**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
- 69 graduate students
- 17 undergraduate students
- 41 invited talks at national and international conference/workshops including 1 keynote
- 3.8 million dollars revenue
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The University of Calgary and the Province of Alberta have presciently invested in quantum science and technology from the early days of the field. Now quantum science and technology is a huge endeavour worldwide, with billions of dollars invested by governments. Hundreds of millions of dollars has recently been awarded by the Canadian government including three Canada First Research Excellence Fund (CFREF) awards of $75m in federal funding made outside of Alberta.

At this critical stage of quantum science and technology, which is maturing from curiosity-driven foundational research to strategic knowledge-transfer activities, the University of Calgary is well poised to take a leadership role through its combined strengths in computer science, quantum information, nanoscience and quantum optics roots. Researchers at the University of Calgary have fortuitous linkage and collaboration with Alberta agencies CanmetENERGY and the National Institute for Nanotechnology plus companies such as Norcada, Resolved Instruments, FireWater Fuel, and Quantum Silicon.

The Institute for Quantum Science and Technology (IQST) in the Faculty of Science encompasses and represents quantum activities at the University of Calgary. IQST is a vehicle for providing a voice for the University of Calgary community of quantum researchers and technologists with the collective voice reaching stakeholders within and beyond the University. Organizationally, IQST operations have been supported by Alberta Innovates Technology Futures, which has been subsumed into the single unified organization Alberta Innovates.

IQST hosts 14 research groups with a total of about 104 members including professors, research staff and students. The four themes of the Institute are (i) quantum optics, (ii) molecular modelling, (iii) nanotechnology, and quantum optics and quantum information. Although “quantum” is not explicitly stated in some themes, all four themes emphasize quantum aspects.

The strengths of the Institute for Quantum Science and Technology are exemplified by its accomplishments in research and training. The publication and graduate student metrics provide a quantitative summary of the achievements. The fourteen research groups within the Institute have had 66 papers published including 14 in the top-tier journals of Nature, Nature Communications, Nature Photonics, Nature Nanotechnology, Proceeding of the National Academy of Sciences of the United States of America, ACS Nano, Optica, and Physical Review Letters. Sixteen students enrolled in the graduate studies programs in 2016/2017. Five MSc students and seven PhD students completed their research and moved on to academic and industrial positions.

The quality of the students and postdocs in the Institute is excellent as evidenced by them winning awards and prizes. One postdoc received a postdoctoral fellowship from NSERC and one PhD student held NSERC Vanier Scholarship. Two PhD
students and one MSc student received NSERC graduate scholarships. Two postdocs obtained PIMS Postdoctoral Fellowships. Eight Alberta Innovates Graduate Scholarships were held by graduate students in the Institute. Seven postdocs were supported by Eyes High Postdoctoral Fellowships jointly funded by Alberta Innovates and the University of Calgary. One PhD student received the Arthur Bollo-Kamara Graduate Scholarship. Three graduate students had their summer research in the Institute under NSERC USRA awards and eight Alberta Innovates Graduate Scholarships were held by graduate students in the Institute. Seven postdocs were supported by Eyes High Postdoctoral Fellowships jointly funded by Alberta Innovates and the University of Calgary. One PhD student received the Arthur Bollo-Kamara Graduate Scholarship. Three undergraduate students had their summer research in the Institute under NSERC USRA awards and three international undergraduate students had their summer internships under MITACS Globalink.

Five graduate students held University of Calgary Queen Elizabeth II Graduate Scholarships, two PhD students were recipients of a University of Calgary Silver Anniversary Scholarships, and one PhD student was a recipient of the University of Calgary Chancellor’s Graduate Medal. One PhD student received an Izaak Walton Killam Pre-doctoral Scholarship and two students obtained Eyes High Doctoral Recruitment Scholarships. Four students were awarded the Department of Physics and Astronomy Internal Award and one student received the Eric Milner Prize of the Department of Mathematics and Statistics.

The Institute’s Director Barry Sanders received a Doctor of Science degree from the Imperial College London and he was awarded a Killam Annual Professorship. Gilad Gour received the University of Calgary’s Student Union 2017 First and Second Year Teaching Excellence Award.

The Institute prioritizes outreach as well as research and training. Hosting conferences and holding Quantum Public Lectures serve as the main outreach instruments. In June 2016, the Institute was a partner of the deMon developers’ conference in Calgary from 10 to 15 May 2017. The Workshop was successful and attracted 34 participants representing institutions from nine countries (Brazil, Canada, China, Czech Republic, France, Germany, Mexico, Sweden and USA).

The Quantum Public Lectures serve to convey leading breakthroughs in quantum science and technology to the public. Paul Corkum from the University of Ottawa delivered a public lecture titled “A molecule takes a selfie while creating the world’s shortest light pulses” to 240 persons on 24 November 2016. This lecture was co-sponsored by Faculty of Science Alumni Relations team as a joint outreach event.

In summary IQST is performing splendidly in research, training and outreach. Furthermore, IQST is playing a leading role in developing the Quantum Alberta initiative. Globally, quantum science and technology has become increasingly popular as an interdisciplinary scientific endeavour and is now strategically important. IQST’s reputation for breakthrough research results and outstanding training have made the University of Calgary a major player on the world’s quantum stage.

Barry Sanders
Director, IQST
The Faculty of Science has been catalyzing change and inspiring discovery, creativity and innovation for over 50 years. In late September 2017, the Faculty launched its five-year strategic plan, “Curiosity Sparks Discovery!” where we outline a bold direction for our future. Science addresses many of the biggest challenges we face in society, and we are excited to be a part of creating solutions. (http://www.ucalgary.ca/science/strategic_plan)

As Dean of the faculty and Chair of the Board of Directors for the Institute for Quantum Science and Technology (IQST), I am pleased to see how IQST contributes to the faculty’s vision and acts as a catalyst for advancing the exciting multidisciplinary area of quantum science.

Strategically, IQST is a tangible example of the faculty’s evolving mission. This multidisciplinary group of researchers from computer science, mathematics and statistics, chemistry, and physics and astronomy come together because they are problem-solvers, keen to investigate solutions to key theoretical and experimental topics in quantum science and technology.

On behalf of the Board, we are continually impressed at how the IQST team brings a profound knowledge of quantum science and a deep commitment for how its applications can improve human existence and unlock our digital future. We see that in the quality of their students, postdoctoral researchers, faculty members, and their outreach activities.

In particular, I would like to commend IQST for engaging the public and many Faculty of Science alumni through the Annual Quantum Public Lecture. This much-anticipated event highlights how science can capture our curiosity and provide a window into how the world works.

The Faculty of Science, along with IQST, is part of a university that is one of Canada’s most dynamic and enterprising cities. Together, we will harness our current strengths, look to future opportunities and allow for the exploration of new discoveries. I encourage everyone to spend some time reviewing the annual report to learn more about IQST’s achievements this past year.

Lesley Rigg
Dean
Chair, IQST Board of Directors
Research Achievements

Institute for Quantum Science and Technology members have made significant research achievements in the past year. The following exposition of achievements provides a sample of the kinds of activities and breakthroughs seen within Institute for Quantum Science and Technology.

Thompson is a member of the international ALPHA (Antihydrogen Laser PHysics Apparatus) collaboration based at CERN, which is the European Organization for Nuclear Research. ALPHA creates trapped antihydrogen atoms and performs precise comparison with hydrogen to study symmetries between matter and antimatter. This past year ALPHA reported, in Nature, the first observation of a spectral line in antihydrogen.

A collaboration between the groups of Tittel and Simon yielded a proof-of-principle demonstration of non-destructive detection of photonic qubits using a Tm:LiNbO$_3$ waveguide. This Nature Communications Paper suggests a new key component of quantum photonics based on rare-earth-ion-doped crystals.

In an Optica paper, Simon and Lvovsky proposed and demonstrated super-resolution imaging with linear optics and homodyne detection without any need for nonlinear optics or near-field imaging. Lvovsky’s group also implemented a method for “breeding” the Schrödinger cat state, which is a superposition of two coherent light waves with opposite amplitudes. The group produce a large-amplitude Schrödinger cat state from two small-amplitude cat states. This result is described in their Nature Photonics article.

Gour co-authored an article, distinguished as an Editors’ Suggestion, in Physical Review Letters. They critically examined physical consistency of quantum-coherence resource theories. Sanders was a co-author of a Physical Review Letters article as well: this article proposes an optical scheme, employing optical parametric down-converters interlaced with nonlinear sign gates, that completely converts a pump field in a photon-number state to an equal number of signal-idler photon pairs. The proof relies on amplitude amplification, analogous to that employed in Grover search.

In a Proceedings of the National Academy of Sciences of the United States of America paper, Kusalik and coworkers obtained evidence from mixed-hydrate nucleation for a funnel model of crystallization. Importantly, they show that the phenomenological similarities between crystallization and protein folding result from similarities between features of these microscopic ordering processes. In another work co-authored by Kusalik and published in ACS Nano, they provide molecular-level insights into self-assembly in metal–organic frameworks. Their molecular-dynamics simulations elucidate the early stages of the self-assembly mechanism for an important class of nanoporous materials.

These scientific achievements are significant to quantum science and published in top journals. Institute for Quantum Science and Technology is fortunate to have these scientists on board, and these achievements are not a complete list for Institute for Quantum Science and Technology but rather a representative sample of the activities and quality seen in the Institute’s research.
Awards

International Awards
Imperial College London Doctor of Science Degree
Barry C. Sanders

National Awards
MITACS Globalink
Arun Rajendran
Rishabh Shukla
Xinxin Tang

NSERC Alexander Graham Bell Canada Graduate Scholarship – Doctoral
David Lake
Matthew Mitchell

NSERC Alexander Graham Bell Canada Graduate Scholarship – Master’s
Stephen Wein

NSERC Postdoctoral Fellowship
Hoan Bui Dang

NSERC USRA
Bipinmeet Chawla
David Gisu Ham
Aiden Huffman

NSERC Vanier Scholarship
Carlos Enriquez-Victorero

PIMS Postdoctoral Fellowship
Mehdi Ahmadi
Hoan Bui Dang

Provincial Awards
Alberta Innovates Graduate Students Scholarship
Chris Healey
Sourabh Kumar
David Lake
Hon-Wai Lau
Thomas Lutz
Tamiko Masuda
Stephen Wein
Parisa Zarkeshian

Arthur Bollo-Kamara Graduate Scholarship
Ebenezer Owusu-Ansah
University of Calgary Awards

Alberta Innovates Technology Futures (AITF)/Eyes High Postdoctoral Fellowship
Gabriel Aguilar (ended November 2016)
Ronnie Banerjee
John Patrick Hadden
Nikolai Lauk
Florian Senn
Namrata Shukla
Hristina Zhekova

Chancellor’s Graduate Medal
Neil Sinclair

Department of Mathematics and Statistics Eric Milner Prize
Mark Girard

Department of Physics and Astronomy Internal Award
Abdullah Khalid
Pantita Palittapongarnpim
Shakib Vedaie
Yadong Wu

Eyes High Doctoral Recruitment Scholarship
Andrew Evans
Sourabh Kumar
Yasser Novo-Fernandez

Izaak Walton Killam Pre-Doctoral Scholarship
Mark Girard

Killam Annual Professor
Barry C. Sanders

Queen Elizabeth II Graduate Scholarship
Aaron Barclay
Alex Cameron
Keenan Fanning
Hamidreza Kaviani
Taozhe Wu

Silver Anniversary Graduate Fellowship
Kyle Hall
Marcelo Wu

The Student Union 2017 First and Second Year Teaching Excellence Award
Gilad Gour
Key Performance Indicators

Graduate student enrolment and quality of entrants

One MSc student from Ghana has second class upper division, so his GPA is not calculated.

Publications and Presentations
(highlighted portion with IQST student)
**External Awards (Chairs, Fellowships and Scholarships)**

- Faculty Chairs
- Postdoctoral Fellows
- Graduate Students
- Undergraduate Students

**Trainee Destinations after IQST**

- Academia
- Industry
- Other
Visitors

- Professors
- Postdoctoral Fellows
- Students
- Industry

[Bar chart showing the number of visitors in each category]
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.

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.
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. Gilad Gour

Dr. Peter Høyer
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.

Quantum Information Technology with Light and Experimental Quantum Optics

Concentrates on implementing light for the purposes of quantum information technology — that is, learning to synthesize, control, characterize, and store arbitrary quantum states of the electromagnetic field, as well as causing photons to interact with each other. We work on achieving sub-Rayleigh resolution of optical imaging using passive imaging devices.
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.

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 a context of High Performance Computing.
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.
Theoretical Quantum Optics

We use quantum optical approaches to study potential applications of 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). Our theoretical research is often done in close collaboration with leading experimental groups.

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.
Quantum Cryptography and Communication

Builds photon-based quantum cryptography systems through optical fibres and targets the development of a quantum repeater to extend quantum cryptography past its current distance limit. Develops novel techniques for practical photonic quantum communication primitives such as quantum teleportation, plus hitherto unrealized means for efficient and reversible transfer of quantum information between photons and atoms for temporal storage.

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.
Institute Structure

The Institute is managed on a day-to-day level by the Institute Director and the Institute Administrator. The Director and his research group are additionally supported by an administrative assistant. 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 Technology Officer, Raytheon BBN Technology

John Kendall

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)

Mark Williams

Executive Committee

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

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

Yujun Shi  
Associate Professor, Department of Chemistry, University of Calgary

Wolfgang Tittel  
Professor, Department of Physics and Astronomy, University of Calgary
Council

Faculty Members

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

David Feder
Associate 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

Alex Lvovsky
Professor, Department of Physics and Astronomy, University of Calgary

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

Dennis Salahub
Professor, Department of Chemistry, University of Calgary

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

Yujun Shi
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

Wolfgang Tittel
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

Richard Zach
Professor, Department of Philosophy, University of Calgary
Postdoctoral Fellows

Gabriel Aguilar (resigned November 2016 → Assistant Professor, Federal University of Rio de Janeiro)
Mehdi Ahmadi
Ronnie Banerjee
Hoan Bui Dang
Roohollah Ghobadi
Sandeep Goyal (completed May 2016 → Assistant Professor, Indian Institute for Science Education and Research, Mohal)
John Patrick Hadden
Nikolai Lauk
Young Choon Park
Florian Senn (completed October 2016)
Namrata Shukla
Mauricio Chagas da Silva (completed October 2016)
Neil Sinclair
Chukman So
Rim Toukabri (completed September 2016)
Lucile Veissier (resigned June 2016 → Postdoctoral Fellow, Université Paris-Sud Orsay)
Ehsan Zahedinejad (resigned August 2016 → Researcher, 1Qbit)
Qiang Zhou (completed March 2017 → Assistant Professor, University of Electronic Science and Technology)

Research Engineers & Research Assistants

Volodimir Kiselyov (resigned September 2016)
Daniel Oblak

Students

Graduate Students (PhD Program)

Mohsen Bagheri Mehrab
Stephanie Bovincini
Archismita Dalal
Katelynn Daly
Raphael Dong
Carlos Enriquez-Victorero
Andrew Evans
Mohsen Falamarzi Askarani
Akihiko Fujii

Mark Girard
Sumit Goswami
Kyle Hall
Chris Healey
Hamidreza Kaviani
Abdullah Khalid
Behzad Khanaliloo (graduated December 2016 → Engineer, Lumerical Inc.)
Mohrmandasdeghe Khazali (graduated December 2016 → Postdoctoral Fellow, Aarhus University)
Faezeh Kimiae Asadi
Sourabh Kumar
David Lake
Hon-Wai Lau
Pascal Lefebvre
Thomas Lutz
Armando Marenco (graduated January 2017)
Adam Mayer
Matthew Mitchell
Ali Mohandesi
Eugene Moiseev
James Moncreiff
Yasser Novo-Fernandez
Varun Narasimhachar (graduated August 2016 → Postdoctoral Fellow, National University of Singapore)
Ebenezer Owusu-Ansah
Eduardo Paez
Pantita Palittapongarnpim
Alireza Poostindouz
Marcel.i Grimau Puigibert
Anastasia Pushkina
Nafiseh Sang-Nourpour
Issaka Seidu (graduated February 2017 → Postdoctoral Fellow, Carleton University)
Neil Sinclair (graduated May 2016 → Postdoctoral Fellow, University of Calgary)
Arina Tashchilina
Raju Valivarthi
Priyaa Varshinee Srinivasan
Seyed Shakib Vedaie
Marcelo Wu (graduated March 2017 → Postdoctoral Fellow, National Institute for Standards and Technology)
Taozhe Wu
Yadong Wu
Parisa Zarkeshian
Graduate Students (MSc Program)

Eric Ampong
Paul Anderson
Aaron Barclay
Alex Cameron
Jacob Davidson
Chetan Deshmukh (graduated February 2017 → PhD Student, Institute of Photonic Sciences, Barcelona)
Nuiok Dicaire
Alison Fulton
Abhirup Goswami (graduated September 2016 → PhD Student, Queensland University of Technology)
Masoud Habibi Davijani
Shreyas Jalnapurkar
Jiawei Ji
Mojtaba Komeili
Tamiko Masuda
Eugene Moiseev (transferred September 2016 → PhD Student, University of Calgary)
Alireza Poostindouz (graduated August 2016 → PhD Student, University of Calgary)
Mohammad Rahmati
Lohrasp Seify (graduated April 2016 → Trading Analyst, Parker Trading Corp.)
Stephen Wein
Weihuang Xu
Fan Yang (graduated August 2016 → PhD Student, University of British Columbia)

Undergraduate Students

Burke Brockelbank (UofC PHYS598)
Alex Cameron (Summer Research)
Bipinmeet Chawla (NSERC USRA)
Leonardo Cotta (Research Assistant)
David Gisu Ham (NSERC USRA)
Aiden Huffman (NSERC USRA)
Jonathan Kung (UofC CHEM502)
Kimberley Owen (UofC PHYS598)
Arun Rajendran (MITACS Globalink)
Charmaine Sablay (UofC CHEM402)
Alexander Shock (UofC PHYS598)
Rishabh Shukla (MITACS Globalink)
Raunak Singh (UofC CHEM502)
James Stevenson (UofC CHEM402)
Xinxin Tang (MITACS Globalink)
Bryce Taylor (UofC PHYS599)
Tracy Tran (UofC CHEM299)

Administration

Jing (Nancy) Lu (Administrator)
Priya Varshnee Srinivasan (Part-Time Webmaster)
Lucia Wang (Administrative Assistant)
Refereed Journals


W. H. Kan, R. Dong, J.-S. Bae, S. Adams and V. Thangadurai, “Probing surface valence, magnetic property, and oxide ion diffusion pathway in B-site ordered perovskite-type BaₓCa₀.₆₇M₀₀.₃₃NbO₃₋ₓ(ₓ=0, 1, 2, 3)”, Solid State Ionics 290: 90-97, July 2016.


**Refereed Conference Proceedings**


**Books and Chapters**


**Student Theses**

C. Deshmukh, “Towards non-destructive detection of photonic qubits using a rare-earth-ion doped crystal” (MSc Thesis), February 2017.

A. Goswami, “Analysis of a deterministic entangled photon pair source using single photons” (MSc Thesis), September 2016.


F. Yang, “Far-field linear optical superresolution via heterodyne detection in a higher-order local oscillator mode” (MSc Thesis), August 2016.

**Intellectual Property**


Invited Presentations at Workshops/Conferences


6 Sep 2016, Y. J. Shi, “Study of decomposition of methyl-substituted silane molecules on hot metal surfaces and in the gas phase”, The 9th International Conference on Hot Wire (Cat) and Initiated Chemical Vapor Deposition (HWCVD 9), Philadelphia, United States of America, 6 Sep 2016–9 Sep 2016.


Collaborations

International Institutions

Aarhus University, Denmark
Beijing University of Posts and Telecommunications, 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 del Instituto Politécnico Nacional (CINVESTAV), Mexico
Chinese Academy of Science's Institute of Geology and Geophysics, People's Republic of China
Chinese Academy of Science's Institute for Coal Research, People's Republic of China
Czech Academy of Sciences, Czech Republic
Durham University, United Kingdom
École Polytechnique Fédérale de Lausanne, Switzerland
European Organization for Nuclear Research (CERN), Switzerland
Hebei University of Technology, People's Republic of China
Henan University of Science and Technology, People's Republic of China
Imperial College London, United Kingdom
Indian Institute of Science Education and Research – Mohali, India
Institute of Nuclear Physics of Polish Academy of Science, Poland
Institute of Science and Technology Austria
Institute for Research in Fundamental Sciences (IPM), Tehran, Iran
Institut Charles Gerhardt (CNRS), France
Institut d’Optique, France
Institut de Ciències Fotòniques, Spain
Isfahan University of Technology, Iran
Istituto di Fotonica e Nanotecnologie (IFN-CNR), Italy
Istituto Italiano di Tecnologia, Italy
Jacobs University, Germany
Koç University, Turkey
Korea Basic Science Institute (Busan), South Korea
Kyoto University, Japan
Laboratoire de Chimie Physique (CNRS), France
Marquette University, United States of America
Massachusetts Institute of Technology, United States of America
Montana State University, United States of America
Moscow Institute of Physics and Technology, Russia
Nagoya University, Japan
Nanjing University of Science and Technology, People's Republic of China
National Centre for Spinal Disorders, Hungary
National Institute for Standards and Technology (Boulder), United States of America
National University of Sciences and Technology, Pakistan
National University of Singapore
P. N. Lebedev Physical Institute of the Russian Academy of Sciences, Russia
Politecnico di Milano, Italy
Public Authority for Applied Education and Training, Kuwait
Purdue University, United States of America
Shanghai Jiao Tong University, People’s Republic of China
Soreq Nuclear Research Centre, Israel
Southern Illinois University, United States of America
Stanford University, United States of America
Stockholm University, Sweden
Swansea University, United Kingdom
The Cockroft Institute, United Kingdom
The Russian Quantum Centre, Russia
Université Catholique de Louvain, Belgium
Universidade Federal do Rio de Janeiro, Brazil
Università della Calabria, Italy
Università di Pisa, Italy
University College Dublin, Ireland
University College London, United Kingdom
University of California at Berkeley, United States of America
University of California at San Diego, United States of America
University of Electronic Science and Technology, People’s Republic of China
University of Liverpool, United Kingdom
University of Leipzig, Germany
University of Manchester, United Kingdom
University of Michigan, United States of America
University of Minas Gerais, Brazil
University of Queensland, Australia
University of Science and Technology of China,
People’s Republic of China
University of Tabriz, Iran
University of Tokyo, Japan
University of Wisconsin at Madison, United States of America
University of Zurich, Switzerland
Vision Research Institute, Lowell, United States of America
Weizmann Institute of Science, Israel

National Institutions
Canadian Institute for Advanced Research
McGill University
National Institute for Nanotechnology
National Research Council of Canada, Ottawa
Queen’s University
Simon Fraser University
TRIUMF
University of Alberta
University of British Columbia
University of Lethbridge
University of Ottawa
University of Saskatchewan
University of Victoria
University of Waterloo
York University

Industrial & Government
BBN Raytheon Technologies
Lawrence Berkeley National Laboratory
Lawrence Livermore National Laboratory
NASA Jet Propulsion Laboratory
Natural Resources Canada CanmetENERGY
## Visitors

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
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</thead>
<tbody>
<tr>
<td>Hessa Alotaibi</td>
<td>Public Authority for Applied Education and Training, Kuwait</td>
</tr>
<tr>
<td>Gustavo Amaral</td>
<td>Pontifical Catholic University of Rio de Janeiro</td>
</tr>
<tr>
<td>Mohammad Amin</td>
<td>D-Wave Systems</td>
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<tr>
<td>Simon Apers</td>
<td>Ghent University</td>
</tr>
<tr>
<td>Andrew Cameron</td>
<td>University of Prince Edward Island</td>
</tr>
<tr>
<td>Paul Corkum</td>
<td>University of Ottawa</td>
</tr>
<tr>
<td>Dan Dalacu</td>
<td>National Research Council of Canada</td>
</tr>
<tr>
<td>Timothy Duty</td>
<td>University of New South Wales</td>
</tr>
<tr>
<td>Matthew Fisher</td>
<td>University of California at Santa Barbara</td>
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<tr>
<td>Greg Gabrenya</td>
<td>D-Wave Systems</td>
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<tr>
<td>Mercedes Gimeno-Segovia</td>
<td>University of Bristol</td>
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<tr>
<td>Eduardo Guendelman</td>
<td>Ben Gurion University</td>
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<tr>
<td>Yu Guo</td>
<td>Shanxi Datong University</td>
</tr>
<tr>
<td>Lizandra Barrios Herrera</td>
<td>Instituto Superior de Tecnologias y Ciencias Aplicadas, Cuba</td>
</tr>
<tr>
<td>Garrett Hickman</td>
<td>University of Maryland</td>
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<td>Jeremy Hilton</td>
<td>D-Wave Systems</td>
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<tr>
<td>Scott Hopkins</td>
<td>University of Waterloo</td>
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<tr>
<td>Said Jalife Jacobo</td>
<td>Centro de investigacion y de estudios avanzados (Cinvestav)</td>
</tr>
<tr>
<td>David Jennings</td>
<td>Imperial College London</td>
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<td>Ebrahim Karimi</td>
<td>University of Ottawa</td>
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<td>Andrew King</td>
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<tr>
<td>Harish Kugel</td>
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<tr>
<td>Arturo Lezama</td>
<td>Universidad de la República, Uruguay</td>
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<tr>
<td>Xiaohong Li</td>
<td>Henan University of Science and Technology</td>
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<tr>
<td>Guilhem Madiot</td>
<td>Université Paris-Sud</td>
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<tr>
<td>Josh Mutus</td>
<td>Google</td>
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<tr>
<td>Matthew Posner</td>
<td>University of Southampton</td>
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<td>Liang Qiu</td>
<td>China University of Mining and Technology</td>
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<td>Dongxiao Quan</td>
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<td>Arun Rajendran</td>
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<td>Mark Saffman</td>
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<tr>
<td>Yuval Sanders</td>
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<td>Rishabh Skukla</td>
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<tr>
<td>Alp Sipahigil</td>
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<td>Michail Skoteiniotis</td>
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<tr>
<td>Hennie Snyman</td>
<td>Nelson Mandela Metropolitan University</td>
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<tr>
<td>Wanjun Su</td>
<td>Fuzhou University</td>
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<tr>
<td>Xinxin Tang</td>
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<td>Hailin Wang</td>
<td>University of Oregon</td>
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<td>Nathan Wiebe</td>
<td>Microsoft Research</td>
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<td>Colin Williams</td>
<td>D-Wave Systems</td>
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<td>Haider Zia</td>
<td>University of Electronic Science and Technology of China</td>
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<tr>
<td>Haimin Zheng</td>
<td>China University of Petroleum</td>
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## Affiliation

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. I. Lvovsky</td>
<td>Quantum Optics Group Leader</td>
<td>The Russian Quantum Center</td>
</tr>
<tr>
<td>D. R. Salahub</td>
<td>Honorary Professor</td>
<td>Henan University of Technology</td>
</tr>
<tr>
<td>B. C. Sanders</td>
<td>“Qianren” Professor</td>
<td>University of Science and Technology of China</td>
</tr>
<tr>
<td>W. Tittel</td>
<td>Associated Professor</td>
<td>Montana State University</td>
</tr>
<tr>
<td>Course Name</td>
<td>Instructor</td>
<td>Description</td>
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</tr>
<tr>
<td>CHEM689 Molecular Driving Forces</td>
<td>P. G. Kusalik</td>
<td>In this introduction to statistical mechanics we will explore the basis from which to understand molecular driving forces. We will also examine how this formalism is applied within computer simulations of liquids, solids and solutions. The emphasis will be on physical models and interpretations, with applications to systems of chemical and biochemical interest. Selected topics from the recent literature will also be included. We will closely follow the required text, Molecular Driving Forces by Dill and Bromberg.</td>
</tr>
<tr>
<td>CHEM689 Modeling Multiscale Systems</td>
<td>D. R. Salahub</td>
<td>The course will build on a basic knowledge of classical and quantum mechanics to explore modern methods of simulating complex systems in chemistry, physics, biology and materials science. The student will acquire an understanding of the main approaches in quantum chemistry, molecular dynamics and the kinetics of coupled systems of chemical equations (e.g., the Kinetic Monte Carlo method). Hands-on experience with some of the techniques will be obtained and the student will be able to tailor the applications to his or her areas of interest, for example, heterogeneous, homogeneous or enzymatic catalysis, genetic regulatory networks, integrated nano-systems, etc.</td>
</tr>
<tr>
<td>PHYS543 Quantum Mechanics II</td>
<td>N. Moazzen-Ahmadi</td>
<td>Theory of angular momentum and applications, perturbation theory and applications. Identical particles. Introduction to relativistic wave equations.</td>
</tr>
<tr>
<td>PHYS677 Implementations 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>
</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>Chair, Division of Atomic, Molecular and Optical Physics</td>
<td>Canadian Association of Physicists</td>
</tr>
<tr>
<td>P. E. Barclay</td>
<td>Associate Editor</td>
<td><em>Optics Express</em></td>
</tr>
<tr>
<td>P. G. Kusalik</td>
<td>Chair, Chemistry/Biochemistry Resource Allocation Committee</td>
<td>Compute Canada</td>
</tr>
<tr>
<td>A. I. Lvovsky</td>
<td>Member, International Advisory Board</td>
<td><em>Journal of Physics B</em></td>
</tr>
<tr>
<td>A. I. Lvovsky</td>
<td>Member, NSERC Strategic Partnership Grants for Projects, Information and Communication Selection Panel</td>
<td>Natural Sciences and Engineering Research Council of Canada</td>
</tr>
<tr>
<td>A. I. Lvovsky</td>
<td>Deputy Editor</td>
<td><em>Optics Express</em></td>
</tr>
<tr>
<td>D. R. Salahub</td>
<td>Member, Editorial Board</td>
<td><em>Advances in Physical Chemistry</em></td>
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<tr>
<td>D. R. Salahub</td>
<td>Member, Editorial Board</td>
<td><em>Advances in Quantum Chemistry</em></td>
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<tr>
<td>D. R. Salahub</td>
<td>Member, Editorial Board</td>
<td><em>Computation</em></td>
</tr>
<tr>
<td>D. R. Salahub</td>
<td>Vice Chair, Editorial Board</td>
<td><em>Interdisciplinary Science: Computational Life Sciences</em></td>
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<tr>
<td>D. R. Salahub</td>
<td>Member, Editorial Board</td>
<td><em>Journal of Computational Chemistry</em></td>
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<tr>
<td>D. R. Salahub</td>
<td>Member, Academic Editorial Board</td>
<td><em>PLOS-One</em></td>
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<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, Steering Committee</td>
<td>Quantum Africa Conference Series</td>
</tr>
<tr>
<td>B. C. Sanders</td>
<td>Editor-in-Chief</td>
<td><em>New Journal of Physics</em></td>
</tr>
<tr>
<td>Y. J. Shi</td>
<td>Associate Editor</td>
<td><em>Canadian Journal of Chemistry</em></td>
</tr>
<tr>
<td>R. I. Thompson</td>
<td>Director, Student Affairs</td>
<td>Canadian Association of Physicists</td>
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<td>R. I. Thompson</td>
<td>Member, Editorial Board</td>
<td><em>Physics in Canada</em></td>
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<td>R. I. Thompson</td>
<td>University of Calgary Representative, Board of Management</td>
<td>TRIUMF National Laboratory</td>
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<td>R. I. Thompson</td>
<td>General Faculties Council, Board of Governors</td>
<td>University of Calgary</td>
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<td>R. I. Thompson</td>
<td>Chair, Graduate College Steering Committee</td>
<td>University of Calgary</td>
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<tr>
<td>W. Tittel</td>
<td>Member, Editorial Board</td>
<td><em>Quantum Science and Technology</em></td>
</tr>
<tr>
<td>S. Trudel</td>
<td>Chair, Materials Chemistry Division</td>
<td>Chemical Institute of Canada</td>
</tr>
</tbody>
</table>
Quantum Public Lecture

The Quantum Public Lectures serve 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 Paul Corkum from University of Ottawa delivered a public lecture titled “A molecule takes a selfie while creating the world’s shortest light pulses” to about 200 persons on 24 November 2016, and this event was supported by the Faculty of Science Alumni Relations team as a joint outreach effort. The lecture was broadcast by interactive video to the University of Lethbridge.

Outreach Lectures

10 May 2016, D. R. Salahub, “50 years of trying to understand natural and life sciences – learning from giants”, Faculty of Science, Henan University of Technology, People’s Republic of China (lecture to 250 undergraduate).


29 Mar 2017, D. R. Salahub, “50 years of trying to understand natural and life sciences – learning from giants”, Henan University of Technology, People’s Republic of China (lecture to 250 graduate students).
## Media Coverage

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<tr>
<th>Source</th>
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<tr>
<td>Maclean's</td>
<td>Trudeau versus the experts: Quantum computing in 35 seconds: Barry C. Sanders</td>
<td>19 Apr 2016</td>
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<tr>
<td>CBC News</td>
<td>The debate over preserving Calgary’s architectural heritage: Barry C. Sanders</td>
<td>15 May 2016</td>
</tr>
<tr>
<td>Physicsworld.com</td>
<td>The June 2016 issue of Physics World is now out: Barry C. Sanders</td>
<td>1 Jun 2016</td>
</tr>
<tr>
<td>Eureka Alert</td>
<td>Russian physicists create a high-precision “quantum ruler”: Alex Lvovsky</td>
<td>23 Jun 2016</td>
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<tr>
<td>Science Daily</td>
<td>Physicists create a high-precision “quantum ruler”: Alex Lvovsky</td>
<td>23 Jun 2016</td>
</tr>
<tr>
<td>TASS.com</td>
<td>Russian physicists create highly precise “quantum ruler”: Alex Lvovsky</td>
<td>23 Jun 2016</td>
</tr>
<tr>
<td>UToday</td>
<td>Physicist exploring new ways to think about science and how to teach it: Barry C. Sanders</td>
<td>8 Jul 2016</td>
</tr>
<tr>
<td>Lenta.ru</td>
<td>Environmentalists described the quantum tunnels in the human brain: Christoph Simon, Paul Barclay</td>
<td>19 Jul 2016</td>
</tr>
<tr>
<td>РИА Новости</td>
<td>Scientists spoke about the quantum tunnels in the human brain: Christoph Simon, Paul Barclay</td>
<td>20 Jul 2016</td>
</tr>
<tr>
<td>Capital TV</td>
<td>Dr. Barry Sanders’ public lecture on Dr. Abdus Salam: Barry C. Sanders</td>
<td>30 Jul 2016</td>
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<tr>
<td>Daily Jehan-e-Pakistan</td>
<td>Habib University hosts Dr. Barry Sanders’ public lecture: Barry C. Sanders</td>
<td>30 Jul 2016</td>
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<tr>
<td>Daily Ausaf</td>
<td>Habib University hosts Dr. Barry Sanders’ public lecture: Barry C. Sanders</td>
<td>30 Jul 2016</td>
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<tr>
<td>Daily Jang</td>
<td>Habib University hosts four-day quantum information summer school: Barry C. Sanders</td>
<td>30 Jul 2016</td>
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<tr>
<td>Newa-e-Waqt</td>
<td>Habib University hosts four-day quantum information summer school: Barry C. Sanders</td>
<td>30 Jul 2016</td>
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<tr>
<td>Pakistanblogs.com</td>
<td>Habib University hosts QISS, aims for development of a national collaboration in Pakistan: Barry C. Sanders</td>
<td>30 Jul 2016</td>
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<tr>
<td>thenews.com.pk</td>
<td>Physicists laud Dr. Abdus Salam’s contributions: Barry C. Sanders</td>
<td>31 Jul 2016</td>
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<tr>
<td>Pakobserver.net</td>
<td>Habib University hosts Summer School: Barry C. Sanders</td>
<td>5 Aug 2016</td>
</tr>
<tr>
<td>pstimes.com</td>
<td>Habib University hosts QISS, aims for development of a national collaboration in Pakistan: Barry C. Sanders</td>
<td>5 Aug 2016</td>
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<tr>
<td>CTV</td>
<td>Canadian researchers lead the way towards unhackable internet communication: Wolfgang Tittel</td>
<td>19 Sep 2016</td>
</tr>
<tr>
<td>Mail on Sunday</td>
<td>Quantum teleportation breakthrough as scientists send data across cities – and it could lead to UNBREAKABLE encryption for computer networks: Wolfgang Tittel</td>
<td>19 Sep 2016</td>
</tr>
<tr>
<td>BBC</td>
<td>Teleportation step toward quantum internet: Wolfgang Tittel</td>
<td>20 Sep 2016</td>
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<tr>
<td>Calgary Herald</td>
<td>University of Calgary manages to teleport photons, paving way for quantum Internet: Wolfgang Tittel</td>
<td>20 Sep 2016</td>
</tr>
<tr>
<td>Source</td>
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<tr>
<td>Calgary Sun</td>
<td>How Calgary researchers solved a quantum conundrum using city hall and a photon: Wolfgang Tittel</td>
<td>20 Sep 2016</td>
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<tr>
<td>CBC Calgary</td>
<td>Teleportation across Calgary marks “major step” toward creation of “quantum internet”: Wolfgang Tittel</td>
<td>20 Sep 2016</td>
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<tr>
<td>Metronews.ca</td>
<td>U of C researcher teleports photons across Calgary: Wolfgang Tittel</td>
<td>20 Sep 2016</td>
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<tr>
<td>Motherboard</td>
<td>Scientists set a new distance record for quantum teleportation: Wolfgang Tittel</td>
<td>20 Sep 2016</td>
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<tr>
<td>The Christian Science Monitor</td>
<td>Could quantum teleportation help ensure online privacy?: Wolfgang Tittel</td>
<td>20 Sep 2016</td>
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<tr>
<td>UToday</td>
<td>Beam me up Scotty! Researchers teleport particle of light six kilometres: Wolfgang Tittel</td>
<td>20 Sep 2016</td>
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<tr>
<td>UToday</td>
<td>University of Calgary physicists create nano-sized device with huge potential in field of quantum computing: Paul Barclay</td>
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<tr>
<td>CBC Homestretch</td>
<td>Calgary Jenny Howe gets to the bottom of teleportation: Wolfgang Tittel</td>
<td>21 Sep 2016</td>
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<tr>
<td>Global TV</td>
<td>Why teleportation could one day be a reality: Wolfgang Tittel</td>
<td>22 Sep 2016</td>
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<tr>
<td>The Loop</td>
<td>Moving around of information: Wolfgang Tittel</td>
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<tr>
<td>CBC Radio: Quirks and Quarks</td>
<td>Quantum teleportation: Wolfgang Tittel</td>
<td>24 Sep 2016</td>
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<td>CIFAR</td>
<td>New distance record for quantum teleportation: Wolfgang Tittel</td>
<td>7 Oct 2016</td>
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<tr>
<td>UofA Faculty of Science News</td>
<td>Less is more when it comes to atomic-scale manufacturing: Robert Wolkow</td>
<td>28 Oct 2016</td>
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<td>UToday</td>
<td>2016 Killam Scholars and award winners celebrated at annual reception: Barry C. Sanders</td>
<td>28 Oct 2016</td>
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<tr>
<td>The Globe and Mail</td>
<td>Tiny Alberta-made sensor may open door to hand-held drug tests: Paul Barclay, Mark Freeman</td>
<td>31 Oct 2016</td>
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<tr>
<td>UToday</td>
<td>PhD grad aims to take the mystery out of quantum science: Neil Sinclair, Wolfgang Tittel, Barry C. Sanders</td>
<td>14 Nov 2016</td>
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<tr>
<td>National Post</td>
<td>Does the mind use fibre optics? Calgary team floats “out-there” theory of light communication in the brain: Christoph Simon</td>
<td>20 Nov 2016</td>
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<tr>
<td>Calgary Herald</td>
<td>Does the mind use fibre optics? Calgary team floats “out-there” theory of light communication in the brain: Christoph Simon</td>
<td>21 Nov 2016</td>
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<tr>
<td>Newstalk770</td>
<td>Fibre optics and the brain: Christoph Simon</td>
<td>21 Nov 2016</td>
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<tr>
<td>UToday</td>
<td>A molecule takes a selfie: Paul Corkum</td>
<td>24 Nov 2016</td>
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<tr>
<td>Youtube: SciHerald</td>
<td>Brain optics, THz identification of cancer DNA, and “hairy” black holes: Christoph Simon, Paul Barclay, Sourabh Kumar</td>
<td>1 Dec 2016</td>
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<tr>
<td>The Wall Street Journal</td>
<td>After 1,000 year slumber, China vows to invent again: Barry. C. Sanders</td>
<td>6 Dec 2016</td>
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<tr>
<td>UToday</td>
<td>Researchers explore the possibility of a “fibre optic network” in the brain: Christoph Simon</td>
<td>7 Dec 2016</td>
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<td>The Globe and Mail</td>
<td>Canadians solve key puzzle for future of encryption: Wolfgang Tittel</td>
<td>20 Dec 2016</td>
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<td>UToday</td>
<td>Top research stories of 2016: Teleportation, bear attacks, and an app for people with celiac disease: Wolfgang Tittel</td>
<td>23 Dec 2016</td>
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<tr>
<td>UofA Faculty of Science News</td>
<td>What’s cooler than being cool?: Lindsay LeBlanc</td>
<td>25 Jan 2017</td>
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<tr>
<td>UToday</td>
<td>International research team shines light on mystery of antimatter: Rob Thompson, Andrew Evans</td>
<td>3 Feb 2017</td>
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<tr>
<td>UToday</td>
<td>UCalgary researchers awarded NSERC Strategic Partnership Grants for high-priority impacts: Paul Barclay</td>
<td>15 Feb 2017</td>
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<tr>
<td>ScienceNews</td>
<td>Millions of atoms entangled in record-breaking quantum tests: Christoph Simon, Wolfgang Tittel</td>
<td>27 Mar 2017</td>
</tr>
<tr>
<td>UToday</td>
<td>Project expands research collaborations in Pan-Africa, Pakistan and Peru: Barry, C. Sanders</td>
<td>29 Mar 2017</td>
</tr>
</tbody>
</table>
FINANCES

Operating Account (unaudited)

Total Expenditures: $79k
Research Grants (unaudited)

**BY FUNDING AGENCY**

- NSERC [28%]
- Canada Foundation for Innovation [22%]
- Compute Canada [11%]
- Canadian Institute for Advanced Research [2%]
- Alberta Innovates Technology Futures (AITF) [13%]
- Government of Alberta [17%]
- Industry [3%]
- National Research Council Canada [4%]

Total Revenue: $3,806k

**BY ORIGIN**

- National Funding [67%]
- Provincial Funding [33%]

Total Revenue: $3,806k
OBJECTIVES FOR NEXT YEAR

PAUL BARCLAY

- Demonstrate optomechanically induced transparency in a diamond device.
- Demonstration of optomechanical control of diamond spins.
- Evaluation of the possibility of observing room temperature quantum effects in diamond optomechanical devices.
- Demonstration of doubly resonant photon down-conversion from 780 nm band to the 1550nm band using a microcavity.
- Implant and characterize spectral properties of SiV defects in diamond chips.
- Together with Freeman and other NINT researchers, enhance sensitivity of silicon photonics nanocavity torque magnetometer technology.
- Publish proposal for detecting optical angular momentum states of light using optomechanical devices.

DAVID FEDER

- Explore how to perform universal measurement-based quantum computation with symmetry protected many-body states.
- Understand the violation of entanglement area laws in fermionic matter.
- Attempt to construct universal resources for measurement-based quantum computation with interacting fermionic particles on lattices.
- Explore novel phases for ultracold atoms confined in optical cavities and optical lattices.

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 algorithms for generalized quantum walks systems.
- Determine necessary and sufficient conditions for speed up of generalized quantum walks.
PETER KUSALIK
- Develop and test an effective interaction potential for OH radical in water that faithfully reproduces the structural features observed from ab initio simulations.
- Explore the behaviour of OH radical at the surfaces of water and ice.
- Determine the stability and reactivity of hemi-bonded complexes of OH radical with Cl\(^-\) or Br\(^-\) anions.
- Develop and test empirical and coarse-grain potential models appropriate for simulations studies of self-assemble processes in Zn/ carboxylate MOFs.
- Determine the key factors impacting the nucleation process of gas clathrate hydrates from gas mixtures of varying compositions.
- Examine in influences of surfaces on the nucleation of gas hydrates from water-in-oil emulsions, in complimentary simulations and experimental studies.

ALEX LVOVSKY
- Build an entangled state between a Schrödinger cat and the polarization of a single photon.
- Obtain superresolution with pairs of point objects that are separated by a few tens of nm.
- Demonstrate complete reconstruction of an image with sub-diffraction resolution.

NASSER MOAZZEN-AHMADI
- Record and analyse laboratory infrared spectra of hydrocarbons relevant to the methane cycle in the atmospheres of Titan and the Giant Planets.
- Construct highly-accurate potential energy surfaces for characterization of intermolecular forces.
- Measure low-frequency intramolecular vibrational fundamentals of molecular clusters via combination bands.
- Provide high resolution spectroscopic data to test the onset of superfluidity in CH\(_2\)COOH-(He)\(_4\) as the smallest superfluid cluster.
- Record and analyse laboratory spectra of H\(^+\)- and He-hydrocarbons for elucidation of collisional processes between molecular hydrogen and rare gas with hydrocarbon trace species for planetary applications.
- Perform structural determination of complexes formed from carbon monoxide and carbon dioxide.

DENNIS SALAHUB
- Advance multi-scale modelling methodologies and their implementation in efficient computer codes, with an immediate focus on and implementation of the GGA+U methodology for strongly correlated systems, dispersion corrections and quantum capping potentials for QM/MM calculations.
- Develop multiscale modelling of nanocatalysis for oil sands upgrading by extending our work on molybdenum carbide to include mixed-valence ceria-metal catalysts to split water, using the produced hydrogen for hydrocracking over molybdenum carbide.
- Perform multiscale QM/MM studies of the mechanism of action of important enzymes; continue studies of the heme peroxidases in order to verify, or falsify, the presence of electron density circuits.

BARRY C. SANDERS
- Develop a wavelet-based quantum algorithm for quantum computer simulation of a multi-scale renormalizable quantum field theory.
- Operationalize fundamental quantum protocols.
- Formalize the machine-learning description of quantum control.
- Determine how to postselect a controlled-controlled-not gate with ten-photon entangled state.
- With Wolkow at the University of Alberta and with Quantum Silicon Incorporated, design and test all-silicon proof of concept atom-scale circuitry for quantum adiabatic annealing.

YUJUN SHI
- Investigate chemical vapor deposition chemistry of silicon nitride using aminosilanes as novel precursors.
- Explore the pulsed laser dewetting method for the formation of bimetallic nanoparticles.
- Advance the development of a theoretical model in characterizing the temperature profile in the process of pulsed laser dewetting.
- Develop methods using chemical vapor deposition to form Si-based nanostructures.

**CHRISTOPH SIMON**
- Develop proposals for room-temperature quantum photonics involving defects in diamond and opto-mechanical systems.
- Work on quantum networks with rare-earth ions, pursuing both approaches based on single ions and on ensembles.
- Study transducers between superconducting qubits and photonic qubits, based on defects in solids and on opto-mechanical systems.
- Study potential sources of bio-photons in the brain, with a focus on singlet oxygen and the possible role of spin.
- Study entangled-photon microscopy, in particular using nano-diamonds.

**ROBERT THOMPSON**
- Observe optical transition in trapped atomic antihydrogen.
- Use geochemical techniques to determine double-ß half-life for $^{96}$Zr.
- Finalize design of the ALPHA-g apparatus.

**WOLFGANG TITTEL**
- Develop and demonstrate key components for quantum repeater-based quantum key distribution especially quantum memory for light, measurement-device-independent quantum key distribution, and quantum teleportation.
- Explore how to map quantum information between superconducting qubits and telecommunication-wavelength photons.

**SIMON TRUDEL**
- Investigate photochemical formation of nanoparticles for water electrolysis.
- Develop in situ and in oprando methods for x-ray based spectroscopy at the Canadian Light Source.
- Develop novel magnetic nanoparticles for magnetic resonance imaging.
Appendix 1:
Charter of the Institute for Quantum Science and Technology

Name and Affiliation
1. The name of the organization shall be the Institute for Quantum Science and Technology (hereinafter referred to as “Institute”). The Institute formally reports to the Faculty of Science and is governed by the Faculty of Science Research Institutes Policy (hereinafter referred to as “Policy”).

Reporting Structure
2. The Institute reports to the Dean, Faculty of Science (s. 4.7).

Approval and Review Bodies
3. The body responsible for approving, reviewing, and renewing the Institute under the Policy (s. 5.1) is the Faculty of Science Executive Committee.

Term of the Institute
4. Under the Policy Institutes are normally established for a five (5) year term (s. 4.3). The current term of the Institute ends 31 December 2018. The Institute is eligible for renewal upon favourable review (s. 4.4).

Goals
5. In keeping with the Policy (s. 4.1) the goals of the Institute shall be:
   a) to conduct leading research in key theoretical and experimental topics of quantum science and technology;
   b) to provide excellent education and training in quantum science and technology and cognate areas;
   c) to foster linkage between the Institute and other quantum science and technology institutes and with industrial partners.

Schedule of Review
6. The review process is specified in the Faculty of Science Research Institutes Procedures (hereinafter referred to as: “Procedures”). Reviews will occur as specified in the Procedures (s. 2.6). The Procedures call for notice of review to be given no later than 9 months before the end of term of the Institute, with a decision no later than 3 months before the end of the term.

Institute Board of Directors
7. a) The governing body of the Institute shall be referred to as the “Board of Directors” (hereinafter “Board”).
   b) Membership of the Board shall comprise:
      i. The Dean of Science (or designate) will Chair the Board and appoint a Vice Chair from among other board members;
ii. At least 4 “members at large,” drawn from or nominated by

- companies whose primary operations are synergistic with quantum information science
- agencies that provide funding for quantum information science research in Alberta; and
- leading members of the quantum information science academic community.

At least one (1) “member at large” shall be appointed from each of these three categories.

c) The Dean of Science shall appoint “members at large”. Terms of appointment, commencing on April 1, shall normally be for three years. This length of appointment may be varied to ensure an appropriate staggering of terms. Members of the Board shall be eligible for re-appointment for consecutive terms of office.

d) The Board shall be responsible for the overall success and governance of the Institute. More particularly, its responsibilities include:

i. approving and/or amending this Charter under the provisions of clause 10 below
ii. ensuring that relevant University policies are respected (see section 9 below)
iii. appointing a Director for the Institute
iv. approving the Institute’s budget and strategic plans
v. determining membership categories and requirements for the Institute
vi. determining the procedures and requirements of general meetings of institute members (with at least one such meeting required annually)

vii. helping to create opportunities for the Institute

viii. facilitating the periodic reviews and external assessments of the Institute, as required by the Policy and Procedures of the Faculty of Science.

e) The Board shall appoint a Secretary of the Board for a three-year term. The Board can revoke such appointment at any time. The Secretary is not a Board Member and is not eligible to vote.

f) The Board shall meet not less than once in each calendar year, prior to the annual general meeting of Institute members. Special Meetings of the Board shall be convened by the Chair of the Board or upon the written request of at least two (2) members of the Board addressed to the Chair.

i. At least thirty days notice of any meeting shall be given in writing to each member of the Board. Such notice shall specify the time, place and agenda of the meeting.

ii. At any meeting of the Board 50 percent of members, present physically or via teleconference, shall constitute a quorum.

g) The cost for Board members of attending Board meetings (annual and special) will be incurred by the Institute.

Director

8. a) The Director reports to the Board and to the University through the Dean of the Faculty of Science (who, directly or through a designate, chairs the Board).

b) The Director exercises a general superintendence over the operational affairs of the Institute in accordance with the goals of the Institute, and within Board-approved budgets and strategic plans.
The Institute shall submit an annual report (July 15) on its activities to the Dean of the Faculty of Science.

c) The duties of the Director shall include, but not be limited to, the following:

i. preparing an annual budget and strategic plan for consideration and approval by the Board;

ii. preparing periodic financial updates for consideration by the Board;

iii. ensuring that all Institute policies and procedures adopted by the Board are made widely known among Institute members and stakeholders, including the broader University of Calgary community;

iv. preparing an annual report on the Institute’s affairs, which shall include reporting on measures of success;

v. making any additional submissions or reports, as appropriate or requested, to the Board or the University of Calgary on any matter affecting the Institute;

vi. facilitating the periodic reviews and external assessments of the Institute required by the Policy and Procedures of the Faculty of Science.

Policies and Procedures

9. The Institute will operate in accordance with all applicable University of Calgary policies and procedures.

Amendments

10. Amendments to this Charter shall require approval by the Dean and two-thirds of the Board. The Dean will refer proposed amendments to the Faculty of Science Executive Committee.
### Appendix 2: IQST Use of Space

#### Offices

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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