenge Program</td>
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<tr>
<td>B. C. Sanders</td>
<td>Member, Evaluation Committee</td>
<td>Photonique Quantique Québec</td>
</tr>
<tr>
<td>B. C. Sanders</td>
<td>Scientific Director</td>
<td>Quantum City, Calgary</td>
</tr>
<tr>
<td>B. C. Sanders</td>
<td>Chair, Steering Committee</td>
<td>Quantum Africa Conference Series</td>
</tr>
<tr>
<td>B. C. Sanders</td>
<td>Member, Quantum Working Group 3, Cercle en recherche et</td>
<td>Québec Ministère des Relations internationales et de la Francophonie</td>
</tr>
<tr>
<td>B. C. Sanders</td>
<td>innovation Québec-Europe (CRIQUE)</td>
<td></td>
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<tr>
<td>B. C. Sanders</td>
<td>Member, Mirror Committee ISO/TC 229</td>
<td>Standards Council of Canada</td>
</tr>
<tr>
<td>B. C. Sanders</td>
<td>Chair, Catalyst Grants Support Committee</td>
<td>University of Calgary</td>
</tr>
<tr>
<td>B. C. Sanders</td>
<td>Co-Chair, Quantum Computing Task Force</td>
<td>University of Calgary</td>
</tr>
<tr>
<td>Y.-J. Shi</td>
<td>Associate Editor</td>
<td>Canadian Journal of Chemistry</td>
</tr>
<tr>
<td>C. Simon</td>
<td>Member, Advisory Board of AEP/NANO/SDT</td>
<td>National Research Council Canada</td>
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<tr>
<td>M. Trifkovic</td>
<td>Associate Editor</td>
<td>Physics of Fluids</td>
</tr>
<tr>
<td>M. Trifkovic</td>
<td>Member, Prize Selection Committee</td>
<td>Journal of Process Control</td>
</tr>
<tr>
<td>S. Trudel</td>
<td>Member, Scholarship and Fellowship Committee</td>
<td>Natural Sciences and Engineering Research Council (NSERC)</td>
</tr>
</tbody>
</table>
OUTREACH LECTURES

2 June 2022, H. Zadeh Haghighi, “Quantum physics and its applications: Advancing subject awareness in high school students”, Center for Learning at Home, Okotoks, 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 Peter Zoller from University of Innsbruck delivered a public lecture titled “A taste of quantum: A quantum leap in quantum information” to about 180 persons on 11 October 2022 in the Telus Spark Science Centre in Calgary, and this event was supported by the Faculty of Science marketing and communication team as a joint outreach effort. This public lecture was part of 2022 Alberta Quantum Summit organized by Quantum City, Government of Alberta’s Major Innovation Fund Quantum Project and Quantum Alberta.

MEDIA COVERAGE

<table>
<thead>
<tr>
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<th>Date</th>
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<tbody>
<tr>
<td>Abu Dhabi TV</td>
<td>10th annual hackathon for social good at NYU Abu Dhabi: Dorcas Addo &amp; Pragati Gupta</td>
<td>1 April 2021</td>
</tr>
<tr>
<td>UToday</td>
<td>International team of scientists finds new and simpler way to generate “quantum light”: Christoph Simon</td>
<td>8 April 2021</td>
</tr>
<tr>
<td>Betakit.com</td>
<td>Alberta launches new innovation strategy focused on attracting tech talent, capital: Quantum</td>
<td>12 April 2022</td>
</tr>
<tr>
<td>CCA-Reports.ca</td>
<td>CCA appoints expert panel on quantum technologies: Barry C. Sanders</td>
<td>26 May 2022</td>
</tr>
<tr>
<td>Quantamagazine.org</td>
<td>Physicists rewrite the fundamental law that leads to disorder: Carlo Maria Scandolo</td>
<td>26 May 2022</td>
</tr>
<tr>
<td>Globe and Mail</td>
<td>Canadian company Xanadu achieves &quot;big leap forward&quot; in quantum computer race: Barry C. Sanders</td>
<td>1 June 2022</td>
</tr>
<tr>
<td>UCalgary News</td>
<td>UCalgary graduate students accelerate online security with quantum physics: Jordan Smith</td>
<td>6 June 2022</td>
</tr>
<tr>
<td>Calgary Herald</td>
<td>Global tech firm Mphasis launches in Calgary with potential for hundreds of jobs: Quantum City</td>
<td>7 June 2022</td>
</tr>
<tr>
<td>Calgary Herald</td>
<td>Alberta investing $23 million toward UofC’s Quantum City: Barry C. Sanders</td>
<td>9 June 2022</td>
</tr>
<tr>
<td>UCalgary News</td>
<td>Quantum City ready to make big moves with universe’s tiniest objects: Barry C. Sanders, Paul Barclay, Daniel Oblak and Megan Lee</td>
<td>10 June 2022</td>
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<tr>
<td>Source</td>
<td>Title of Article</td>
<td>Date</td>
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<tr>
<td>Calgary Herald</td>
<td>Philanthropic lawyer tagged as Calgary’s citizen of the year: Barry C. Sanders</td>
<td>15 June 2022</td>
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<tr>
<td>Calgary.ca</td>
<td>2022 Calgary Awards recipients: Barry C. Sanders</td>
<td>15 June 2022</td>
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<tr>
<td>UCalgary News</td>
<td>Quantum scientist Barry Sanders spreads knowledge far and wide: Barry C. Sanders</td>
<td>17 June 2022</td>
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<tr>
<td>UCalgary News</td>
<td>UCalgary community members honoured at prestigious Calgary Awards: Barry C. Sanders</td>
<td>17 June 2022</td>
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<td>UCalgary News</td>
<td>Big quantum week ahead for University of Calgary and Quantum City: Quantum Alberta &amp; Quantum City</td>
<td>7 October 2022</td>
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<td>Alharak Alsaeyasi</td>
<td>Sudanese scientists and researchers from abroad present scientific lectures: Barry C. Sanders</td>
<td>29 December 2022</td>
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<td>The Hill Times</td>
<td>Quantum innovation depends on diversified startups investments, say experts: Daniel Oblak</td>
<td>1 February 2023</td>
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</table>
Research Grants
(unaudited)

BY ORIGIN

TOTAL RESEARCH FUNDING: $10.3M

Provincial Funding (61.19%)

National Funding (38.81%)
BY FUNDING AGENCY

TOTAL RESEARCH FUNDING: $10.3M

- Government of Alberta (48.6%)
- National Research Council Canada (11.6%)
- Natural Sciences and Engineering Research Council of Canada (16.5%)
- Social Sciences and Humanities Research Council of Canada (1.2%)
- MITACS (0.1%)
- Industry (0.4%)
- Canada Foundation for Innovation (9.4%)
- Alberta Innovates (3.4%)
- Other Grants (4.1%)
- University of Calgary (4.8%)
Objectives for Next Year

PAUL E. BARCLAY
- Measure diamond optomechanical devices in 100 mK environment, with the goal of observing quantum motion
- Demonstrate interactions between high frequency mechanical resonators mediated by a shared coupling to an optical cavity mode
- Demonstrate optomechanical crystal in hBN van der Walls material
- Elucidate the mechanism for unexpected multiphoton emission in diamond nanostructures

SHABIR BARZANJEH
- Develop integrated topologically insulated entangled sources
- Fabricate quantum-limited amplifiers
- Develop quantum imaging and sensing using single photon sources and single photon sensitive cameras

LEONID BELOSTOTSKI
- Demonstrate cryo-cooled complementary metal-oxide semiconductor (CMOS) oscillators experimentally for quantum-computer drive and readout
- Develop cryogenic low-noise amplifier and an analog-to-digital converter (ADC) for future use in a quantum-computer integrated drive and control integrated circuits (ICs)
- Develop cryogenic noise-parameter models for FDSOI MOSFETs

DAVID L. FEDER
- Develop a reinforcement-learning approach to search for good quantum error correction codes in continuous-variable graph states
- Analyze the topological properties of microring resonator arrays
- Extend recently discovered families of one-dimensional resource states for measurement-based quantum teleportation to two dimensions, in order to perform universal measurement-based quantum computation
Institute for Quantum Science and Technology

TIM FRIESEN

- Ascertain the influence of interactions on topological states for spin-orbit-coupled Bose-Einstein condensates in optical lattices
- Perform improved precision hyperfine spectroscopy of antihydrogen
- Make first direct measurement of the Lamb-shift in antihydrogen
- Develop new microwave resonator and Penning trap electrode to induce antiproton spin flip transitions in antihydrogen
- Improve magnetometry for antihydrogen 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

PETER HØYER

- Develop quantum algorithms for graph problems

PIERRE KENNEPOHL

- Explore the role of charge transfer processes in the decoherence lifetime of transition metal-based molecular electron spin qubits
- Define the benefits of charge-neutral molecular electron spin qubits (how important are counterions?)

PETER G. KUSALIK

- Examine the factors important in the stability and mechanism of formation of aqueous nanobubbles
- Develop and test empirical and coarse grain potential models appropriate for simulations studies of self-assembly processes in zinc-carboxylate metal-organic frameworks
- Use machine learning approaches to characterize formation of order during metal-organic frameworks 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
- Reveal how the aqueous solution structure of potassium dihydrogen phosphate impacts its crystal nucleation and growth

NASSER MOAZZEN-AHMADI

- Design and test a photonic gas sensor for use at mid-infrared wavelengths
- Develop accurate global potential energy surfaces for molecular complexes
- Spectroscopic studies of microsolvation of carbon dioxide in in rare gases
DANIEL OBLAK
- Detect effect of magnetic fields on photon emission from biological samples using an electron-multiplying charge-coupled device camera and multimode-fibre-coupled superconducting nanowire single-photon detectors
- Extend storage time and efficiency of photons in ytterbium-doped material
- Demonstrate interaction between microwave field and ytterbium-yttrium oxyorthosilicate at sub-Kelvin temperatures
- Demonstrate hole-burning and measure coherence time of molecular lanthanide crystals
- Demonstrate generation of multipartite entangled states
- Develop proof-of-concept of measurement-device-independent quantum key distribution system with post-processing included
- Implement polar code-based error-reconciliation for quantum key distribution

CLAUDIA GOMES DA ROCHA
- Develop a computational description of electronic quantum transport in metal-oxide-based and carbon-based nanomaterials that can be applied in next-generation neuromorphic systems
- Characterize the optical transmission, thermal properties, and electrical resistance of metallic nanowire thin films to improve transparent conductor technologies
- Develop architectures for quantum neuromorphic networks and quantum sensor devices

DENNIS R. SALAHUB
- Develop new quantum chemistry/machine-learning algorithms for global structure optimization
- Develop new quantum chemistry/machine-learning algorithms for transition states and molecular dynamics
- Explore the potential of quantum computers for quantum chemistry and for machine learning
- Advance the design of new nanocatalysts by machine learning for quantum chemistry
- Advance the design of new multi-elemental perovskite materials for thermal, optical and electrochemical production of hydrogen using advanced machine learning for quantum chemistry methods
- Coordinate an international collaboration on artificial intelligence for design of new materials producing improved methods and software

BARRY C. SANDERS
- Devise pulse engineering to enhance performance of ion-trap quantum computing
- Develop a simple yet complete model for clock networks to analyse if and how quantum enhancements could apply
- Complete a conceptual framework for interconnecting machine learning and control in both classical and quantum domains
- Construct, employ and characterize quantum-enhanced computer programs for solving problems in energy and health sectors
- Develop a best-practice verification & validation framework for the quantum supply chain
CARIO MARIA SCANDOLO
- Establish quantum causality in the framework of operational probabilistic theories
- Explore how classical probabilities emerge from entanglement
- Generalize thermodynamic fluctuation relations to resource theories
- Generalize the objectivity mechanism in general probabilistic theories
- Formulate physical theories on Boolean lattices

YUJUN SHI
- Explore the technique of solid-state thermal dewetting for the fabrication of bimetallic and high-entropy alloy nanoparticles
- Develop a protocol to use the pulsed laser-induced dewetting method for large-area production of metal nanoparticles
- Develop the growth method for low-dimensional semiconductor nanostructures

CHRISTOPH SIMON
- Identify promising tasks—time series prediction, classification and quantification of potential quantum advantage for quantum neuromorphic computing with nonlinear oscillators and spin networks
- Collaborate on experiments and model magnetic-field on biophoton emission, pigmentation, anesthesia, and stem cell growth. Model flavin adenine dinucleotide as a potential biological quantum sensor for quantum biology
- Implement quantum memories, quantum repeaters and distributed quantum computing with Rydberg atoms, T centres in silicon, nitrogen-vacancy centres in diamond, rare-earth ion doped crystals and fibers, and hybrid alkali-noble gas vapours for quantum networks
- Quantum sensing with nitrogen-vacancy centres (for magnetoencephalography) and biophotons

ROB I. THOMPSON
- Resolve atomic structures of antihydrogen
- Upgrade the ALPHA-g apparatus for precision gravitational free-fall experiments on antihydrogen in the ALPHA-g apparatus
- Develop laser-based ion-source options for TITAN

MILANA TRIFKOVIC
- Expand the use of quantum dots in development of quantum optical circuits through far-from-equilibrium templating techniques

SIMON TRUDEL
- Develop amorphous materials for use in optoelectronic devices
- Develop materials for use in transistors
- Develop reverse monte Carlo simulations of X-ray absorption spectra
IQST adds value to the University of Calgary in the following ways

Enables multidisciplinary research through financial 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