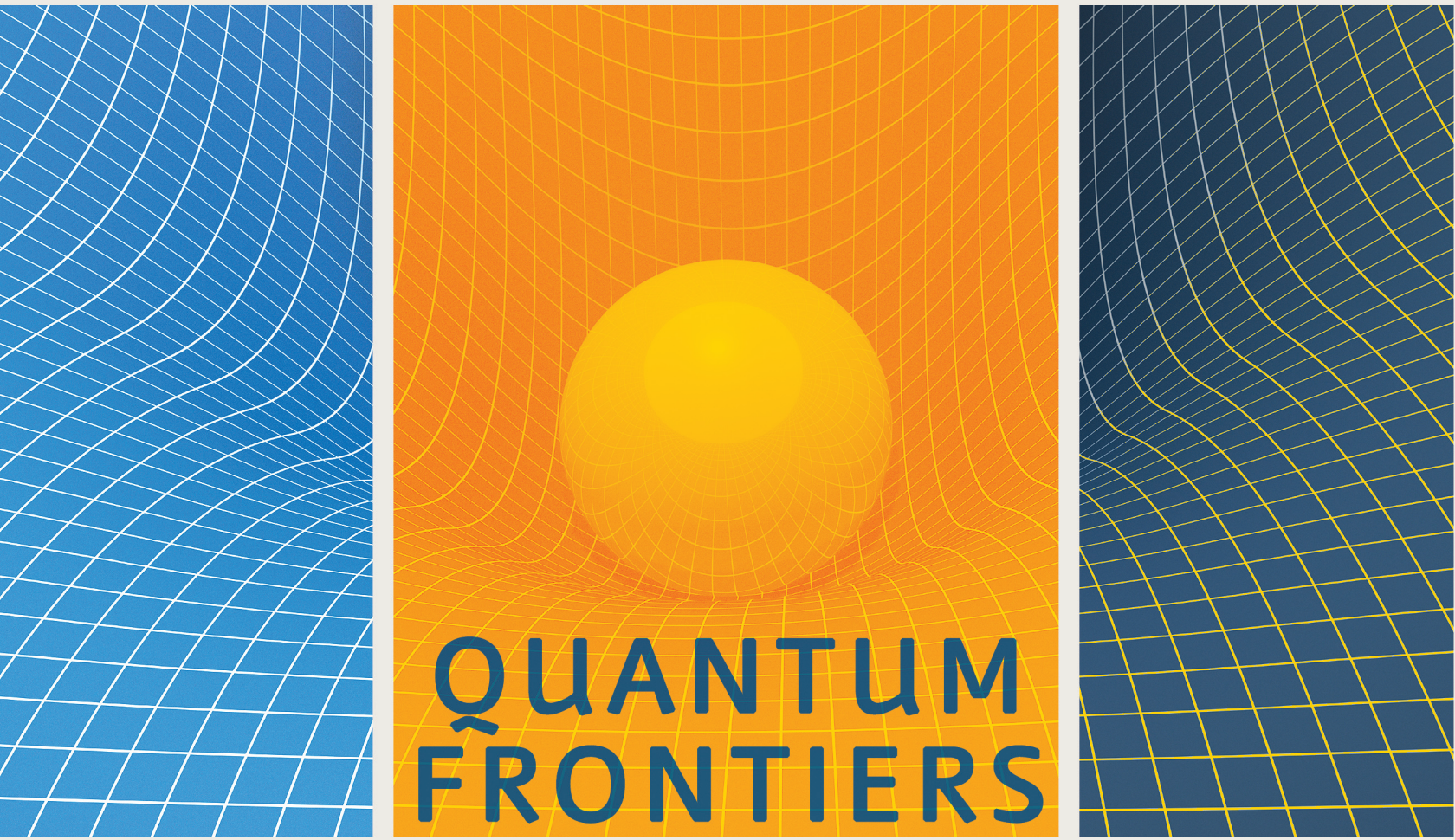

QUANTUM FRONTIERS

ANNUAL REPORT 2008-2009

Institute for
Quantum Information Science
at the University of Calgary

VISION

To be a world leader in research, teaching, and outreach in pure and applied quantum information science and technology.

MISSION STATEMENT

To conduct world leading experimental and theoretical research in quantum information; to provide deep and diverse education and training for senior undergraduate and graduate students; and to conduct vigorous outreach and service to the public, the University, industry, and the quantum information science community.

KEY FACTS

- 9 postdoctoral associates/fellows, 37 graduate students, and 12 undergraduate students (7 are in NSERC USRA program).
- 34 visiting researcher during the year including 3 long-term visiting professor and 3 long-term visiting students.
- 42 publications in refereed journals and conference proceedings with one published in Physical Review Letters and one published in Science.
- 33 invited talks at national and international conferences/workshops including one plenary talk and one keynote.
- More than 32 poster and oral presentation done by students at national and international conferences/meetings/workshops.
- Cash income $2.8 million in 2008/09.

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Director's Report

The University of Calgary Institute for Quantum Information Science continued to grow both in stature and in numbers. The Institute hosted two international conferences, increased student numbers, and has a new incoming faculty member.

Dr. Alex Lvovsky was Chair of the prestigious biennial Quantum Communication, Measurement and Computing conference held 19-24 August 2008 at the University of Calgary. The conference had over 300 participants, and papers from the conference are published in a conference proceedings. IQIS co-hosted with the University of Calgary's Centre for Information Security and Cryptography the Third International Conference on Information-Theoretic Security. Dr. Barry Sanders was General Chair and Dr. Rei Safavi-Naini was Program Chair, and Rei was editor of the refereed proceedings for the conference. This conference had over fifty participants, including leading quantum cryptographers, information theorists, and cryptographers.

Dr. Karl-Peter Marzlin left the University of Calgary to commence a faculty position at St. Francis Xavier University in Nova Scotia but retains an adjunct position at the University of Calgary and continues to supervise students as an IQIS affiliate. Dr. Christoph Simon accepted an offer to join the Department of Physics & Astronomy as an Associate Professor and to become an IQIS affiliate. Christoph is currently at the University of Geneva and is well known for his contributions to theoretical quantum optics, especially as the subject pertains to experimental foundations of quantum mechanics and to experimental quantum information.

The experimental quantum nanoscience search, which will involve a 50% secondment to the National Institute for Nanotechnology in Edmonton, is underway. An excellent candidate was selected for a faculty position in the quantum computing group in the Department of Computer Science, but this position appears to be subject to the University's hiring freeze so this candidate may not receive an offer. The quantum information groups in the Departments of Computer Science and Mathematics & Statistics are below the critical threshold of two faculty members so the faculty freeze is quite detrimental to IQIS's strategy.

As last year was the fifth year of my iCORE Professorship, the iCORE grant supporting this position expired. My application for an iCORE Chair was approved, and this funding is being used to provide partial support for the new faculty positions. The grant is also providing approximately 25% of the costs for operating the Institute as well. University funding corresponds to $75,000 per annum, but the costs of running the Institute are at least $105,000 per annum.

IQIS researchers reported many advances, resulting in 33 refereed journal publications, 9 refereed conference papers, and 33 invited presentations. One advance deserves special attention. Dr. Alex Lvovsky's group reported a new experimental method for efficient characterization of quantum optical processes. Whereas quantum information tasks such as teleportation or memory are typically proved by characterizing examples of the tasks performed in the laboratory, Alex's group performs a complete characterization without prior assumptions by injecting many different laser pulses through the process and then learning the process through optical homodyne tomography on the output states. This result was reported in a Science article in 2008.

IQIS members continue to be highly involved in various research networks. IQIS is a member of the NSERC Innovation Platform for QuantumWorks, and I am one of the three theme leaders. My theme is on devices. Several IQIS members are in the Network Centres of Excellence for Mathematics of Information Technology and Complex Systems, and I am the national project leader for quantum information processing within this network. Three IQIS members are also members of the Canadian Institute for Advanced Research program on quantum information.

Internationally IQIS and the Institute for Quantum Computing at the University of Waterloo are the two Canadian partners in the European Union-Canada Framework for Co-operation in Higher Education, Training and Youth (EU-Canada Program), and the European partners are the Laboratoire de Recherche en Informatique in Paris and the Max Planck Institute for the Science of Light in Erlangen. These national and international networks show how IQIS is building on its cohesive team and international reputation to become an integral part of national and international quantum information networks.

Administratively, IQIS continues to improve operations and enhance its profile. IQIS Administrator Nancy Jing Lu is working with the University to upgrade the third floor hallway of Science B so that the IQIS portion of the floor will have a corporate appearance including picture boards and information displayed on the walls. The databases continue to be developed and greatly assist with the myriad of reports that members and the Institute itself must produce. The IQIS charter is due to expire on 31 December 2009 so efforts have been underway to establish a new charter that properly reflects IQIS's repositioning to the Faculty of Science.

As IQIS students have been graduating, IQIS members noticed that theses were not stating that students were in IQIS. It turned out that the university-provided LaTeX files were rigidly design to show only the student's Department. IQIS now has modified class files for students so that the student's Department and IQIS are both shown on thesis title pages.

Finally, I would like to mention that IQIS is looking forward to the second annual IQIS Board Meeting. In response to issues raised by Board members in 2008, the Board has expanded to included Dr. Jim Haslett from the Department of Electrical and Computer Engineering at the University of Calgary. Another important issue arose at the first Board meeting, namely that an explicit statement of value added by the existence of IQIS was needed. This value-added statement now appears at the end of this year's Annual Report.

Barry Sanders, Director, IQIS

II Quantum Information Research Groups at the Institute

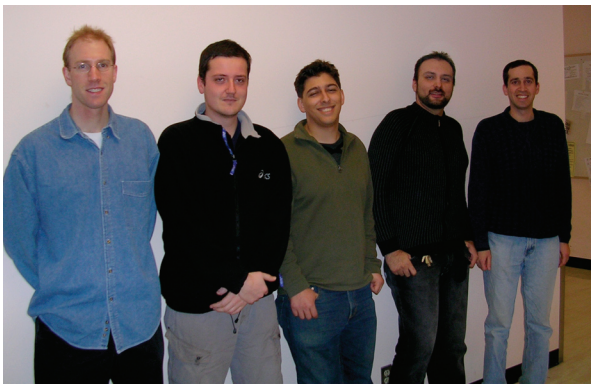
Ultracold Atoms and Condensed Matter Theory

DR. DAVID FEDER

Ultracold atomic gases enable the creation of completely new states of matter that only exist at temperatures extremely close to absolute zero. These systems can be strongly decoupled from their environment and are therefore well-suited for the exploration of novel phenomena in quantum matter and the construction of quantum information devices. We are studying the superfluid behavior and strong correlation properties of ultracold atoms, particularly those subjected to rapid rotation and to optical lattice potentials (crystals formed by laser interference). The resulting states are expected to be useful for the implementation of quantum algorithms. In particular, we are interested in quantum computation based on measurements only (the so-called one-way model and its extensions), on quantum walks, and on braiding of particles with fractional statistics (topological quantum computation with anyons).

Quantum Information Theory

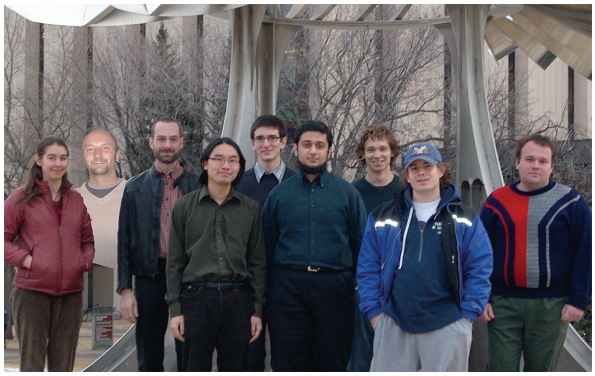
DR. GILAD GOUR



Quantum resources, like entanglement, are the key ingredients of quantum information processing tasks. They are needed in many cases where quantum networks contain certain kinds of limitations or imperfections. For example, situations in which parties in the network are not familiar with the exact orientation of each other (i.e. they are lacking a shared reference frame) induce limitations called super-selection rules. With such restrictions new quantum resources are needed. Our group objectives are to study the fascinating resource theories that emanate from such constraints. The study of quantum information in the presence of super-selection rules, for example, not only lead to new, interesting physics and the discovery of new resources, but also have applications in related fields, such as quantum cryptography, quantum optics, and quantum communication.

Quantum Computing

DR. PETER HØYER



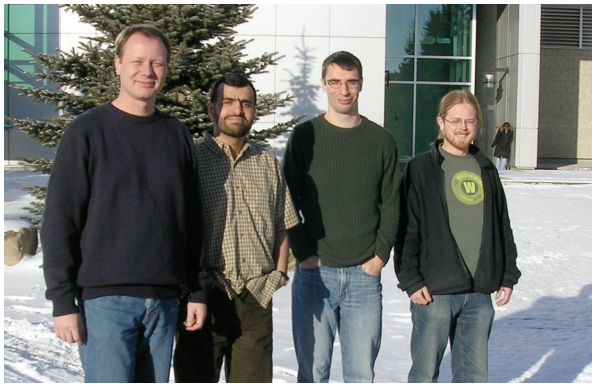
The Quantum Computing Research Group within the Department of Computer Science conducts research in computational aspects of quantum mechanical systems. We study systems based on quantum mechanical principles. Our research areas include quantum algorithmics, quantum complexity theory, quantum communication complexity, quantum information theory, and quantum computer simulations of quantum mechanical systems. Our work is collaborative. Together with researchers at other groups and institutions in North America and Europe, we explore the possibilities and limitations of quantum computing. We organized and hosted the Third and Sixth Canadian Summer School on Quantum Information Processing (Equips). Our work is internationally and nationally funded, we offer courses on quantum computing, and we provide a rich and flexible environment.

Quantum Information Technology with Light and Experimental Quantum Optics

DR. ALEX LVOVSKY

Photons are excellent carriers of quantum information. One can build an entire quantum information processor by means of single-photon sources, detectors, and simple linear optical elements such as mirrors and beam splitters. Our group 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.

Theoretical Quantum Optics and Nonlinear Optics



DR. PETER MARZLIN
(moved to St. Francis Xavier University in July 2008)

Atom-light interaction touches most fundamental aspects of quantum mechanics; many-particle effects in dense atomic gases, the nature of quantum states of light, and even relativity are relevant to understand it. Despite this conceptual depth it is also very close to experiments. We investigate novel effects in this interaction for use in quantum information processing; stopping of light or strong interaction between two photons may be used to realize a quantum memory or controlled quantum gates, respectively. We study the use of electromagnetically induced transparency, atom-atom correlations, and dielectric media for this goal and are also considering problems in relativistic quantum information theory.

Quantum Information Science

DR. BARRY SANDERS

Quantum information science is revolutionizing the principles of information, communication, and computation. Our efforts are focused on studies of quantum information resources (such as entanglement and measurements), tasks (such as quantum teleportation, cryptography, and fingerprinting), and implementations (such as photon-based realizations), and our goal is to make quantum information work in the real world.

Quantum Cryptography and Communication

DR. WOLFGANG TITTEL

Photons and atoms are key constituents for long distance quantum communication and quantum networks. Our group's effort focuses on the building of 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. This includes developing novel techniques for rendering photonic quantum communication primitives such as quantum teleportation practical, plus hitherto unrealized means for efficient and reversible transfer of quantum information between photons and atoms for temporal storage.

III Management

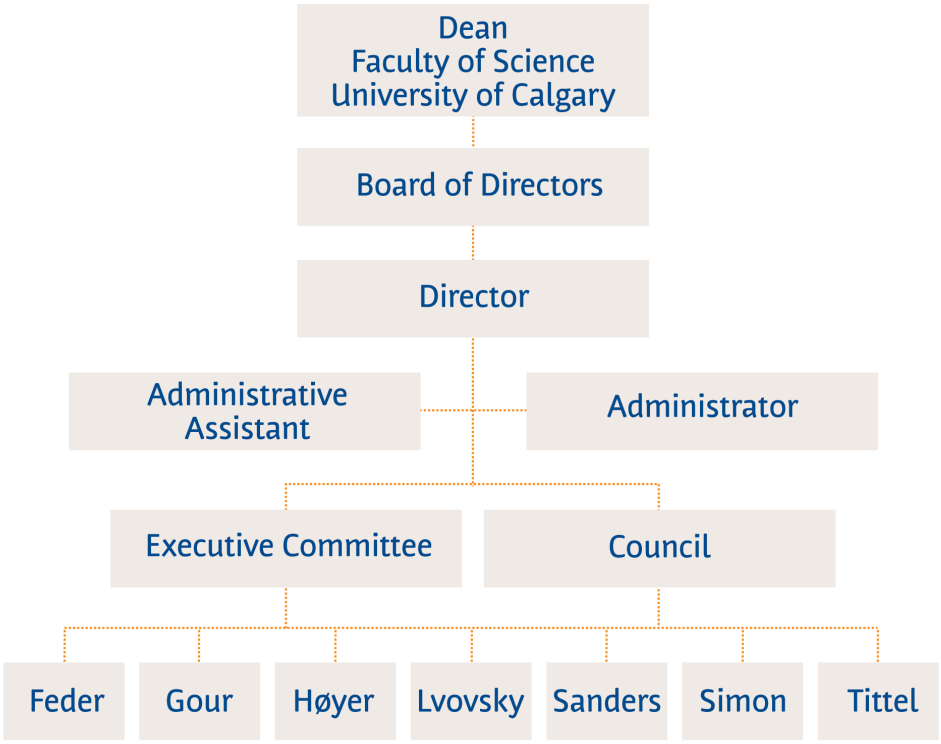
A. Structure

The organizational structure of the Institute is depicted in the organizational chart below. 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, Deputy Director, Administrator, and two faculty members other than the Director and Deputy Director. The Executive meets monthly to discuss and make decisions on executive matters. The Executive receives advice and guidance from the IQIS Council, which comprises all full and affiliate faculty members of the Institute.

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

Organizational Chart – Institute for Quantum Information Science



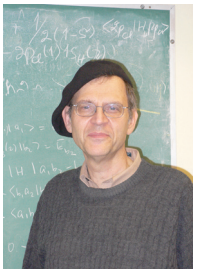
B. Board of Directors

CHAIR

Dr. J. Sandy Murphree
Dean, Faculty of Science, University of Calgary

Dr. J. S. (Sandy) Murphree is an experienced space physicist who came to the University of Calgary in 1975 as a Postdoctoral Fellow. He served as a Research Associate, and Adjunct Associate Professor before being appointed as an Associate Professor in 1988. In 1991 Dr. Murphree was promoted to Professor, and in 1995 he became Head of the Department of Physics and Astronomy until June 2000. He was appointed Associate Dean (Research and Academic Affairs) in July 2003, with the title changing to Vice-Dean a year later. He became Acting Dean in July 2005, and in March 2006 he became Dean of Science.

MEMBERS



Dr. Paul Brumer
Professor, Department of Chemistry, Faculty of Arts and Science, University of Toronto

Dr. Brumer joined University of Toronto in 1975 after completing his BSc at Brooklyn College and his PhD at Harvard University and was appointed a University Professor in 1995. Dr. Brumer has been at the forefront of two major areas in chemical physics: using nonlinear mechanics to understand molecular dynamics, and controlling chemical reactions with lasers.

Dr. Brumer's work has been recognized in numerous ways. He has been an A.P. Sloan Foundation Fellow and is a Fellow of the Royal Society of Canada, the Chemical Institute of Canada and the American Physical Society. He has received two Canada Council Killam Research Fellowships and is one of the youngest recipients of the CIC Palladium Medal, the highest award of the Chemical Institute of Canada. He was the recipient of the prestigious 2000 Killam Memorial Prize in Physical Sciences and is currently both a Distinguished University Professor and the Roel Buck Chair in Chemical Physics at the University of Toronto.

Dr. Jim Haslett
Professor, Department of Electrical and Computer Engineering, University of Calgary

Dr. Haslett holds the position of "University Professor" and is also a Professor in the Department of Electrical and Computer Engineering at the University of Calgary. He has been an academic staff member at the University of Calgary for the past 39 years, and was the Head of the Department from 1986 to 1997.

Dr. Haslett is currently the Principal Investigator of the iCORE-funded Advanced Technology Information Processing Systems (ATIPS) Lab at the University of Calgary. He held the TRLabs/iCORE/NSERC Senior Industrial Research Chair in Wireless Communications from 2002 to 2007, building a team of researchers specializing in radio frequency integrated circuit (RFIC) design for wireless communications applications. He has published over 200 papers in peer-reviewed journals and conference proceedings, and holds 12 patents, many of which have been licensed to industry. He has graduated over 40 MSc and PhD students during his career.

Dr. Haslett is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), a Fellow of the Engineering Institute of Canada, and a Fellow of the Canadian Academy of Engineering. He and his students have won numerous national and international awards for their research work. He is currently a member of the Editorial Review Committees of five IEEE Transactions, is a member of several technical and executive committees of international IEEE Conferences, and is also a member of the provincial iCORE internal review committee which establishes research chair programs in Alberta.

Professor Sir Peter Knight
Principal, Faculty of Natural Sciences, Imperial College London

Professor Sir Peter Knight is Senior Principal at Imperial College, London U.K., and is past Head of Imperial's Department of Physics. He is a past President of the Optical Society of America and a past Chair of the European Physical Society's Quantum Electronics and Optics Division, and has been Chief Scientific Advisor to the UK National Physical Laboratory. He is chair of the UK Government Defence Scientific Advisory Committee.

Professor Sir Peter Knight is renowned for research in quantum optics, strong field physics, and quantum information and is widely recognized for both his research and communication abilities and achievements, including having been a Parsons Memorial Lecturer in 1991 and Wood Memorial Lecturer in 1996, winner of the Thomas Young Medal and Prize in 1999 and joint winner of the Einstein Medal and Prize for Laser Science of the Society of Optical and Quantum Electronics and Eastman Kodak in 1996. He is the 2008 winner of the Optical Society of America's Ives Medal.

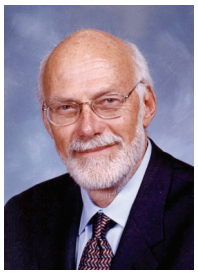
Dr. Greg Luoma
President, LuomaTech Inc.

Dr. Luoma has over 25 years of experience conducting, managing, and directing large and diverse technology development programs in defence and public security. He also has internationally recognized technical expertise in defence against Weapons of Mass Destruction, in advanced materials and analytical chemistry. He has published extensively in the open literature, has represented the Canadian government and GD Canada on numerous international technical panels, and has been an invited speaker at many international technical conferences and military symposia. Dr. Luoma holds BSc, MSc and PhD degrees in Chemistry from the University of British Columbia.

In January 2009, Dr. Luoma initiated his own company, LuomaTech Inc., to provide technical and strategic business consulting services to Defence and security organizations.

From 2004 to 2008, Dr. Luoma served as Chief Technology Officer for GD Canada, successfully re-inventing the company's technology strategy as well as maintaining oversight for all R&D. His leadership contributed to revenue growth exceeding 15% per year and new business opportunities exceeding $100M. He also revamped the process for SRED tax credit reporting, generating a high level of credibility with Revenue Canada and >$10M in tax credits per year. From 1998 to 2004, Dr. Luoma held positions at GD Canada as Director of R&D and Chief Scientist, successfully aligning internal R&D with business goals. He also led efforts to commercialize biodetection technology which successfully captured over $60M of new business for GD Canada.

From 1992 to 1998, Dr. Luoma served as Section Head, Chemical and Biological Defence, at Defence Research and Development Canada (DRDC) Suffield where he led a team of 40 scientists in developing defensive systems against chemical and biological weapons. A number of those systems and solutions were transitioned to industry during his tenure to become successful products in international defence markets, including a world leading biodetection system that Dr. Luoma personally developed. Prior to his term at DRDC Suffield, he was a Group Leader at the Defence Research Establishment Pacific, leading a group providing analytical chemistry support to the Canadian Navy in Victoria while conducting research into the use of advanced materials in military platforms.



Dr. Brian Unger
Professor, Department of Computer Science, University of Calgary

Dr. Unger is currently Interim President and CEO of Cybera Inc. (www.cybera.ca). He is also Professor Emeritus and the Executive Director of the Grid Research Centre at the University of Calgary. Dr. Unger is the Special Advisor for iREACH ("informatics for rural empowerment and community health"), a research project supported by the International Development Research Centre of Canada (IDRC) and by the Cambodian Ministry of Commerce (ireach.org.kh). He was the founding President of the Netera Alliance that is now Cybera Inc. and the founding President of iCORE from 1999 through 2004.

Dr. Unger was the founding board chair of C3.ca Inc., a national consortium aimed at building Canada's infrastructure in high performance computation. C3.ca was one of the originators of the current Compute Canada initiative. He was a Co-Principal Investigator of WestGrid (www.westgrid.ca) from 2002 to 2008, which raised $48 million to provide research infrastructure for Western Canadian universities. He was the founding president and CEO of a for-profit startup company, Jade Simulations, that developed and marketed parallel simulation software products from 1988 through 1993.

Dr. Unger was named a Canada Pioneer of Computing at the IBM CASCON conference in Toronto in October 2005, and received the IWAY Public Leadership award for outstanding contributions to Canada's information society in 2004, and the 1993 ASTech award for "Innovation in Alberta Technology" for research in parallel simulation and distributed computation.

DIRECTOR

Dr. Barry C. Sanders
iCORE Chair of Quantum Information Science

Dr. Barry Sanders is iCORE Chair of Quantum Information Science and Director of the Institute for Quantum Information Science at the University of Calgary. He received his Bachelor of Science degree from the University of Calgary in 1984 and then completed a Diploma of Imperial College under the supervisor of Professor T. W. B. Kibble. Subsequently he completed a PhD at Imperial College under the supervision of Professor Sir Peter Knight at Imperial College. Following completion of the PhD in 1987, he was a postdoctoral research fellow under the supervision of Professor Gerard Milburn, first at the Australian National University and then at the University of Queensland, and also under the supervision of Professor Crispin Gardiner who was then at the University of Waikato.

Dr. Sanders is especially well known for seminal contributions to theories of quantum-limited measurement, highly nonclassical light, practical quantum cryptography, and optical implementations of quantum information tasks. His current research interests include quantum resources and algorithms and also optical and atomic implementations of quantum information tasks and protocols. Recently Dr. Sanders has developed research activities in quantum processes in biological systems and also on machine learning approaches to quantum control.

Dr. Sanders is a Fellow of the Institute of Physics (U.K.), the Optical Society of America, the Australian Institute of Physics, and the American Physical Society. He is a past President of the Australian Optical Society, former Secretary-Treasurer of the American Physical Society Topical Group on Quantum Information, Chair of the Canadian Association of Physicists Division of Atomic and Molecular Physics and Photonic Interactions, a member of the American Institute of Physics Education Advisory Committee, and an editorial board member for Physical Review A, New Journal of Physics, Optics Communications, and Applied Mathematics and Information Sciences. He also serves the Optical Society of America as Leader of the Quantum Optical Science and Technology Technical Group. In addition, Dr. Sanders serves on numerous conference committees for the American Physical Society, the International Society for Optical Engineering (SPIE), the Optical Society of America, and international quantum information conferences.

IV Performance & Analysis

A. Research and Development

1. Refereed publications

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A. Kamli, S. A. Moiseev and B. C. Sanders, "Coherent control of low loss surface polaritons", *Physical Review Letters* **101**(26): 263601 (4 pp.), 22 December 2008. (Selected for the January 2009 issue of Virtual Journal of Ultrafast Science).

R. Karasik, K.-P. Marzlin, B. C. Sanders and K. B. Whaley, "Criteria for dynamically stable decoherence-free subspaces and incoherently generated coherences", *Physical Review A* **77**(5): 052301 (12 pp.), 1 May 2008. (Selected for the May 2008 issue of Virtual Journal of Quantum Information) .

J. S. Kim, A. Das and B. C. Sanders, "Entanglement monogamy of multipartite higher-dimensional quantum systems using convex-roof extended negativity", *Physical Review A* **79**(1): 012329 (7 pp.), 30 January 2009. (Selected for the February 2009 Virtual Journal of Quantum Information).

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2. Professional magazines

N. S. Babcock, "Quantum theory at burning man", *The Quantum Times* **3**(2), 1 – 3, 22 September 2008.

B. C. Sanders, "In the quantum world, seeing is understanding", *Reach Magazine* **9**(1): 4 – 7, 1 February 2009.

B. C. Sanders, "Science without borders", *Physics Today* **61**(5): 51 – 52, 5 May 2008.

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3. Books

None.

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G. Campbell, C. Healey, J. Appel, K.-P. Marzlin and A. I. Lvovsky, "Generation of squeezed vacuum states via polarization self-rotation", Proceedings of Quantum Communication, Measurement and Computing (QCMC 2008) **1110**, University of Calgary, Alberta, Canada, 19 Aug 2008 – 24 Aug 2008, Published by American Institute of Physics Inc., Melville, United States of America: 173 – 176, 21 March 2009.

S. Ghose, N. Sinclair, S. Debnath and A. Kabra, "Analysis of a tripartite Bell inequality for 3-qubit states", Proceedings of Quantum Communication, Measurement and Computing (QCMC 2008) **1110**, University of Calgary, Alberta, Canada, 19 Aug 2008 – 24 Aug 2008, Published by American Institute of Physics Inc., Melville, United States of America: 95 – 98, 21 March 2009.

E. Figueroa, J. Appel, C. Kupchak, M. Lobino, D. Korystov and A. I. Lvovsky, "Electromagnetically-induced transparency and squeezed light", Proceedings of Quantum Communication, Measurement and Computing (QCMC 2008) **1110**, University of Calgary, Alberta, Canada, 19 Aug 2008 – 24 Aug 2008, Published by American Institute of Physics Inc., Melville, United States of America: 249 – 252, 21 March 2009.

N. Jain, S.-H. Youn and A. I. Lvovsky, "Quantum tomography of the single-photon state generated by down conversion in a periodically poled KTP crystal", Proceedings of Quantum Communication, Measurement and Computing (QCMC 2008) **1110**, University of Calgary, Alberta, Canada, 19 Aug 2008 – 24 Aug 2008, Published by American Institute of Physics Inc., Melville, United States of America: 201 – 204, 21 March 2009.

R. Karasik, K.-P. Marzlin, B. C. Sanders and K. B. Whaley, "Incoherently generated coherences", Proceedings of Quantum Communication, Measurement and Computing (QCMC 2008) **1110**, University of Calgary, Alberta, Canada, 19 Aug 2008 – 24 Aug 2008, Published by American Institute of Physics Inc., Melville, United States of America: 33 – 36, 21 March 2009.

K. Kuntz, B. Braverman, S.-H. Youn, M. Lobino, E. M. Pessina and A. I. Lvovsky, "Spatial and temporal characterization of a Bessel beam produced using a conical mirror", Proceedings of Quantum Communication, Measurement and Computing (QCMC 2008) **1110**, University of Calgary, Alberta, Canada, 19 Aug 2008 – 24 Aug 2008, Published by American Institute of Physics Inc., Melville, United States of America: 291 – 294, 21 March 2009.

M. Lobino, D. Korystov, C. Kupchak, E. Figueroa, B. C. Sanders and A. I. Lvovsky, "Coherent-state quantum process tomography", Proceedings of Quantum Communication, Measurement and Computing (QCMC 2008)**1110**, University of Calgary, Alberta, Canada, 19 Aug 2008 – 24 Aug 2008, Published by American Institute of Physics Inc., Melville, United States of America: 447 – 450, 21 March 2009.

A. MacRae, G. Campbell, A. Ordog and A. I. Lvovsky, "Simultaneous slow light pulses with matched group velocities via double-EIT", Proceedings of Quantum Communication, Measurement and Computing (QCMC 2008) **1110**, University of Calgary, Alberta, Canada, 19 Aug 2008 – 24 Aug 2008, Published by American Institute of Physics Inc., Melville, United States of America: 269 – 272, 21 March 2009.

R. Ursin, T. Jennewein, J. Kofler, J. M. Perdigues, L. Cacciapuoti, C. J. de Matos, M. Aspelmeyer, A. Valencia, T. Scheidl, A. Fedrizzi, A. Acin, C. Barbieri, G. Bianco, C. Brukner, J. Capmany, S. Cova, D. Giggenbach, W. Leeb, R. H. Hadfield, R. Laflamme, N. Lutkenhaus, G. Milburn, M. Peev, T. Ralph, J. Rarity, R. Renner, E. Samain, N. Solomos, W. Tittel, J. P. Torres, M. Toyoshima, A. Ortigosa-Blanch, V. Pruneri, P. Villoresi, I. Walmsley, G. Weihs, H. Weinfurter, M. Zukowski, A. Zeilinger, "Space-QUEST: Experiments with quantum entanglement in space", Proceedings of the 59th International Astronautical Congress (IAC) 2008, Glasgow, United Kingdom, 29 Sept – 3 Oct 2008.

5. Patents

None.

6. Presentations (presenter is underlined)

1 Apr 2008, B. C. Sanders, P. Xue and A. Blais, "Quantum walks on circles in phase space via cavity or circuit quantum electrodynamics", University of Southern California, Quantum Information and Condensed Matter Physics Seminar.

7 Apr 2008, B. C. Sanders, P. Xue and A. Blais, "Quantum walks on circles in phase space via cavity or circuit quantum electrodynamics", University of Maryland, Department of Physics.

10 Apr 2008, W. Tittel and S. Hosier, "The QC2-Lab: Applied research for real-world applications" (invited), Southern Alberta Intellectual Property Network – Annual Conference, Calgary, Canada, 10 Apr 2008.

18 Apr 2008, D. L. Feder, "Implementing a spectral transform with ultrabold atoms in optical lattices", CIFAR Ultracold Matter Meeting, Banff, Canada, 18 Apr 2008.

20 Apr 2008, K.-P. Marzlin, I. Mahmoud and B. C. Sanders, "Atomic many-body effects in the propagation of slow light through atomic gases" (invited), Cold Atoms, Banff, Canada, 17 Apr 2008 – 20 Apr 2008.

23 Apr 2008, P. Xue and Y. F. Xiao, "Universal quantum computation in deocoherence-free subspace with neutral atoms", National University of Defense Technology, Department of Physics.

24 Apr 2008, P. Xue, B. C. Sanders, A. Blais and K. Lalumière, "Quantum walks on circles in phase space via superconducting circuit QED", National University of Defense Technology, Department of Physics.

28 Apr 2008, P. Xue and B. C. Sanders, "Quantum walks on circles in phase space", University of Science and Technology of China, Key Lab of Quantum Information, CAS.

2 May 2008, G. Gour, "A few open problems in quantum information" (invited), North-South Dialogue on Mathematics, University of Calgary, Canada, 2 May 2008 – 3 May 2008.

3 May 2008, P. Xue and B. C. Sanders, "Quantum walks on circles in phase space", Tsinghua University, Department of Physics.

5 May 2008, A. I. Lvovsky, "Memory for light and quantum communication", University of Vienna, Department of Electrical Engineering.

5 May 2008, P. Xue and B. C. Sanders, "Quantum walks on circles in phase space", Fujian Normal University, Department of Physics.

22 May 2008, M. Lobino, J. Appel, E. Figueroa, D. Korystov and A. I. Lvovsky, "Electromagnetically induced transparency and squeezed light" (invited), 4th Workshop ad Memoriam of Carlo Novero: Advances in Foundations of Quantum Mechanics and Quantum Information with atom and photons, Turin, Italy, 19 May 2008 – 23 May 2008.

27 May 2008, B. C. Sanders, "Quantum walks on circles in phase space via cavity or circuit quantum electrodynamics" (contributed), 4th Workshop ad Memoriam of Carlo Novero: Advances in Foundations of Quantum Mechanics and Quantum Information with atom and photons, Turin, Italy, 19 May 2008 – 23 May 2008.

29 May 2008, R. Karasik, K.-P. Marzlin, B. C. Sanders and K. B. Whaley, "Multi-particle decoherence free subspaces in extended systems" (contributed), K5.00009, 39th Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics (DAMOP 2008), State College, United States of America, 27 May 2008 – 31 May 2008.

29 May 2008, B. C. Sanders, R. Karasik, K.-P. Marzlin and K. B. Whaley, "Incoherently generated coherence and immunity to decoherence" (contributed), K5.00008, 39th Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics (DAMOP 2008), State College, United States of America, 27 May 2008 – 31 May 2008.

30 May 2008, J. J. Choquette, K.-P. Marzlin and B. C. Sanders, "Collective excitation of surface plasmons by a linear dipole array" (contributed), R1.00072, 39th Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics (DAMOP 2008), State College, United States of America, 27 May 2008 – 31 May 2008.

30 May 2008, A. I. Lvovsky, "Storage of squeezed light as a step towards universal quantum memory" (invited), O2.00003, 39th Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics (DAMOP 2008), State College, United States of America, 27 May 2008 – 31 May 2008.

30 May 2008, A. MacRae, G. Campbell and A. I. Lvovsky, "Demonstration of double electromagnetically induced transparency in a hot atomic vapour" (contributed), P5.00011, 39th Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics (DAMOP 2008), State College, United States of America, 27 May 2008 – 31 May 2008.

30 May 2008, A. MacRae, G. Campbell, Z.-B. Wang, K.-P. Marzlin, B. C. Sanders and A. I. Lvovsky, "Giant optical nonlinearities between two matched pulses" (poster), R1.00073, 39th Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics (DAMOP 2008), State College, United States of America, 27 May 2008 – 31 May 2008.

2 Jun 2008, K.-P. Marzlin, "Slow light and its application in quantum information", University of Saskatchewan, Department of Physics and Engineering Physics.

5 Jun 2008, B. C. Sanders, "Time-ordered decompositions of exponential operators generated by time-dependent Hamiltonians", Theory Canada 4, Montréal, Canada, 4 Jun 2008 – 7 Jun 2008.

5 Jun 2008, F. Bussières, N. Godbout, J. Jin, S. Lacroix, J. Nguyen, J. A. Slater, Y. Soudagar, T. Stuart and W. Tittel, "A quantum tale of two different yet inseparable photons" (poster, contributed), The Third QuantumWorks Annual General Meeting , Montréal, Canada, 5 Jun 2008 – 6 Jun 2008.

5 Jun 2008, I. Lucio Martinez, P. Chan, S. Hosier, M. Xiaofan and W. Tittel, "Towards fast quantum secured communication" (poster), The Third QuantumWorks Annual General Meeting , Montréal, Canada, 5 Jun 2008 – 6 Jun 2008.

9 Jun 2008, F. Bussières, J. A. Slater, Y. Soudagar, S. Lacroix, N. Godbout and W. Tittel, "A quantum tale of different, yet inseparable photons" (poster), Physics in Canada 64(2):139, Canadian Association of Physicists Congress (CAP 2008), Laval University, Quebec City, Canada, 8 Jun 2008 – 11 Jun 2008.

9 Jun 2008, P. Høyer, "Grover's algorithm" (invited), The Eighth Canadian Summer School on Quantum Information, Montréal, Canada, 9 Jun 2008 – 13 Jun 2008.

9 Jun 2008, P. Høyer, "Lower bounds on quantum searching" (invited), The Eighth Canadian Summer School on Quantum Information, Montréal, Canada, 9 Jun 2008 – 13 Jun 2008.

9 Jun 2008, P. Høyer, "Quantum searching" (invited), The Eighth Canadian Summer School on Quantum Information, Montréal, Canada, 9 Jun 2008 – 13 Jun 2008.

10 Jun 2008, A. Delfan, C. La Mela, E. Saglamyurek and W. Tittel, "Data manipulation via photon echo" (contributed), Physics in Canada 64(2):96, Canadian Association of Physicists Congress (CAP 2008), Laval University, Quebec City, Canada, 8 Jun 2008 – 11 Jun 2008.

10 Jun 2008, B. C. Sanders, R. Karasik, K.-P. Marzlin and K. B. Whaley, "Escaping decoherence" (contributed), Physics in Canada 64(2):96, Canadian Association of Physicists Congress (CAP 2008), Laval University, Quebec City, Canada, 8 Jun 2008 – 11 Jun 2008.

10 Jun 2008, J. A. Slater, F. Bussières, Y. Soudagar, S. Lacroix, N. Godbout and W. Tittel, "A simple method to characterize a synchronous heralded single photon source" (contributed), Physics in Canada 64(2):96, Canadian Association of Physicists Congress (CAP 2008), Laval University, Quebec City, Canada, 8 Jun 2008 – 11 Jun 2008.

11 Jun 2008, P. Chan, I. Lucio Martinez, X. F. Mo and W. Tittel, "Towards fast error correction for quantum key distribution" (contributed), Physics in Canada 64(2):135, Canadian Association of Physicists Congress (CAP 2008), Laval University, Quebec City, Canada, 8 Jun 2008 – 11 Jun 2008.

11 Jun 2008, A. I. Lvovsky, "Quantum memory for continuous-variable optical states" (invited), Physics in Canada 64(2): 134, Canadian Association of Physicists Congress (CAP 2008), Laval University, Quebec City, Canada, 8 Jun 2008 – 11 Jun 2008.

11 Jun 2008, A. MacRae, G. Campbell, K.-P. Marzlin and A. I. Lvovsky, "Double electromagnetically-induced transparency in rubidium vapor" (contributed), Physics in Canada 64(2): 135, Canadian Association of Physicists Congress (CAP 2008), Laval University, Quebec City, Canada, 8 Jun 2008 – 11 Jun 2008.

11 Jun 2008, I. Lucio Martinez, X. F. Mo, P. Chan, S. Hosier and W. Tittel, "Combining quantum key distribution and internetworking over a 12 km real-world fibre link" (contributed), Physics in Canada 64(2):136, Canadian Association of Physicists Congress (CAP 2008), Laval University, Quebec City, Canada, 8 Jun 2008 – 11 Jun 2008.

11 Jun 2008, E. Saglamyurek, A. Delfan, N. Sinclair, C. La Mela and W. Tittel, "Towards quantum memory" (contributed), Physics in Canada 64(2):135, Canadian Association of Physicists Congress (CAP 2008), Laval University, Quebec City, Canada, 8 Jun 2008 – 11 Jun 2008.

11 Jun 2008, P. Xue, B. C. Sanders, A. Blais and K. Lalumière, "Quantum walks on circles in phase space via cavity or circuit quantum electrodynamics" (contributed), Physics in Canada 64(2):135, Canadian Association of Physicists Congress (CAP 2008), Laval University, Quebec City, Canada, 8 Jun 2008 – 11 Jun 2008.

12 Jun 2008, B. C. Sanders, "Quantum optics implementations I" (invited), The Eighth Canadian Summer School on Quantum Information, Montréal, Canada, 9 Jun 2008 – 13 Jun 2008.

12 Jun 2008, B. C. Sanders, "Quantum optics implementations II" (invited), The Eighth Canadian Summer School on Quantum Information, Montréal, Canada, 9 Jun 2008 – 13 Jun 2008.

16 Jun 2008, A. Roy, "Quantum state tomography and 2-designs" (invited), 2008 SIAM Conference on Discrete Mathematics, Burlington, United States of America, 16 Jun 2008 – 19 Jun 2008.

17 Jun 2008, N. S. Babcock, A. de la Lande, D. Salahub and B. C. Sanders, "Coherent & incoherent electron transfer in biological systems", 5th Canadian Quantum Information Students' Conference, Université de Montréal, Montréal, Canada, 15 Jun 2008 – 21 Jun 2008 (awarded best talk).

19 Jun 2008, A. Hentschel and B. C. Sanders, "Artificial intelligence in a quantum world" (contributed), 5th Canadian Quantum Information Students' Conference, Université de Montréal, Montréal, Canada, 16 Jun 2008 – 21 Jun 2008.

30 Jun 2008, A. I. Lvovsky, J. Appel, E. Figueroa, D. Korystov and M. Lobino, "Electromagnetically-induced transparency for quantum optical information processing" (invited), International Laser Physics Workshop (LPHYS'08), Trondheim, Norway, 30 Jun 2008 – 4 Jul 2008.

1 Jul 2008, B. C. Sanders, Z.-B. Wang, K.-P. Marzlin and S. A. Moiseev, "Giant cross-phase modulation for two slowed co-propagating pulses" (invited), International Laser Physics Workshop (LPHYS'08), Trondheim, Norway, 30 Jun 2008 – 4 Jul 2008.

2 Jul 2008, A. Delfan, C. La Mela, M. Underwood, K.-P. Marzlin, S. A. Moiseev and W. Tittel, "Combining quantum memory with state manipulation" (invited), International Laser Physics Workshop (LPHYS'08), Trondheim, Norway, 30 Jun 2008 – 4 Jul 2008.

3 Jul 2008, A. I. Lvovsky, J. Appel, E. Figueroa, D. Korystov and M. Lobino, "Quantum memory for squeezed light" (invited), International Laser Physics Workshop (LPHYS'08), Trondheim, Norway, 30 Jun 2008 – 4 Jul 2008.

4 Jul 2008, S. A. Moiseev, "Raman-echo-quantum memory" (invited), International Laser Physics Workshop (LPHYS'08), Trondheim, Norway, 30 Jun 2008 – 4 Jul 2008.

8 Jul 2008, A. Roy and A. J. Scott, "Unitary t-designs" (contributed), Conference on Algebraic Aspects of Association Schemes and Scheme Rings, Regina, Canada, 8 Jul 2008 – 11 Jul 2008.

8 Jul 2008, M. Skotiniotis, A. Roy and B. C. Sanders, "On the epistemic view: strengths and weaknesses of Spekkens' toy theory", Perimeter Institute for Theoretical Physics, Foundation of Quantum Mechanics Seminar Series.

14 Jul 2008, A. Kamli, S. A. Moiseev and B. C. Sanders, "Surface polariton-polariton induced transparency in left-handed materials" (contributed), 3rd International Conference on Quantum Information (ICQI 2008), Boston, United States of America, 13 Jul 2008 – 16 Jul 2008.

16 Jul 2008, A. I. Lvovsky, "Electromagnetically-induced transparency with squeezed light" (invited), 3rd International Conference on Quantum Information (ICQI 2008), Boston, United States of America, 13 Jul 2008 – 16 Jul 2008.

29 Jul 2008, B. C. Sanders, "Simulating Hamiltonian evolution on a quantum computer" (invited), Frontiers of Quantum and Mesoscopic Thermodynamics (FQMT08), Prague, Czech Republic, 28 Jul 2008 – 2 Aug 2008.

12 Aug 2008, E. Figueroa, J. Appel, D. Korystov, M. Lobino and A. I. Lvovsky, "Interfacing quantum light with atoms using electromagnetically-induced transparency" (invited), SPIE Optics and Photonics (QCQI 2008), San Diego, United States of America, 10 Aug 2008 – 14 Aug 2008.

12 Aug 2008, A. Hentschel and B. C. Sanders, "Learned feedback control mechanisms for a quantum system", University of Alberta, Alberta Ingenuity Centre for Machine Learning.

13 Aug 2008, A. I. Lvovsky, "Memory for light and quantum communication" (invited), Banff Science Communications Workshop, Banff, Canada, 10 Aug 2008 – 23 Oct 2008.

19 Aug 2008, G. Berlin, G. Brassard, F. Bussières and N. Godbout, "A fair loss-tolerant quantum coin flipping protocol" (poster, contributed, refereed), Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

20 Aug 2008, F. Bussières, J. A. Slater, N. Godbout and W. Tittel, "Hybrid entanglement for quantum communication" (poster, contributed, refereed), P1-42, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

20 Aug 2008, E. Figueroa, J. Appel, D. Korystov, M. Lobino, C. Kupchak and A. I. Lvovsky, "Electromagnetically-induced transparency and squeezed light" (poster), P1-30, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

20 Aug 2008, J. S. Kim and B. C. Sanders, "Generalized W-class state and its monogamy relation" (poster), P1-71, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

20 Aug 2008, D. P. Chi, J. W. Choi, G. Jeong, J. S. Kim, T. Kim and S. Lee, "Monogamy equality in $2 \otimes 2 \otimes d$ quantum systems" (poster), P1-70, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

20 Aug 2008, D. Markham, A. Roy and B. C. Sanders, "Secret sharing using graph states" (poster), P1-81, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

20 Aug 2008, B. T. Semnani and G. Gour, "Superselection rule-resource theory in the presence of partial prior knowledge" (poster), P1-86, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

20 Aug 2008, C. Wang, B. C. Sanders, P. Xue and W. P. Zhang, "Measurement of a charge qubit with a nanocantilever" (poster), P1-3, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

20 Aug 2008, P. Xue, B. C. Sanders, A. Blais and K. Lalumière, "Quantum walks on circles in phase space via superconducting circuit QED" (poster), P1-20, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

21 Aug 2008, J. J. Choquette, K.-P. Marzlin, R. Stock and B. C. Sanders, "Cooperative emission into surface plasmons" (poster), P2-6, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

21 Aug 2008, R. Karasik, K.-P. Marzlin, B. C. Sanders and K. B. Whaley, "Decoherence free subspaces and incoherently generated coherences" (poster), P2-60, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

21 Aug 2008, K. Kuntz, B. Braverman, M. Lobino and A. I. Lvovsky, "Spatial and temporal characterization of a Bessel beam produced using a conical mirror" (poster), P2-36, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

21 Aug 2008, C. La Mela, A. Delfan and W. Tittel, "Non-orthogonal state discrimination in a photon echo based optical memory" (poster), P2-57, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

21 Aug 2008, M. Lobino, E. Figueroa, D. Korystov, C. Kupchak, B. C. Sanders and A. I. Lvovsky, "Coherent states characterization of quantum-optical processes" (poster), P2-26, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

21 Aug 2008, S. A. Moiseev, A. Kamli and B. C. Sanders, "Control of slow surface polaritons in left-handed materials" (poster), P2-42, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

21 Aug 2008, S. A. Moiseev and W. Tittel, "Quantum compression and decompression of light pulses based on photon echo with generalized CRIB" (poster), P2-2, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

21 Aug 2008, Y. R. Sanders and G. Gour, "Concurrence monotones as conditions for entanglement catalysis" (poster), P2-73, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

21 Aug 2008, M. Skotiniotis, G. Gour, A. Roy and B. C. Sanders, "A contextual toy model" (poster), P2-85, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

21 Aug 2008, M. Underwood, K.-P. Marzlin, S. A. Moiseev and W. Tittel, "Adapting CRIB-based memories to photon state manipulation" (poster), P2-59, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

23 Aug 2008, G. Howard and B. C. Sanders, "Entanglement swapping with imperfect sources and detectors" (poster), P3-14, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

23 Aug 2008, S.-H. Youn, N. Jain and A. I. Lvovsky, "Quantum tomography of the single photon state generated by down-conversion in a periodically poled KTP crystal" (poster), P3-25, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

23 Aug 2008, J. Joo, A. Laing, T. Rudolph and J. L. O'Brien, "Bell's inequality test with an optical two-qutrit entangled state" (poster), P3-15, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

23 Aug 2008, D. P. Chi, J. W. Choi, J. S. Kim, T. Kim and S. Lee, "Quantum states for perfectly secure secret sharing" (poster), P3-49, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

23 Aug 2008, A. MacRae, G. Campbell, A. Ordog, Z.-B. Wang, B. C. Sanders, K.-P. Marzlin and A. I. Lvovsky, "Towards giant optical nonlinearities using double electromagnetically induced transparency" (poster), P3-36, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

23 Aug 2008, I. Mahmoud, K.-P. Marzlin and B. C. Sanders, "Refractive index of driven dense atomic gases" (poster), P3-35, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

23 Aug 2008, I. Lucio Martinez, P. Chan, X. F. Mo, S. Hosier and W. Tittel, "Towards GHz clocked QKD for telecommunication networks" (poster), P3-7, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

23 Aug 2008, A. Roy, M. Rötteler and C. Godsil, "Quantum state tomography using two-outcome measurements" (poster), P3-59, Quantum Communication, Measurement and

Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

23 Aug 2008, B. C. Sanders, "Quantum information science in Calgary" (invited), The 2008 iCORE Summit, Banff, Canada, 21 Aug 2008 – 23 Aug 2008.

23 Aug 2008, S. Ghose and N. Sinclair, "Tripartite entanglement and nonlocality in 3-qubit states" (poster, contributed, refereed), Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

23 Aug 2008, W. Tittel, "Research exchange on quantum cryptography" (contributed), The 2008 iCORE Summit, Banff, Canada, 21 Aug 2008 – 23 Aug 2008.

23 Aug 2008, Z.-B. Wang, K.-P. Marzlin, S. A. Moiseev and B. C. Sanders, "Giant cross-phase modulation in double electromagnetically induced transparency and its applications" (poster), P3-34, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

23 Aug 2008, N. Wiebe, D. W. Berry, P. Høyer and B. C. Sanders, "Quantum computer simulation of time dependent Hamiltonians" (poster), P3-55, Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

24 Aug 2008, G. Gour, R. W. Spekkens, B. C. Sanders and P. S. Turner, "Resource theories, SU(2) super selection rule, and time inversion" (contributed), Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

24 Aug 2008, P. Høyer, "What quantum computers cannot do" (invited), Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

24 Aug 2008, R. W. Spekkens and G. Gour, "The resource theory of quantum reference frames" (invited), Quantum Communication, Measurement and Computing (QCMC 2008), University of Calgary, Calgary, Canada, 19 Aug 2008 – 24 Aug 2008.

26 Aug 2008, M. Lobino, E. Figueroa, D. Korystov, C. Kupchak, B. C. Sanders and A. I. Lvovsky, "A continuous-variable approach to process tomography" (invited), Quantum Estimation: Theory and Practice, Waterloo, Canada, 25 Aug 2008 – 30 Aug 2008.

27 Aug 2008, N. S. Babcock, "Quantum theory at mathcamp" (invited), Burning Man, Black Rock City, United States of America, 25 Aug 2008 – 1 Sep 2008.

27 Aug 2008, J. S. Kim and B. C. Sanders, "Generalized W-class state and its monogamy relation" (contributed), 8th Asian Conference on Quantum Information Science (AQIS08), Seoul, Republic of Korea , 25 Aug 2008 – 31 Aug 2008.

28 Aug 2008, J. Joo, T. Rudolph and B. C. Sanders, "Non-locality tests for an optical two-qudit state" (contributed), 8th Asian Conference on Quantum Information Science (AQIS08), Seoul, Republic of Korea, 25 Aug 2008 – 31 Aug 2008.

28 Aug 2008, D. P. Chi, J. W. Choi, J. S. Kim, T. Kim and S. Lee, "Quantum states for perfectly secure secret sharing" (poster), 8th Asian Conference on Quantum Information Science (AQIS08), Seoul, Republic of Korea, 25 Aug 2008 – 31 Aug 2008.

30 Aug 2008, D. P. Chi, J. W. Choi, G. Jeong, J. S. Kim, T. Kim and S. Lee, "Monogamy of entanglement in $2 \otimes 2 \otimes d$ quantum systems" (contributed), 8th Asian Conference on Quantum Information Science (AQIS08), Seoul, Republic of Korea, 25 Aug 2008 – 31 Aug 2008.

2 Sep 2008, J. S. Kim, "Monogamy of entanglement", Seoul National University, Department of Mathematical Science.

3 Sep 2008, J. Joo, "Quantum computation in optical lattices", Seoul National University, Department of Physics.

9 Sep 2008, J. Joo, "Teleportation on optical qutrits", Sogang University, Department of Physics.

11 Sep 2008, A. I. Lvovsky, "Towards a universal light storage machine", University of Toronto, Department of Physics.

12 Sep 2008, J. Joo, "One-way quantum computation with quantum error-correcting code", Korea Institute for Advanced Studies, Computer Science School.

12 Sep 2008, P. Xue, B. C. Sanders, A. Blais and K. Lalumière, "Quantum walks on circles in phase space via superconducting circuit QED", University of Toronto, Department of Physics.

24 Sep 2008, A. I. Lvovsky, "Quantum information with atoms and photons" (invited), International Iran Summer School on Quantum Information (IISSQI 2008), Kish, Islamic Republic of Iran, 13 Sep 2008 – 27 Sep 2008.

26 Sep 2008, W. Tittel, "Quantum cryptography", University of Alberta, Faculty of Engineering.

28 Sep 2008, B. C. Sanders, "Quantum walking via superconducting circuit quantum electrodynamics", Sharif University of Technology, Department of Physics.

6 Oct 2008, B. C. Sanders, "Algorithms for quantum simulation" (keynote, invited), NATO Advanced Research Workshop: Recent Advances in Nonlinear Dynamics and Complex System Physics: From Natural to Social Sciences and Security (RAND&CSP'08), Tashkent, Republic of Uzbekistan, 6 Oct 2008 – 11 Oct 2008.

8 Oct 2008, I. Lucio Martinez, P. Chan, M. Xiaofan, S. Hosier and W. Tittel, "Towards fast quantum key distribution with quantum frames" (poster), SECOQC International Conference, Vienna, Austria, 8 Oct 2008 – 12 Oct 2008.

24 Oct 2008, B. C. Sanders, "Oracle identification problem and a Deutsch-Josza type of algorithm for 'continuous variable' quantum information" (invited), Quantum Information

Science Scotland (QUISCO), St. Andrews, United Kingdom, 24 Oct 2008.

12 Nov 2008, A. I. Lvovsky, "Quantum refrigerator for light", Massachusetts Institute of Technology, Optics and Quantum Electronics Seminar.

12 Nov 2008, B. C. Sanders, "Efficient algorithm for quantum simulation" (invited), International Conference on Recent Trends in Mathematical Sciences (ICRMS 2008), Kingdom of Bahrain, 10 Nov 2008 – 12 Nov 2008.

14 Nov 2008, A. I. Lvovsky, "How memory for light helps quantum communication", University of Manitoba, Department of Physics & Astronomy.

14 Nov 2008, A. I. Lvovsky, "Memory for light: why, how, when?", University of Winnipeg, Department of Physics.

15 Nov 2008, B. C. Sanders, "Towards quantum information processing on a silicon surface" (invited), CIFAR Nanoelectronics Meeting, Halifax, Canada, 13 Nov 2008 – 16 Nov 2008.

26 Nov 2008, A. I. Lvovsky, "Storage of light and quantum communication", University of Alberta, Department of Physics.

5 Jan 2009, M. Lobino, C. Kupchak, E. Figueroa and A. I. Lvovsky, "Process tomography of quantum-optical" (invited), Physics of Quantum Electronics (PQE 2009), Snowbird, United States of America, 4 Jan 2009 – 8 Jan 2009.

5 Jan 2009, B. C. Sanders, M. Lobino, D. Korystov, C. Kupchak, E. Figueroa and A. I. Lvovsky, "Complete characterization of quantum-optical processes" (plenary), Physics of Quantum Electronics (PQE 2009), Snowbird, United States of America, 4 Jan 2009 – 8 Jan 2009.

12 Jan 2009, N. S. Babcock, A. de la Lande, D. Salahub and B. C. Sanders, "Living quantum engines" (invited), First Workshop on Quantum Technology in Biological Systems, Singapore, 11 Jan 2009 – 16 Jan 2009.

14 Jan 2009, J. S. Kim, A. Das and B. C. Sanders, "Entanglement monogamy of multipartite higher-dimensional quantum systems using convex-roof extended negativity" (poster), The Twelfth Workshop on Quantum Information Processing (QIP 2009), Santa Fe, United States of America, 12 Jan 2009 – 16 Jan 2009.

14 Jan 2009, D. P. Chi, J. W. Choi, G. Jeong, J. S. Kim, T. Kim and S. Lee, "Monogamy equality in $2 \otimes 2 \otimes d$ quantum systems" (poster), The Twelfth Workshop on Quantum Information Processing (QIP 2009), Santa Fe, United States of America, 12 Jan 2009 – 16 Jan 2009.

14 Jan 2009, D. P. Chi, J. W. Choi, J. S. Kim, T. Kim and S. Lee, "Quantum states for perfectly secure secret sharing" (poster), The Twelfth Workshop on Quantum Information Processing (QIP 2009), Santa Fe, United States of America, 12 Jan 2009 – 16 Jan 2009.

17 Feb 2009, B. C. Sanders, "Towards an experimental realization of a quantum walk with a coin: Superconducting circuit quantum electrodynamics & trapped ion", University of Rochester, Department of Physics and Astronomy.

18 Feb 2009, N. S. Babcock, A. de la Lande, D. Salahub and B. C. Sanders, "Living quantum engines", University of Sydney, Quantum Information Theory @ Sydney.

18 Feb 2009, B. C. Sanders, "Quantum computing: animations and simulations", University of Rochester, Department of Physics & Astronomy.

20 Feb 2009, A. Scherer, G. Howard, B. C. Sanders and W. Tittel, "Quantum states prepared by practical entanglement swapping" (poster), 11th Anniversary SQuInT Annual Workshop, Seattle, United States of America, 19 Feb 2009 – 22 Feb 2009

25 Feb 2009, N. S. Babcock, A. de la Lande, D. Salahub and B. C. Sanders, "Living quantum engines", University of Queensland, Quantum Nanoscience Group.

4 Mar 2009, D. L. Feder, "Cooling ultracold bosons in optical lattices with quantum walks", École Polytechnique, Institut d'Optique.

16 Mar 2009, W. Tittel, "Photon-echo quantum memory", University of Waterloo, Institute for Quantum Computing.

25 Mar 2009, N. S. Babcock, A. de la Lande, D. Salahub and B. C. Sanders, "Bioelectric motors: bridging the gap", Universität Innsbruck, Institut für Theoretische Physik.

7. Collaborations

Institution	Location
Australian National University	Canberra, Australia
Centrum voor Wiskunde en Informatica Amsterdam, The Netherlands	Amsterdam, The Netherlands
Chonnam National University	Gwangju, Republic of Korea
East China Normal University	Shanghai, People's Republic of China
École Polytechnique Montréal	Montréal, Canada
Electronics and Telecommunications Research Institute	Daejeon, Republic of Korea
Imperial College London	London, United Kingdom
Indian Institute of Technology Bombay	Bombay, India
Indian Institute of Science Bangalore	Bangalore, India
Institute of Physics, Chinese Academy of Science	Beijing, People's Republic of China
Jaypee Institute of Information Technology	Noida, India
King Khalid University	Abha, Kingdom of Saudi Arabia
King Saud University	Riyadh, Kingdom of Saudi Arabia
Kyung Hee University	Seoul, Republic of Korea
Laboratoire Aimé Cotton	Paris, France
Laboratoire de Chimie de la Matière Condensée de Paris	Paris, France
Lund University	Lund, Kingdom of Sweden
Macquarie University	Sydney, Australia
Masaryk University	Brno, Czech Republic
Montana State University	Bozeman, United States of America
National Institute for Nanotechnology	Edmonton, Canada
Pirelli Labs	Milano, Italy
Seoul National University	Seoul, Republic of Korea
Southern Alberta Institute of Technology	Calgary, Canada
St. Francis Xavier University	Antigonish, Canada
The National Centre for Mathematics and Physics	Riyadh, Kingdom of Saudi Arabia
University of Bahrain	Kingdom of Bahrain
University of California at Berkeley	Berkeley, United States of America
Université Claude Bernard Lyon 1	Lyon, France
Université Denis Diderot	Paris, France
Université de Genève	Genève, Switzerland
University of Melbourne	Melbourne, Australia
Université de Montréal	Montréal, Canada
University of New Mexico	Albuquerque, United States of America
University of Oregon	Eugene, United States of America
Universität Paderborn	Paderborn, Federal Republic of Germany
Université Paris-Sud	Paris, France
Universität Potsdam	Potsdam, Federal Republic of Germany
University of Science and Technology of China	Hefei, People's Republic of China

Institution	Location
Université de Sherbrooke	Sherbrooke, Canada
University of Southern California	Los Angeles, United States of America
University of Sydney	Sydney, Australia
University of Texas at Austin	Austin, United States of America
University of Toronto	Toronto, Canada
University of Waterloo	Waterloo, Canada
Wilfrid Laurier University	Waterloo, Canada
Zavoisky Kazan Physical Technical Institute of the Russian Academy of Science	Kazan, Russia

Map overlay of collaboration with IQIS

8. Visitors

Name	Dates of Visit	Home Institution
Sun-Hyun Youn	12 Dec 2006 – 31 Aug 2008	Chonnam National University, Republic of Korea
Felix Bussières	16 Jan 2007 – 30 Jun 2009	Université de Montréal, Canada
Ali Kamli	1 Sep 2007 – 31 Dec 2008	King Khalid University, Abha, Kingdom of Saudi Arabia
Chang Wang	22 Oct 2007 – 23 Oct 2008	East China Normal University, Shanghai, People's Republic of China
Sergey Moiseev	11 Jan 2008 – 31 Dec 2008	Zavoisky Kazan Physical Technical Institute of Russian Academy of Sciences, Russia
Anindita Banerjee	02 Apr – 30 Jun 2008	Jaypee Institute of Information Technology, Noida, India

Name	Dates of Visit	Home Institution
Dominic Berry	19 Apr – 4 May 2008 28 Oct – 7 Nov 2008	Macquarie University, Sydney, Australia
Benoît Valiron	21 – 25 Apr 2008	University of Ottawa, Canada
Anirban Das	01 May – 10 Aug 2008	University of Southern California, Los Angeles, United States of America
Tom Osborn	15 – 19 Jun 2008	University of Manitoba, Winnipeg, Canada
Soojoon Lee	8 – 26 Aug 2008	Kyung Hee University, Seoul, Republic of Korea
Timothy Ralph	18 – 19 Aug 2008	University of Queensland, Brisbane, Australia
Andrew Scott	18 – 19 Aug 2008	Griffith University, Nathan, Australia
Martin Plenio	25 Aug 2008	Imperial College London, United Kingdom
Viacheslav Belavkin	25 – 28 Aug 2008	University of Nottingham, United Kingdom
Cecilia Cormick	25 – 27 Aug 2008	Universidad de Buenos Aires, Argentina
Damian Markham	25 – 30 Aug 2008	Université P. M. Curie (Université Paris 7), Paris, France
Mohan Sarovar	25 Aug – 6 Sep 2008	University of California at Berkeley, United States of America
David Petrosyan	8 – 9 Sep 2008 24 – 25 Nov 2008	Institute of Electronic Structure & Laser (IESL) & Foundation for Research and Technology – Hellas (FORTH), Heraklion, Greece
Yunjiang Wang	15 Sep 2008 – 31 Dec 2009	Xidian University, Xian, People's Republic of China
Simon Huisman	01 Oct 2008 – 7 Feb 2009	University of Twente, Enschede, The Netherlands
Peter Rabl	20 – 21 Oct 2008	The Institute for Theoretical Atomic, Molecular and Optical Physics (ITAMP) at the Harvard-Smithsonian Center for Astrophysics and the Physics Department, Harvard University, Cambridge, United States of America
Robert Wolkow	21 Oct 2008	University of Alberta & National Institute for Nanotechnology, Edmonton, Canada
Tzu-Chieh Wei	3 – 4 Nov 2008	University of Waterloo, Canada
Christoph Simon	17 – 18 Nov 2008	Université de Genève, Switzerland
Benjamine Fortescue	1 Dec 2008 – 2 Mar 2009	University of Toronto, Canada
Hans Briegel	10 – 15 Dec 2008	Institute for Quantum Optics and Quantum Information (IQOQI) of the Austrian Academy of Sciences, Innsbruck, Austria
Marlan Scully	11 – 12 Dec 2008	Texas A&M University, College Station, United States of America
Shmuel Friedland	5 – 9 Jan 2009	University of Illinois at Chicago, United States of America
Jop Briët	19 Jan – 16 Feb 2009	Centrum voor Wiskunde en Informatica (CWI), Amsterdam, The Netherlands
Douglas Stebila	17 – 19 Feb 2009	University of Waterloo, Canada
Markus Aspelmeyer	10 Mar 2009	Institute for Quantum Optics and Quantum Information (IQOQI) of the Austrian Academy of Sciences, Vienna, Austria
Alberto Marino	11 – 15 Mar 2009	National Institute of Standards and Technology, Gaithersburg, United States of America
Dylan Mahler	16 – 17 Mar 2009	Lakehead University, Thunder Bay, Canada

B. Teaching, Training and Education

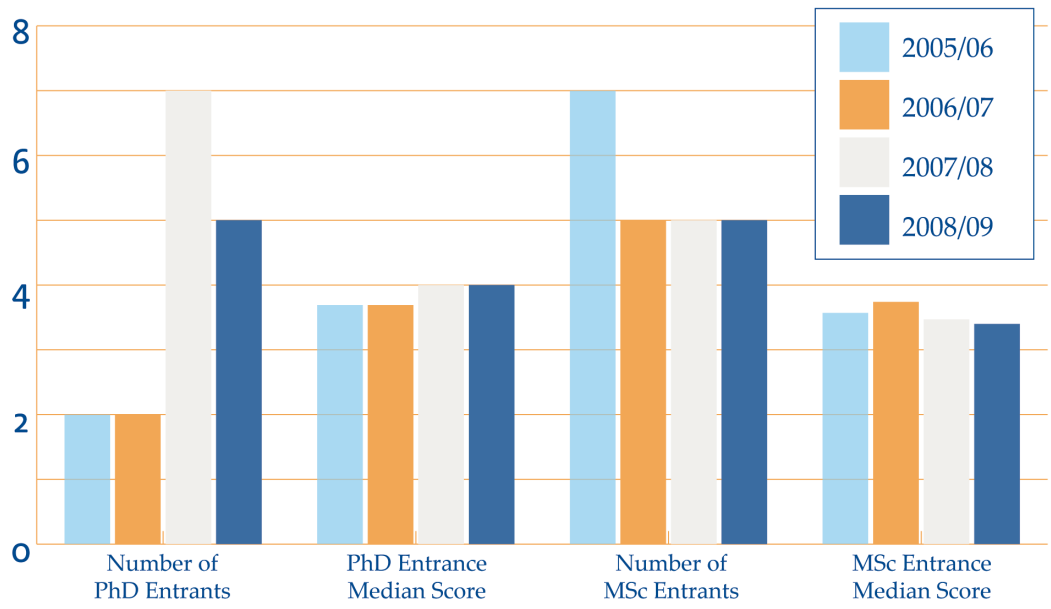
1. Undergraduate projects and supervision

Name	Name of Project	Supervisor
Steven Dalla Vicenza	Quantum information (NSERC USRA)	D. Feder
Katherine Perrin	Dynamics of superfluid fermi gases (PHYS 598)	D. Feder
Michelle Liu	Relativistic quantum resources (NSERC USRA)	G. Gour
Yuval Sanders	When is entanglement catalysis possible? (NSERC USRA)	G. Gour
Erwan Bimbard	Two-photon optical state engineering (visiting student from École Normale Supérieure)	A. I. Lvovsky
Travis Brannan	Construction of a magneto-optical trap for Rubidium atoms (NSERC USRA)	A. I. Lvovsky
Boris Braverman	Generating Bessel beams with conical mirrors (NSERC USRA)	A. I. Lvovsky
Lucia Duca	Single neutral atom traps (visiting student from University of Bologna)	A. I. Lvovsky
Chris Healey	Squeezing via self-rotation; construction of a magneto-optical trap for Rubidium atoms (summer research)	A. I. Lvovsky
Simon Huisman	Fock state tomography (visiting student from University of Twente)	A. I. Lvovsky
Katanya Kuntz	Generating Bessel beams with conical mirrors (summer research)	A. I. Lvovsky
Anna Ordog	Electromagnetically-induced transparency with a frequency comb (summer research) & Broadband delay and storage of light (PHYS 598)	A. I. Lvovsky
Anthony Praseuth	Controlled irreversible inhomogeneous broadening in optical cavities (summer research) & Photon-echo quantum memory in a cavity (PHYS 598)	K.-P. Marzlin
Kevin Hynes	Probabilistic information-theoretic security for communication (NSERC USRA)	B. C. Sanders
Terence Stuart	Practical entanglement sources and quantum key distribution systems (NSERC USRA)	W. Tittel

2. Quantum information graduate courses

Course Name	Instructor	Description
CPSC 519 Introduction to Quantum Computation	P. Høyer	Quantum information, quantum algorithms including Shor's quantum factoring algorithm and Grover's quantum searching technique, quantum error correcting codes, quantum cryptography, nonlocality and quantum communication complexity, and quantum computational complexity.
CPSC 619 Quantum Computation	P. Høyer	Quantum information, quantum algorithms including Shor's quantum factoring algorithm and Grover's quantum searching technique, quantum error correcting codes, quantum cryptography, nonlocality and quantum communication complexity, and quantum computational complexity.
PHYS 673 Quantum and Nonlinear Optics	A. I. Lvovsky	Fundamentals of quantum and nonlinear optics including atom-photon interactions, coherence, electromagnetically induced transparency, open systems and decoherence, and applications to quantum information technology.
PHYS 615 Advanced Quantum Mechanics I	B. C. Sanders	Review of special relativity, electrodynamics, and nonrelativistic quantum mechanics. Klein-Gordon and Dirac equations with minimal coupling. Antimatter and the PCT Theorem. Foldy-Wouthuysen transformation and relativistic corrections to Hydrogen spectroscopy. Introduction to quantum field theory. (Formerly: Basic formalism of the theory and its interpretation, symmetry generators. Scattering theory. Bound states. Charged particles in electric and magnetic fields. Approximation methods.)

3. Graduate students: enrolments and quality of entrants



4. Summer schools and student conferences

None

C. Services and Outreach

1. Conference committees

Member(s)	Committee	Conference/Workshop/ Award	Location	Conference Dates
D. Feder	Co-organizer	Perimeter Institute Workshop on "Quantum Information and Graph Theory: Emerging Connections"	Waterloo, Canada	28 Apr – 2 May 2008
D. Feder	Member, Local Organizing Committee	Quantum Communication, Measurement and Computing Conference 2008 (QCMC 2008)	Calgary, Canada	19 – 24 Aug 2008
A. I. Lvovsky	Principal Organizer	Quantum Communication, Measurement and Computing Conference 2008 (QCMC 2008)	Calgary, Canada	19 – 24 Aug 2008
A. I. Lvovsky	Member, Program Committee	Third International Conference on Quantum, Nano, and Micro Technology (ICQNM 2009)	Cancun, Mexico	1 – 7 Feb 2009

Member(s)	Committee	Conference/Workshop/ Award	Location	Conference Dates
A. I. Lvovsky	Member, Quantum Optics Subcommittee	International Quantum Electronics Conference (IQEC)	Baltimore, United States of America	31 May – 5 Jun 2009
A. I. Lvovsky	Member, International Advisory Committee	Eleventh International Conference on Squeezed States and Uncertainty Relations (ICSSUR 2009)	Olomouc, Czech Republic	22 – 26 Jun 2009
A. I. Lvovsky	Member, Program Committee	Fourth International Conference on Quantum, Nano, and Micro Technology (ICQNM 2010)	St. Maarten, Netherlands Antilles	10 – 15 Feb 2010
K.-P. Marzlin	Member, Organizing Committee	International Conference on Information Theoretic Security (ICITS 2008)	Calgary, Canada	10 – 13 Aug 2008
K.-P. Marzlin	Member, Local Organizing Committee	Quantum Communication, Measurement and Computing Conference 2008 (QCMC 2008)	Calgary, Canada	19 – 24 Aug 2008
B. C. Sanders	Member, Program Committee	Third International Conference on Quantum Information (ICQI 2008)	Boston, United States of America	13 – 16 Jun 2008
B. C. Sanders	General Chair	International Conference on Information Theoretic Security (ICITS 2008)	Calgary, Canada	10 – 13 Aug 2008
B. C. Sanders	Member, Local Organizing Committee	Quantum Communication, Measurement and Computing Conference 2008 (QCMC 2008)	Calgary, Canada	19 – 24 Aug 2008
B. C. Sanders	Chair	QuantumWorks Theme B Workshop	Alton, Canada	10 – 11 Sep 2008
B. C. Sanders	Member, Program Committee	International Conference on Quantum, Nano, and Micro Technologies (ICQNM 2009)	Cancun, Mexico	1 – 7 Feb 2009
B. C. Sanders	Review Panelist	European 7th Framework Network "Qubits and Applications" (QAP)	Gothenburg, Sweden	2 – 3 Mar 2009
B. C. Sanders	Member, Program Committee	IEEE Congress on Evolutionary Computation (CEC 2009)	Trondheim, Norway	18 – 21 May 2009
B. C. Sanders	Member, Program Committee	Quantum Communications and Quantum Imaging VII, SPIE Optics and Photonics (QCQI 2009)	San Diego, United States of America	2 – 6 Aug 2009
B. C. Sanders	Member, Program Committee	International Conference on Quantum, Nano, and Micro Technologies (ICQNM 2010)	St. Maarten, Netherlands Antilles	10 – 15 Feb 2010

Member(s)	Committee	Conference/Workshop/ Award	Location	Conference Dates
B. C. Sanders	Member, International Advisory Committee	Group XXVIII Symposium (Group XXVIII 2010)	Newcastle, United Kingdom	26 – 30 Jul 2010
W. Tittel	Member, Program Committee	International Conference on Information Theoretic Security (ICITS 2008)	Calgary, Canada	10 – 13 Aug 2008
W. Tittel	Member, Local Organizing Committee	Quantum Communication, Measurement and Computing Conference 2008 (QCMC 2008)	Calgary, Canada	19 – 24 Aug 2008

2. Professional services

Name	Role	Journal/Society/Institution
K.-P. Marzlin	Associate Editor	*Canadian Journal of Physics*
B. C. Sanders	Member, Advisory Committee on Physics Education	American Institute of Physics
B. C. Sanders	Secretary-Treasurer	American Physical Society Topical Group on Quantum Information
B. C. Sanders	Vice Chair, Division of Atomic and Molecular Physics and Photon Interactions	Canadian Association of Physicists
B. C. Sanders	Member, Academic Program Committee	Faculty of Graduate Studies, University of Calgary
B. C. Sanders	Panel Member	National Science Foundation
B. C. Sanders	Project Leader, Quantum Information Processing	Networks of Centres of Exellence for Mathematics of Information Technology and Complex Systems
B. C. Sanders	Consultant, Appraisals Committee for the MMath/PhD Program in Applied Mathematics at the University of Waterloo	Ontario Council on Graduate Studies
B. C. Sanders	Member, Advisory Board	*Optics Communications*
B. C. Sanders	Chair, 2008 Adolph Lomb Medal Committee	Optical Society of America
B. C. Sanders	Group Leader, Quantum Optical Science and Technology Group	Optical Society of America
B. C. Sanders	Member, Scientific Review Panel	Pacific Institute for the Mathematical Sciences
B. C. Sanders	Member, Advisory Committee	PIMS UofC Steering Committee
B. C. Sanders	Member, Research Management Committee	QuantumWorks NSERC Innovation Platform
B. C. Sanders	Member, Advisory Editorial Board	*Applied Mathematics and Information Sciences*
B. C. Sanders	Member, Editorial Board	*New Journal of Physics*
B. C. Sanders	Member, Editorial Board	*Physical Review A*
W. Tittel	Member	International Space-QUEST (Quantum Entanglement for Space Experiments)

3. Appearances in the media

Source	Title of Article	Location	Date
CONNECT	Cover page and mention in Alberta's action plan: Bringing technology to market – Dr. Wolfgang Tittel	online	10 Jun 2008
University of Calgary News & Events	Quantum leap in hi-tech performance, UofC physicists explore the future of computers … with lasers! Alexander Lvovsky, Eden Figueroa	online	25 Sept 2008
Physicsworld.com	A simpler way to test quantum computers: Alexander Lvovsky	online	25 Sept 2008
Physorg.com	Quantum leap in hi-tech performance: Mirko Lobino, Alexander Lvovsky, Barry Sanders	online	25 Sept 2008
FirstSicence News	Quantum leap in hi-tech performance: Mirko Lobino, Alexander Lvovsky, Eden Figueroa, Barry Sanders, Connor Kupchak, Dmitry Korystov	online	25 Sept 2008
Yahoo News	Scientists take a giant leap forward in developing quantum machines: Mirko Lobino, Alexander Lvovsky, Barry Sanders	online	26 Sept 2008
Innovations Report	Quantum leap in hi-tech performance: Mirko Lobino, Alexander Lvovsky, Barry Sanders	online	26 Sept 2008
AndhraNews.Net	Scientists take a giant leap forward in developing quantum machines: Mirko Lobino, Alexander Lvovsky, Barry Sanders	online	26 Sept 2008
Matter News	University of Calgary physicists unveil novel process that promises to kick-start quantum technology sector: Mirko Lobino, Alexander Lvovsky, Eden Figueroa, Barry Sanders, Connor Kupchak, Dmitry Korystov	online	26 Sept 2008
TopNews.in	Scientists take a giant leap forward in developing quantum machines: Barry Sanders, Mirko Lobino, Alexander Lvovsky		26 Sept 2008
Thaindian News	Scientists take a giant leap forward in developing quantum machines: Barry Sanders, Mirko Lobino, Alexander Lvovsky		26 Sept 2008
Computer Shopper	Scientists make quantum leap towards next-gen supercomputers: Mirko Lobino, Barry Sanders	online	26 Sept 2008
Optics.org	A simpler way to test quantum computers: Alexander Lvovsky	online	29 Sept 2008
Science Daily	Novel process promises to kick-start quantum technology sector: Alexander Lvovsky, Mirko Lobino, Barry Sanders	online	30 Sept 2008
Space Mart	Quantum leap in hi-tech performance: Alexander Lvovsky, Mirko Lobino, Barry Sanders	online	1 Oct 2008
UToday	Seeing the quantum world: Barry Sanders	online	16 Dec 2008

Source	Title of Article	Location	Date
Chemie.de Information Service	"Seeing" the quantum world: Barry Sanders	online	19 Dec 2008
ScienceDaily	"Seeing" the quantum world – Computer animation used to help explain mysteries of quantum physicist: Barry Sanders	online	19 Dec 2008
Aptech	Teleportation: Barry Sanders	online	27 Dec 2008
Global News & Global TV Calgary	Dr. Tittel's research features in the "Future Tech Series" part III by David Boushi		20 Feb 2009

4. Production

Creator(s)	Title	Description
B. S. Sanders & N. Sinclair	Visual information for the quantum age http://www.youtube.com/watch?v=NfvwY8pgqqw	Animation illustrate fundamental achievements in quantum information science

5. Public lectures

None

V Finances

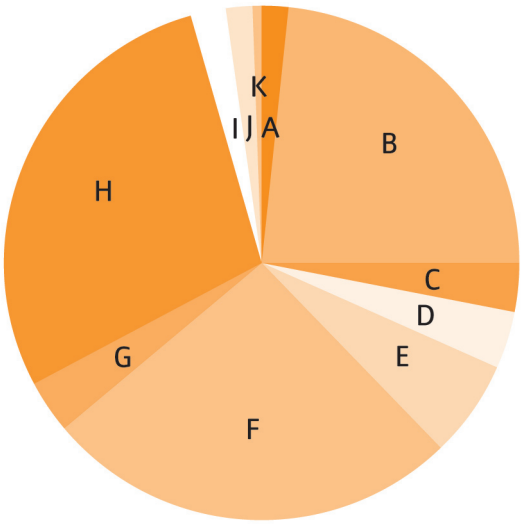
A. Operating Account: Revenue and Expenditure

Income Statements for the period 2008/09 Ending 31 March 2009			
Revenue			
	University of Calgary	$	75,000.00
	ICITS Conference Sponsorship		10,000.00
	ICITS Conference Registration Fee		5,573.32
	MITACS QIP Seminar Series		8,000.00
	Others		1,000.00
	Total Revenue	$	99,573.32
Expenditures			
	Adminstrative Salaries	$	58,799.62
	Benefits		12,196.14
	Equipment		5,332.31
	Office Supplies		1,264.26
	IT Support		918.11
	Software		341.84
	Travel and Other expense - Visitors		3,135.12
	External Seminar (MITACS)		4,443.56
	Postage, Phone, Fax and Courier		452.39
	Special Event and Meetings		3,979.13
	IQIS Annual Report		2,468.21
	IQIS Board Meeting		4,969.79
	Maintenance		237.53
	Other Expenditures		3,769.28
	Total Expenditures	$	102,307.29
Net Operating Results		$	-2,733.97

B. Research Grants: Revenue and Expenditure

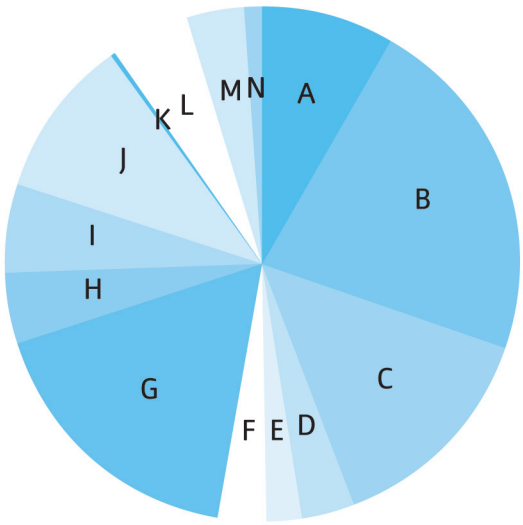
Total Income: $2,810 (in thousands)

A	AIF	$50,666.67
B	CFI	$658,686.82
C	CIFAR	$82,504.98
D	CRC	$100,000.00
E	GDC	$170,000.00
F	iCORE	$739,000.00
G	MITACS	$90,496.76
H	NSERC	$800,318.00
I	QuantumWorks	$60,717.43
J	Other	$47,300.00
K	Interest	$10,273.36



Total Expenditures: $2,564 (in thousands)

A	Student Salaries & Fees	$214,742.55
B	Studentships & Fellowship/ Scholarships	$569,163.42
C	Research Fellows & Associates Salaries	$350,987.09
D	Visiting Professor Salaries	$88,160.87
E	Administrative Support Salaries	$54,746.15
F	Technical Support Salaries	$76,732.70
G	Faculty Salaries	$443,578.45
H	Benefits	$113,544.14
I	Materials & Supplies	$144,869.16
J	Equipment & Freight	$258,418.37
K	Books, Journals & Publications	$1,487.89
L	Travel	$129,139.57
M	Visitors	$97,094.50
N	Other	$21,620.49



VI Plans and Requirements for Next Year

A. Research Objectives

DR. DAVID FEDER

I have three main areas of research, in the general areas of implementing quantum information processing and the fundamental properties of ultracold atomic gases, and various points of overlap between these.

On the quantum information side, I intend to continue investigating the measurement-based (MB) and quantum walk (QW) models of quantum computation (QC). In MBQC, algorithms are carried out solely by making measurements on a highly entangled resource state. The characteristics that such a resource state must have in order to be useful are not presently known, however. What is known is that the vast majority of states cannot be resources. Adam D'Souza and I will be considering various (generally strongly correlated) condensed matter models to determine which (if any) could yield ground states that can be resources for MBQC. This project will build on his Master's work, where he obtained simple criteria to test if a given state is related to a known resource.

In related work, postdoctoral researcher Jaewoo Joo and I will be investigating approaches to MBQC which incorporate error correction. In the QW approach to QC, algorithms are simulated by a single quantum particle that traverses a well-chosen graph. While exponential speed-ups over classical algorithms have been demonstrated using this approach for various toy models, generally the improvements are only polynomial. Worse, the number of vertices in the graphs tends to increase exponentially in the number of simulated qubits. Michael Underwood and I will be investigating how to design graphs to perform particular quantum algorithms, in particular Shor's factoring algorithm, with emphasis on efficiency in the number of graph vertices.

My research on the fundamental properties of ultracold atomic gases will focus on two main problems: atoms in optical lattices, and atoms subjected to rotation. The optical lattice topics to be addressed include how to efficiently cool bosons and fermions in optical lattices under realistic conditions, how to generate effective Hamiltonians that have no counterpart in related condensed matter systems, and how to characterize the ground states of these and related models. All of these topics are ultimately designed to make incremental progress toward an overarching goal: employing ultracold atoms in optical lattices as simulators of quantum many-body Hamiltonians and quantum information devices. I also intend to further investigate the properties of rapidly rotating gases, which are anticipated to yield strongly correlated states akin to those observed in the fractional quantum Hall effect. In particular, I intend to investigate the role of trap anisotropy: as the rotation frequency approaches the smaller of the two trap frequencies, the gas should becomes quasi-one-dimensional, which should yield new phases with no analogue in the usual quantum Hall effect. I expect Kevin van der Bogart to be involved in this research, though his research topic has not yet been finalized.

DR. GILAD GOUR

For every interesting restriction on operations, there is a resulting resource theory. For instance, the restriction of local operations and classical communication (LOCC) in quantum networks leads to the theory of entanglement. Our group's plan for 2009-2010 is to develop new quantitative resource theories that

correspond to a variety of natural restrictions that occur in many physical systems of interest. These include super-selection rules (SSR), the absence of a shared reference frame, imperfect apparatus, and restrictions to Gaussian operations in quantum optics. As these limitations occur naturally in quantum networks, it is critical to overcome them in the most efficient way. The mathematical models to be developed will provide novel techniques to distribute resources in quantum networks, provide analytical methods to quantify quantum resources, propose operational interpretations for the different quantifying measures, identify efficient ways to overcome the set of restrictions, and identify and promote the applications of these new resources, especially in fields such as quantum cryptography.

DR. PETER HØYER

The theory group will be investigating how known protocols for simulating time-independent Hamiltonians can be extended to time-dependent Hamiltonians, while keeping the simulation efficient with arbitrary small provable error bounds.

The theory group will be investigating relationships between adiabatic computations and random walks with focus on proving limits on the strengths of these models. We will consider the speed-up of multi-level adiabatic computations over limited-level adiabatic computations.

The theory group will also consider classifications of quantum correlations and other correlations in terms of their violation of Bell inequalities.

DR. ALEX LVOVSKY

- Understand the reasons for the degradation and improve the lifetime of quantum memory for light based on electromagnetically-induced transparency. Develop full quantum theoretical understanding of this memory and reconcile it with the experimental data acquired by continuous-variable quantum process tomography.
- Demonstrate quantum-optical technology at the two-photon level, i.e. preparation and homodyne tomography of arbitrary superpositions of zero-, one, and two-photon Fock states in a single optical mode.
- Demonstrate rudimentary quantum-state engineering with the new quantum light source based on four-wave mixing in hot atomic vapors.
- Commence experiments on trapping atoms and manipulating atomic states with evanescent fields from optical nanofibers.
- Perform quantum process tomography of the photon annihilation operator.

DR. BARRY SANDERS

We will use machine learning techniques to obtain the best-ever protocol for interferometric adaptive phase measurement. We have found that particle swarm optimization indeed yields a protocol that outperforms the best known adaptive phase method, and we are testing our protocol against practical considerations such as photon losses. Our result will pave the way for using swarm-intelligence machine learning for quantum measurement.

In collaboration with iCORE Chair Wolkow's group, we plan to design a scalable quantum computer circuit on a silicon surface using dangling bonds as charge qubits. We will also identify the coherent tunnelling time between dangling bonds, estimate the decoherence rates, and design a measurement scheme to demonstrate Rabi oscillation dynamics between dangling bonds.

We will develop full mode theory for our nonlinear quantum polaritonics scheme. Some of our calculations argue based on order-of-magnitute size estimates, but we will obtain accurate estimates by performing a modal analysis of Maxwell's equations.

The quantum simulation work will be extended from the time-independent Hamiltonian case to fully time-dependent dynamics with applications to relationships between adiabatic quantum computation and circuit-based quantum computing.

So far complete process tomography is restricted to single mode fields. Theory and experiment will be extended to multi-mode processes. The experiment may take more than a year, but the theory will be in place within a year.

Quantum reference frame theory explains how to sidestep superselection principles. A full, formal theory connecting quantum reference theories has not yet been established. In the coming year, a full and meaningful theory of the connection between reference frames and superselection will be established for cases involving compact group transformations.

DR. CHRISTOPH SIMON (Joined IQIS as an Associate Professor in July 2009)

Quantum physics challenges our most basic concepts about physical reality. To fully understand its conceptual implications, it is essential to try to explore whether there is a fundamental boundary between the quantum and classical worlds. Quantum optical systems are uniquely suited to this research program because they allow a high degree of experimental control and theoretical understanding. The recent impressive experimental progress in quantum optics would not have been possible without the inspiration and guidance provided by theoretical work. My overarching research objective is to lay the theoretical groundwork for experimental research programs that promise to greatly extend the domain where quantum effects such as quantum superpositions and entanglement can be observed.

My interest is currently focused on three particular approaches that promise to make it possible to extend the quantum domain in different and complementary ways. The first approach, based on quantum repeaters, aims to extend the distance over which entanglement can be observed to the intercontinental scale, which, besides its fundamental interest, would also have important applications in quantum information processing, in particular for long-distance quantum cryptography. The second approach, based on high-gain parametric amplification of single photons, may allow quantum experiments with human eyes as detectors. The third approach, based on quantum opto-mechanical systems, may lead to the most massive quantum superpositions to date, and might make it possible to test proposals for the unification of quantum physics and gravity. All these approaches are pursued in close contact with leading experimental groups.

DR. WOLFGANG TITTEL

The activities during the next year will be oriented towards building of complete P2P QC systems, as well as quantum networks with various degree of sophistication, ranging from optical switching nodes to entangled and fully quantum enabled networks.

Quantum Cryptography

- We will extend the polarization-based QKD system to a complete QC system, including random generation of qubits, time tagging of detection events, key sifting, error correction and privacy amplification. The setup will run at a clock frequency of a few MHz. It will be implemented on the UofC-SAIT test-bed link, and will allow the demonstration of the principles of QC plus yield important information for systems design and future packaging.
- We will replace the bulky and expensive function generators used in the current QKD system by small and low cost FPGAs, as required for building a industry grade prototype.
- We will modify the electronic circuit of the single photon detectors to achieve trigger rates of several hundred MHz. This will eventually allow increasing the clock rate of our QC system, and hence the secret key rate, by two orders of magnitude.

Integration and Networks

- We will demonstrate quantum frame determined optical switching between different receiver nodes. This will pave the road for future work on networks that go beyond pre-established P2P links.
- We will devise and implement a protocol to find the best path between a sender and a receiver through a quantum network comprising optical switching nodes. The protocol is likely to involve loss measurements, which we intend to implement via quantum frames.

Quantum Relays

- We will implement and test our entanglement source with universal time-bin analyzers on the fibre optics test-bed link between the UofC and SAIT.
- We will perform a proof-of-principle demonstration of entanglement-based QKD and quantum secret sharing over the fibre link with SAIT.
- We will extend our fibre-based photon pair source into a source of entangled photon pairs, and investigate the possibility of simultaneously generating multiple, pairs of photons with small bandwidth.
- We will set up experiments requiring the simultaneous generation of two photon pairs. In a first step, we will study two-photon interference after the two photons have travelled between the UofC and SAIT. This investigation will start our experimental studies into quantum networks that go beyond optical switching nodes, i.e. networks with entangled nodes.

Quantum Memory

- We will study the possibility to employ atom-mediated state manipulation for high precision metrology (i.e. phase measurements) through multipath interferometry.
- We will characterize spectroscopic properties of $Tm:LiNbO_3$ waveguides as relevant for CRIB based quantum state storage.
- We will implement a quantum state storage protocol, thereby paving the road towards storage of entanglement and fully quantum enabled networks.

B. Space

The Institute had 62 members on 31 March 2009. Of these members, there are 6 faculty members and 1 adjunct faculty member, 6 support staff (including technician, part-time IT support staff and admin support staff), 9 post doctoral fellows/associates, 4 long-term visiting students, 1 long-term visiting professor, and 35 undergraduate and graduate students. Of all students, the division between the Departments of Physics & Astronomy, Computer Science, and Mathematics & Statistics was 30:4:1. The rapid growth of the Institute naturally puts pressure on the availability of space within the University, and particularly within the Faculty of Science.

Floor plans depicting the use of space are provided in Appendix C. Space limitations are particularly evident in the distribution of students and postdoctoral researchers in the Department of Physics & Astronomy.

C. Institute Funding

The University of Calgary provides $75,000 funding p.a. The cost of operating the institute is $102,307.29 in 2008/09, and this cost is projected to be $101,000 in 2009/10.

D. Personnel

Institute personnel comprise the Administrator (1), group administrative assistants (3, supported by individual researcher funding), IT support (1, part-time), webmaster (1, part-time).

VII Appendices

A. Charter

Charter of the Institute for Quantum Information Science at the University of Calgary

Name

1. The name of the organization shall be the Institute for Quantum Information Science at the University of Calgary (hereinafter referred to as "Institute").

Supervising Officer

2. Under the University's policy on Institutes and Centres (ss. 3.4 & 4.6), each institute reports to an appropriate "supervising officer" within the University's administrative structure. The supervising officer of the Institute shall be the Dean of the Faculty of Science.

Approval and Review Bodies

3. The bodies responsible for approving, reviewing, and renewing the Institute under the policy on Institutes and Centres (s. 3.5) are the Dean of the Faculty of Science and the Research Development and Policy Committee (RDPC).

Term of the Institute

4. Under the limited-term provision of the University's policy on Institutes and Centres (s. 4.4), the Institute is established for a five-year term ending 31 December 2009**.** The Institute is eligible for renewal (s. 4.4) upon favourable external review (s. 4.3).

Goals

5. The goals of the Institute shall be:
   a) to establish and maintain leading quantum information science in the areas of quantum algorithms and processing, implications of quantum information on information security and communication complexity, development of physical implementations of quantum information tasks and protocols, and critically evaluate proposals and experimental results in the field;

   b) to educate and train persons with expertise at the frontiers of the allied disciplines of quantum information science;

c) to bring together top researchers in the world in order to further the development of the field of quantum information science through a focused, multi-disciplinary effort;

d) to identify promising research areas that will lead to valuable intellectual property and to conduct research in these areas;

e) to collaborate in complementary research activities in the areas of computer science, engineering, mathematics and experimental and theoretical physics and chemistry.

Targets and Measures of Success

6. At the establishment and/or renewal of an institute, the University's policy on Institutes and Centres (ss. 4.1 & 4.3) requires the setting of targets against which to measure success in adding value. These targets have been developed and will be used to measure success in achieving the above goals during the Institute's five-year term. They are outlined in Appendix 1.

Schedule of Review

7. Under the terms of the University's Institutes and Centres Policy (ss. 4.1-4.3) and Procedures (ss. 2.4-2.6), the Institute undertakes to be reviewed upon the following schedule during its term:

- at the discretion of the Dean of the Faculty of Science, an internal review after two years of the Institute's limited term;

- as required by the policy on Institutes and Centres, an external review during the final 18 months of the Institute's term.

In addition, the Institute shall submit an annual report on its activities to the Dean of the Faculty of Science.

Institute Board of Directors

8. 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 Institute's "supervising officer" (or designate), who shall 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 President of the University of Calgary shall appoint "members at large" on the advice of the supervising officer. 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 University's policy on Institutes and Centres (s. 4.3).

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

9. 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.

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 University's policy on Institutes and Centres (s. 4.3).

Policies and Procedures

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

Amendments

11. Amendments to this Charter shall require approval by the supervising officer and two-thirds of the Board. (The supervising officer may refer proposed amendments to RDPC for its advice.)

Appendix 1

Targets and Measures of Success

Measures of Success:

a) Certified national testbed for quantum cryptography
b) Expertise and productive research
c) Demonstrate quantum memory for light
d) Demonstrate quantum optical state engineering at the multiphoton level
e) Establishment of fundamental relations among measures of quantum complexity
f) Theoretical power and limits of quantum models and protocals
g) Demonstrate few-qubit quantum fingerprinting
h) Efficient numerical simulation routines for quantum communication protocols accounting for realistic imperfections
i) Groundwork for applied research in QIS with expectation of valuable intellectual property
j) Self-funding QIS educational arm based on sophisticated visualization technology in collaboration with Banff New Media Institute
k) IQIS is a demonstrable QIS destination of choice for top students, postdocs, visitors, and prospective faculty

Specific Targets to Achieve by 2010:

Highly Qualified Personnel

- 30 graduate students with median entrance GPA > 3.75 or equivalent
- 2 external awards for students annually
- 8 postdocs including 4 with external fellowships
- 4 annual undergraduate student projects
- 5 summer students including at least 3 NSERC summer scholars
- 7 tenured or tenure-track faculty in QIS including 4 externally funded chairs (iCORE, IRC, CRC, ...)

Education and Training

- 3 graduate courses offered in QIS

- Annually: 4 students/postdocs visiting collaborating institute for at least 4 weeks
- Establishment of QViz as the premier source of sophisticated visualization presentations of QIS

Research Inputs
- At least $1,200,000 external funding for QIS research, stipends, scholarships, and fellowships per annum
- 8 distinguished visitors per annum
- 5 visitors at PhD level or higher per annum who stay at least 4 weeks

Research Outputs
- 30 papers in international refereed journals or refereed conference proceedings per annum including
- 8 in Physical Review Letters, or FOCS/STOC/STACS/ICALP/Complexity
- 1 in Science or Nature every second year commencing in the third year after the establishment of the Institute
- 30 invitations to give talks per annum including 3 keynote/plenary talks
- 15 student oral or poster presentations per annum at QIS conferences

Collaborations
- Demonstrable collaboration with at least 5 leading QIS groups
- Student exchanges with at least 2 leading QIS groups
- At least one corporate partnership with >$100k annual cash support
- Major experimental research project with leading international partner

Service
- Memberships of 8 conference/workshop program committees annually
- Chair or Co-Chair at least one conference biennially
- At least 2 editorial board members of QIS-related journals

B. Performance Indicators

achieved; not yet achieved

Key result areas /performance indicators	*Target (by 2010)*	*Achievements (2008/09)*
Highly Qualified Personnel		
Number of students	30 graduate students	37
Median GPA	30 graduate students with median entrance GPA >3.75 or equivalent	
	- MSc	3.4
	- PhD	4
External Awards	2 external awards for students annually	10
Number of postdoctoral associates	8 postdoctoral associates	9
External Fellowships	8 postdoctoral associates including 4 with external fellowships	1
Undergraduate student projects	4 annual undergraduate student projects	3
Number of summer students	5 summer students including at least 3 NSERC summer scholars	4 – others 7 – NSERC
Number of tenured or tenure-track faculty in QIS	7 tenure-track faculty	6
External funding of faculty	4 externally funded chairs (iCORE, IRC, CRC)	3
Training and Education		
Number of graduate courses	3 graduate courses offered in QIS	4
Students/postdocs visiting collaborating institutes	4 students/postdocs annually visiting collaborating institutes for at least 4 weeks	0
Research Inputs		
Distinguished visitors per annum	8 distinguished visitors per annum	8
Number of visitors	5 visitors at PhD level or higher per annum who stay at least 4 weeks	11

achieved; not yet achieved

Key result areas /performance indicators	*Target (by 2010)*	*Achievements (2008/09)*
Number of publications	30 papers in international refereed journals or refereed conference proceedings per annum including	42
	* 8 in Physical Review Letters, or FOCS/STOC/STACS/ICALP/ Complexity	1
	* 1 in Science or Nature every second year commencing in the 3rd year after the establishment of the Institute	1
Invitations to address conferences	30 invitations to give talks per annum including 3 keynote/plenary talks	33 (2 - keynote/ plenary talk)
Number of student presentations	15 student oral or poster presentations per annum at QIS conferences	32
	Collaborations	
Number of collaborations	Demonstrated collaboration with at least 5 leading QIS groups	10
Number of student exchanges	Student exchanges with at least 2 leading QIS groups	2
Corporate partnership	At least one corporate partnership with >$100k annual cash support	1 - GDC
Major experimental research project	Major experimental research project with leading international partner	0
	Citizenship	
Program committee membership	Membership of 8 conference/workshop program committees annually	13
Chair or Co-Chair	Chair or Co-Chair at least one conference biennially	4
Editorial board membership	At least 2 editorial board membership of QIS-related	4

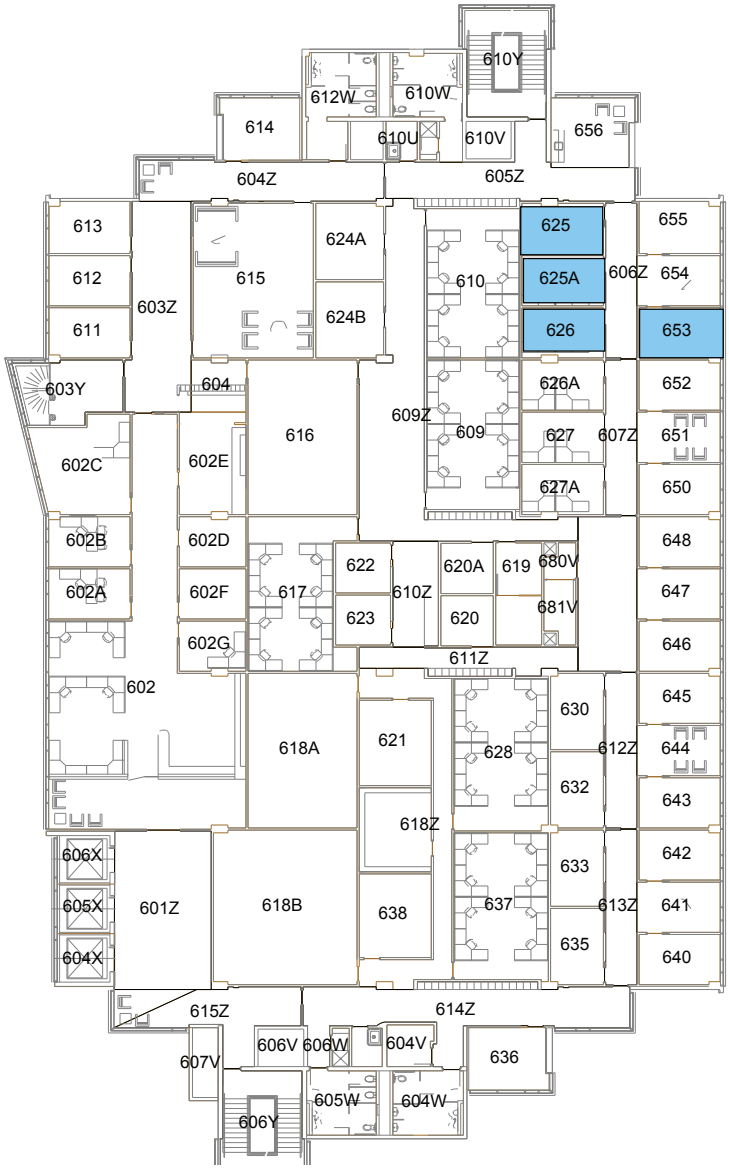
C. Floor Plans for Existing Use of Space

Earth Science Basement

IQIS

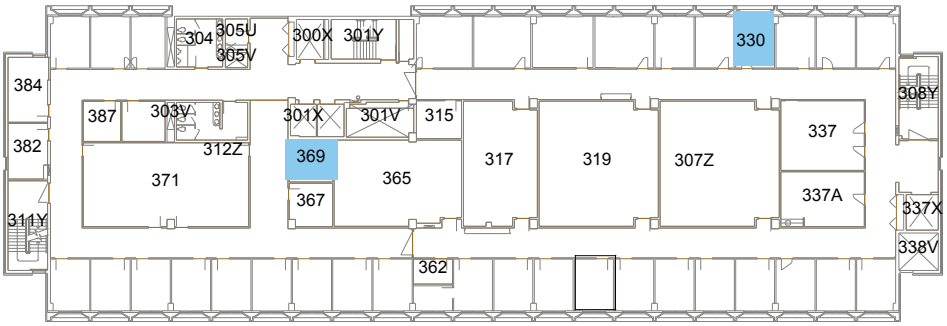
ICT Sixth Floor

IQIS



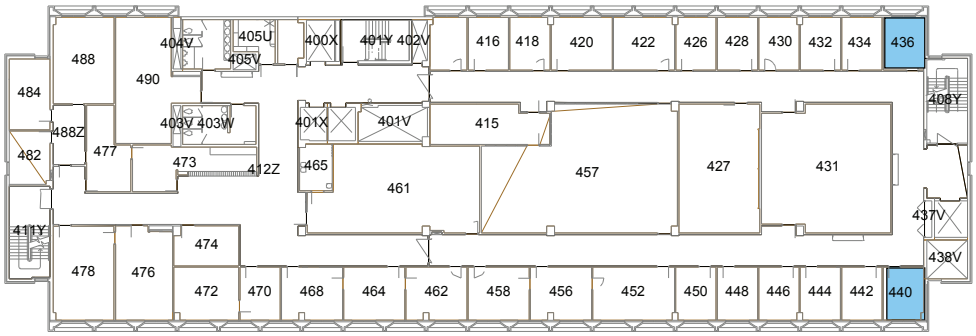
Mathematics Third Floor

IQIS



Mathematics Fourth Floor

IQIS



Science B Basement

IQIS

Science B Main Floor

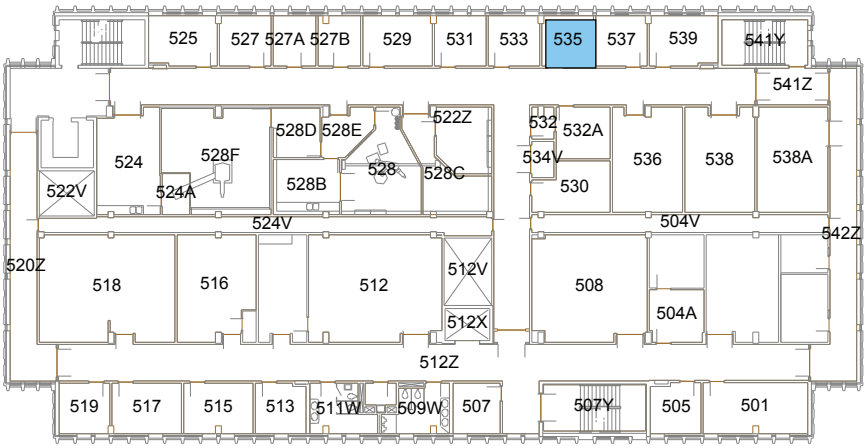
IQIS

Science B Third Floor

IQIS

Science B Fifth Floor

IQIS



IQIS adds value to the University of Calgary in the following ways:

- Fosters a multidisciplinary research team through financial, administrative, and computer support
- Builds a quantum information research community by providing visitor, seminar, and colloquium programs
- Assists new faculty members with a rapid transition to becoming productive researchers with a strong research group and necessary equipment
- Publishes reports and web pages that ensure recognition of the Institute and its researchers as leaders in quantum information
- Supports recruiting efforts to bring the best faculty members, postdoctoral researchers, and graduate students to the University
- Sponsors and provides logistical support for leading international conferences to be held in or near Calgary
- Partners with other quantum information institutes within national and international research and training networks
- Enhances the University's reputation by conducting and disseminating outstanding research results

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