



University of Toronto Research Expertise List

Quantum Technologies

Mar 2023



UNIVERSITY OF
TORONTO

U of T Global Rankings

#1 in Canada | #18 worldwide

THE World University Rankings (2021-2022)

#1 in Canada | #34 worldwide

QS World University Rankings (2021-2022)

A POWERHOUSE FOR INNOVATION & ENTREPRENEURSHIP

600 Startups

More than **\$2.5B** in investment secured by **600+** startups over the past decade.

350+ Private Sector Partners

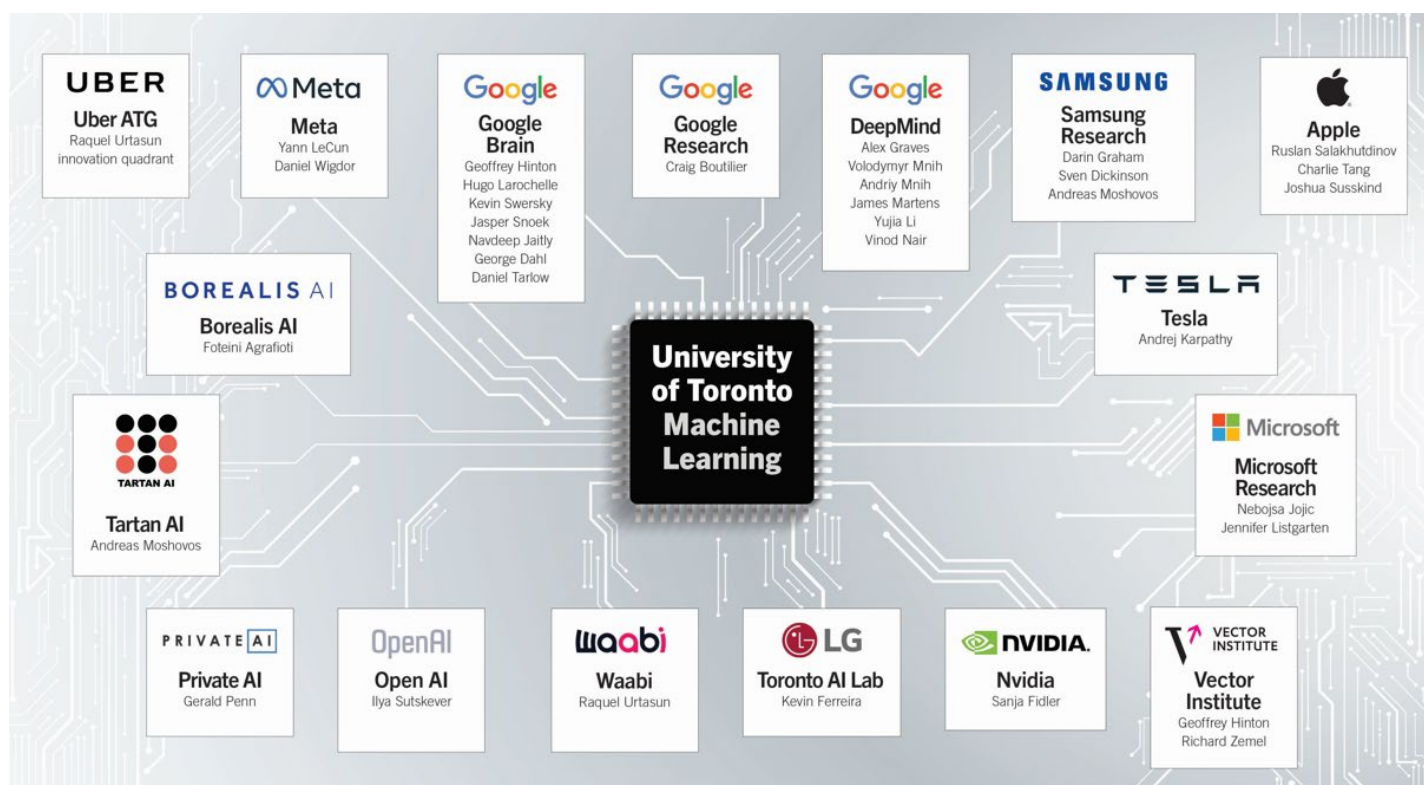
U of T's global reputation as a top research university and its vibrant innovation and entrepreneurship culture attracts industry partners from across Canada and worldwide.

1000+ Patent Applications

U of T is a leader among North American universities for research-based startups, inventions, licenses and options.

U of T EXPERTISE IS SOUGHT BY GLOBAL GIANTS

U of T Faculty and Alumni are hired by some of the most influential tech companies worldwide
(This graphic depicts engagements over the past several years, but may not reflect current status in all cases.)

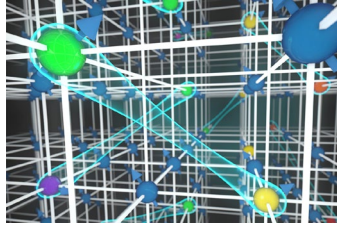


Impact Stories



[U of T and Fujitsu extend agreement to collaborate on cutting-edge computing research](#)

Nov 6, 2020



[Turning water into ice in the quantum realm: U of T, University of Colorado Boulder study](#)

Aug 6, 2019



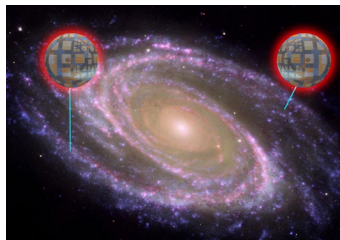
[U of T-supported startup Xanadu aims to lead quantum computing sector](#)

Mar 9, 2023



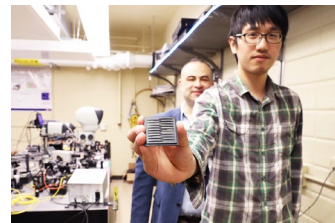
[How quantum is it? U of T physicist Aaron Goldberg may have the answer](#)

Jan 26, 2021



[Remote connections? U of T expert on detangling entanglement in quantum physics](#)

Apr 26, 2019



[U of T researchers to harness quantum properties of light for biomedical imaging, security and more](#)

Aug 20, 2019



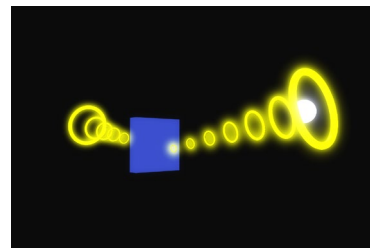
[U of T Acceleration Consortium to use AI to develop advanced materials](#)

Apr 20, 2021



[U of T Entrepreneurship Week 2023: Top 10 startups to watch](#)

Mar 2, 2023



[U of T physicists measure the duration of quantum tunneling for the first time](#)

Jul 23, 2020

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INITIATIVES – KEY RESEARCH CENTRES AND INFRASTRUCTURE

With internationally recognized strengths across a wide breadth and depth of disciplines, the University of Toronto is one of the few global institutions able to implement innovative strategic initiatives that span fields and faculties.

Institutional Initiatives are large-scale, cross-divisional research centres supporting interdisciplinary teams of University of Toronto researchers and partners, addressing grand challenges and pursuing bold ideas that require true collaboration and the integration of various disciplinary research approaches.

These are just some of the collaborative initiatives we are supporting.

Schwartz-Reisman Institute for Technology and Society

<https://srinstitute.utoronto.ca/>

The Schwartz Reisman Institute draws on U of T's signature strengths in the sciences, humanities and social sciences to explore the benefits and challenges that AI, biotechnology and other technological advances present for our economy, our society and our day-to-day lives.

Centre for Analytics and Artificial Intelligence Engineering (CARTE)

<https://www.engineering.utoronto.ca/carte/>

The **Centre for Analytics and Artificial Intelligence Engineering (CARTE)** brings together more than 30 professors with expertise in optimization, analytics and AI, as well as diverse domains such as energy, transportation and life sciences. Artificial intelligence (AI) is increasingly part of our daily lives, with applications from voice-activated assistants to self-driving cars — and its influence continues to grow. This multidisciplinary research centre leverages the power of AI to address challenges in a wide range of fields, including human health, sustainability and advanced manufacturing.

School of Cities

<https://www.schoolofcities.utoronto.ca/>

The **University of Toronto School of Cities** convenes urban-focused researchers, educators, students, practitioners and the general public to explore and address complex urban challenges. The interdisciplinary research is conducted with the aim of making cities and urban regions more sustainable, prosperous, inclusive and just.

University of Toronto Robotics Institute

<https://robotics.utoronto.ca>

The **University of Toronto Robotics Institute** is home to the largest and most diversified robotics research program in Canada. We unite, grow, and catalyze collaborations among the many exceptional robotics research clusters at the University. Serving as the headquarters for robotics collaboration at U of T, we unite leading robotics experts from across the University around three research pillars: Autonomous Field Robotics; Healthcare Robotics; Advanced Manufacturing.

UofT Transportation Research Institute (UTTRI)

<https://uttri.utoronto.ca/>

Faculty members at the **University of Toronto Transportation Research Institute (UTTRI)** specialize in systems analysis and policy evaluation, and are leaders in building and applying cutting-edge computer

simulation models to the analysis and design of complex transportation systems. U of T has an internationally recognized critical mass of researchers with extensive experience in the analysis, planning and design of urban transportation systems, covering roads, transit, freight and active transport modes (walk and bike) across a range of perspectives – travel behaviour, system performance, economics and environmental impacts. We have extensive experience with comprehensive, system-wide, evidence-based policy analysis and decision support, leading to successful transportation facilities implementation and operations.

Centre for Quantum Information and Quantum Control (CQIQC)

<https://cqiqc.physics.utoronto.ca/>

The **Centre for Quantum Information and Quantum Control (CQIQC)** is tasked with promoting research collaborations in the rapidly evolving interdisciplinary fields of quantum information and quantum control. CQIQC's activities at the [University of Toronto](#) encompass the Departments of [Chemistry](#), [Physics](#), [Mathematics](#), [Computer Science](#), [Electrical Engineering](#), and [Materials Science](#). CQIQC members are involved in a variety of theoretical and experimental activities, including coherent control, quantum optics, quantum cryptography, quantum decoherence-control, and quantum algorithms.

School of the Environment

<https://environment.utoronto.ca/>

The **School of the Environment** serves as an interdisciplinary hub for education and scholarship on the environment and sustainability. We create new knowledge; train future leaders; engage and forge partnerships with the wider community; and contribute to positive environmental and social change from the local to the global scale.

University of Toronto Electric Vehicle Research Centre (UTEV)

<https://utev.utoronto.ca/>

The **University of Toronto Electric Vehicle (UTEV) Research Centre** is a game-changing university-industry partnership, focused on next generation of EV technologies. Research is focused in a state-of-the-art battery and power electronics lab, with multi-disciplinary collaborations alongside leading professors from Electrical and Computer Engineering, as well as from other engineering units. In partnership with Industry and Government partners, UTEV researchers study Energy Management and Storage, Advanced Power Modules, Next-generation powertrain, Ubiquitous Charging, and generally new opportunities for EVs.

The UTEV Centre will also be linked to the nascent **University of Toronto Electrification Hub**, bringing together Engineering, Public Health, Urban Planning, Cybersecurity, and Anthropology experts to contribute to the electrification revolution with multidisciplinary research and innovations on material discovery, batteries, chargers, and stationary energy storage, in collaboration with Canada's fast-growing e-mobility sector.

U of T RESEARCHERS

Note: Faculty member entries are listed in two dimensions: **Applications**; and **Platforms**. Many researchers are found on both lists. Details of each researcher may be reviewed by **clicking** (or **[Ctrl]+Click** depending on your system) on the researcher name in the table below: Links after each entry will return here.

APPLICATIONS:

QUANTUM COMPUTING & ALGORITHMS

Alán Aspuru-Guzik	Artur Izmaylov	Ali Sheikholeslami	Sorin Voinigescu
Nathan Wiebe	Daniel James		

QUANTUM DYNAMICS & CONTROL

Paul Brumer	Raymond Kapral	Dvira Segal	R. J. Dwayne Miller
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QUANTUM SECURITY & COMMUNICATION

Glenn Gulak	Hoi-Kwong Lo	Li Qian	Amr Helmy
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QUANTUM SIMULATION & FUNDAMENTAL QUANTUM INFORMATION SCIENCE

Aephraim Steinberg	Joseph Thywissen	Amar Vutha	
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PLATFORMS:

PHOTONS

Amr Helmy	Sajeev John	Joyce Poon	John Sipe
Aephraim Steinberg	Peter Herman	Hoi-Kwong Lo	Li Qian

CONDENSED MATTER & NANOSYSTEMS


Hae-Young Kee	Young-June Kim	Harry Ruda	Ali Sheikholeslami
Sorin Voinigescu	Dvira Segal		

ATOMS & MOLECULES

Aephraim Steinberg	Joseph Thywissen	Amar Vutha	Paul Brumer
Artur Izmaylov			

RESEARCHER DETAILS:

Alán Aspuru-Guzik


	University Affiliations: Computer Science Chemistry CQIQC Chemical Physics Theory Group Vector Institute
	Website: Alán Aspuru-Guzik
	Keywords: AI/ML Quantum Computing algorithms High-performance computing Robotics Self-Driving laboratories Molecular materials discovery Energy & functional materials

Alán Aspuru-Guzik researches the interfaces of quantum information, chemistry, machine learning and physics. He was a pioneer in the development of algorithms and experimental implementations of quantum computers and quantum simulators dedicated to chemical systems. He has studied the role of quantum coherence in the transfer of excitonic energy in photosynthetic complexes, accelerating the discovery by calculating organic semiconductors, organic photovoltaic energy, organic batteries and organic light-emitting diodes.

Professor Aspuru-Guzik is currently the **Canada 150 Research Chair in Quantum Chemistry** as well as a **CIFAR AI Chair at the Vector Institute**.

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Paul Brumer


	University Affiliations: Chemistry CQIQC Chemical Physics Theory Group
	Website: Paul Brumer
	Keywords: Chemical Physics Quantum Mechanics

Paul Brumer and his research group focus on several problems in theoretical chemical physics, such as using lasers to control molecular processes; quantum dynamics on the nanoscale, and how it affects large-molecule processes such as photosynthesis and semiconductor behaviour; and issues in quantum mechanics such as decoherence and entanglement, and classical and quantum chaos.

Professor Brumer holds the rank of **University Professor**, accorded only to the top scholars at UofT.

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Glenn Gulak

	University Affiliations: Electrical & Computer Eng'rg Computer Engineering Group Electronics Group
	Website: Glenn Gulak
	Keywords: FPGAs Cybersecurity Biometrics Quantum cryptography, Quantum Security Quantum Information processing


Glenn Gulak's current research interests are focussed in two areas: algorithms, circuits and system-on-a-chip architectures for digital communications; and biological lab-on-a-chip microsystems.

Professor Gulak is the **co-founder of SHIELD Crypto Systems**, a UofT start-up whose system allows for the processing of encrypted information without first requiring decryption, thus offering protection from exposure to hackers. The system is designed to be resistant to attacks by the next generation of quantum computers.

Professor Gulak holds the **Canada Research Chair in Signal Processing Microsystems**. He currently serves as **Vice-President of the Publications Committee of the IEEE Solid-State Circuits Society**.

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Amr Helmy


	University Affiliations: Electrical & Computer Eng'rg Photonics Group CQIQC
	Website: Amr Helmy
	Keywords: Integrated Quantum Photonics Integrated Non-classical Light Sources Monolithic Nanophotonics Plasmonic Devices and Circuits Quantum Security

Amr Helmy's research interests include photonic device physics and characterization techniques, with emphasis on developing sensing and information processing solutions utilizing plasmonics devices and circuits, nonlinear and quantum photonics, and integrated quantum circuits. His lab engages in interference-facilitated photon pair separation, hyper-entangled sources in semiconductor waveguides, multiple polarization-entangled sources from monolithic semiconductor waveguides, and spectral engineering of photon pairs.

Professor Helmy serves as **Vice-President of the IEEE Photonics Society**.

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Peter Herman


	University Affiliations: Electrical & Computer Eng'rg Photonics Group
	Website: Peter Herman
	Keywords: Photonics Laser technology 3D Nanofabrication

Peter Herman's photonics lab researches 3D nanofabrication by laser holography. Direct writing with femtosecond lasers produces high flexibility to shape 1D, 2D, or 3D templates in photoresist. His group employs a novel phase mask approach to provide rapid writing of photonic band-gap structures, more stable than previous traditional approaches, providing high-volume low-cost manufacturing of photonic crystals. This technology has applications in the production of secure paper currency that cannot be counterfeited. Other applications include extending the Lab-on-a-chip concept to Lab-on-a-Fibre or Lab-in-a-Film microsystems.

Professor Herman is a **Fellow** of the **Optical Society of America**, and a member of the **IEEE Photonics Society**.

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Artur Izmaylov

	University Affiliations: Chemistry Physical/Env Sciences, UTSC CQIQC Chemical Physics Theory Group
	Website: Artur Izmaylov
	Keywords: Photovoltaics Chemical Physics Quantum Mechanics

Artur Izmaylov develops electronic structure and quantum dynamics methods on classical and quantum computers to obtain detailed understanding of quantum dynamics involving changes in spin, energy and charge states in organic photovoltaics, at metallic and semiconductor surfaces, and in bio-molecules. Quantum processes in these systems constitute crucial steps in many areas of fundamental and technological importance: solar energy conversion, UV-light DNA damage, magnetic field sensitivity in living species, catalysis at surfaces, and general surface chemistry.

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Daniel James

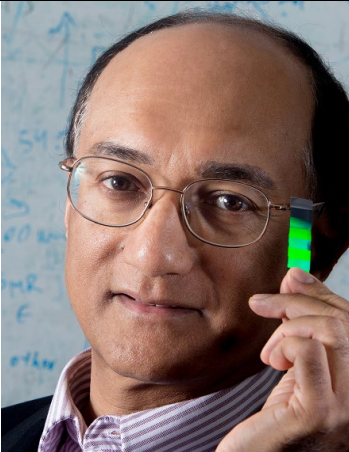
	University Affiliations: Physics CQIQC Quantum Optics Group
	Website: Daniel James
	Keywords: Quantum Optics Quantum Computing Entanglement theory Quantum Information processing

Daniel James and his team conduct theoretical physics research in quantum and classical optics. He is currently developing technologies exploiting fundamental quantum-mechanical phenomena such as entanglement for communications, computation and metrology. His team also works on advance imaging techniques, coherence theory, and light diffraction.

Professor James holds the **Canada Research Chair in Atomic and Optical Physics**.

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Sajeev John


	University Affiliations: Physics Quantum Condensed Matter Group Quantum Optics Group
	Website: Sajeev John
	Keywords: Physics Quantum Optics Photonics Nano-materials

Sajeev John is the co-inventor of the concept of Photonic Band-Gap materials, having introduced the theory of Classical Wave Localization during his PhD studies at Harvard. His current research investigates photonics, nano-science, the harvesting of solar energy, bio-sensors for medical diagnostics, and room-temperature Bose-Einstein condensation.

Professor John holds the rank of **University Professor**, accorded only to the top scholars at UofT. In 2017, he was named an **Officer of the Order of Canada**, "For his revolutionary contributions to optical sciences, notably for his role in the development of new structures capable of harnessing the flow of light." He is the recipient of numerous other awards over his career, and is a **Fellow** of **CIFAR** and numerous other prestigious organizations in Canada and worldwide.

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Raymond Kapral


	University Affiliations: Chemistry CQIQC Chemical Physics Theory Group
	Website: Raymond Kapral
	Keywords: Quantum Dynamics Complex Systems Chemical Physics

Raymond Kapral studies the behaviour of complex systems underlying modern developments in materials science, biochemistry, and quantum dynamics. A quantum mechanical approach to chemical systems can clarify understanding of quantum dynamics and quantum statistical mechanics of such systems, especially where transitions are induced among the quantum degrees of freedom. This can aid in understanding phenomena such as fluid turbulence, and instabilities in lasers and nonlinear optical devices.

Professor Kapral has been named a **Fellow** of the **Royal Society of Canada** and the **Chemical Institute of Canada**; he has also been named a **Fellow** of the **American Physical Society**.

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Hae-Young Kee

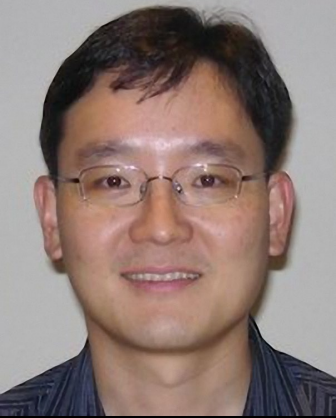
	University Affiliations: Physics Quantum Condensed Matter Group
	Website: Hae-Young Kee
	Keywords: Quantum Materials Quantum Physics Ultracold Atoms

Hae-Young Kee researches theoretical principles of emergent phenomena in complex quantum materials, considering the balance among charge, spin, lattice, and orbital degrees of freedom, and their interplay leading to rich physics. This research has implications for high-temperature superconductors, electronic liquid crystalline materials, ultra-cold systems, and thermoelectric materials. Her team's research interests include High-Temperature Superconductors, Frustrated Magnetic Systems, and Topological Materials.

Professor Kee holds the **Canada Research Chair in Theory of Quantum Materials (Tier I)**. She is a **Fellow** of **CIFAR** and the **American Physical Society**, as well as a **Distinguished Fellow** of the **Asia Pacific Center for Theoretical Physics**.

Return to U of T RESEARCHERS

Young-June Kim


	University Affiliations: Physics Quantum Condensed Matter Group
	Website: Young-June Kim
	Keywords: Magnetic Spectroscopy Quantum Materials Condensed Matter

Young-June Kim and his team study Advanced Materials, playing an increasingly important role in shaping the modern world, with quantum mechanics critical in determining physical properties of materials such as superconductors, thermoelectrics, multiferroics, and magnets. Professor Kim's team discovers new quantum materials, determining their magnetic and electric properties using advanced spectroscopic techniques using x-ray and neutrons.

Professor Kim is a **Fellow** of the **American Physical Society**, and held a **Goldhaber Fellowship** at **Brookhaven National Laboratory**.

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Hoi-Kwong Lo


	University Affiliations: Electrical & Computer Eng'g Physics CQIQC
	Website: Hoi-Kwong Lo
	Keywords: Quantum cryptography Quantum Information processing Entanglement theory Quantum random number generation Quantum key distribution

Hoi-Kwong Lo's current research interest is quantum information processing, particularly, the theory and experiment of quantum cryptography, entanglement theory, and quantum random number generation. In entanglement theory, he and Popescu derived some standard theorems in entanglement manipulations. In the theory of quantum cryptography, he has made several important contributions to the field.

Professor Lo is a **Fellow** of **CIFAR**, the Canadian Institute for Advanced Research.

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R. J. Dwayne Miller


	University Affiliations: Chemistry Physics Biological Physics Group Quantum Optics Group
	Website: Dwayne Miller
	Keywords: Physical Chemistry Quantum Systems Quantum Control

Dwayne Miller directs his research towards three interrelated areas: energy transduction in biological systems; interfacial structure and reaction dynamics; and high-order nonlinear laser spectroscopies as a novel probe of liquid and protein “memory” functions. His lab houses two femtosecond beam lines for atomically resolved dynamics studies, and has developed a number of new spectroscopic tools (coherent multidimensional spectroscopies, laser technologies) to track quantum state dynamics

Professor Miller holds the rank of **University Professor**, accorded only to the top scholars at UofT.

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Li Qian

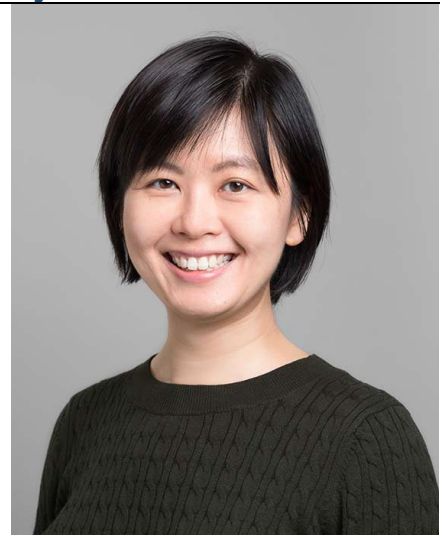
	University Affiliations: Electrical & Computer Eng'rg Photonics Group CQIQC
	Website: Li Qian
	Keywords: Photonics Quantum Optics Quantum Information processing Entanglement theory Quantum key distribution

Li Qian bridges the fields of quantum communication and fibre-based photonic technologies, making vital contributions to bringing quantum technologies from scientific possibility to commercial viability. Her team has also made significant impact in the field of optical metrology, developing technological innovations in fibre-based interferometers creating better methods for dispersion measurements and optical sensing.

Professor Qian’s team invented frequency-shifted interferometry, and some years ago demonstrated the first experimental decoy-state quantum key distribution system. She is currently a **Senior Member of the IEEE**.

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Joyce Poon


	University Affiliations: Electrical & Computer Eng'rg Photonics Group CQIQC
	Website: Joyce Poon
	Keywords: Photonics Silicon Photonics Neurotechnology Quantum Computing Fiber Optics

Joyce Poon and her team specialize in integrated photonic devices and circuits for communications and neurotechnology. For example, silicon photonics have implications for quantum computing. New developments in neurophotonics have possibilities for the neuroscience community.

Professor Poon is currently splitting her time between UofT and the **Max Planck Institute for Microstructure Physics in Germany**. She has held the **Canada Research Chair in Integrated Photonic Devices** since 2012

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Harry Ruda


	University Affiliations: Materials Science & Engineering CQIQC Centre for Advanced Nanotechnology OCCAM
	Website: Harry Ruda
	Keywords: Nanostructures Nanoelectronics Nanophotonics Quantum heterostructures

Harry Ruda's research interests focus on the fabrication and modelling of quantum functional nanostructures, with applications in the fields of nanoelectronics and nanophotonics. He developed some of the first theories of carrier transport in selectively doped quantum heterostructures, contributed to theories for the non-linear optical response of asymmetric quantum heterostructures, and published one of the first reports on growth of semiconductor nanowires.

Professor Ruda is a **Fellow of the Canadian Academy of Engineering (CAE)**.

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Dvira Segal


	University Affiliations: Chemistry Physics Chemical Physics Theory Group CQIQC
	Website: Dvira Segal
	Keywords: Quantum Physics Quantum Systems Quantum Control Quantum Thermodynamics Chemical Physics

Dvira Segal's research is focused on understanding the fundamentals of quantum chemical dynamics, quantum transport at the nanoscale, and quantum thermodynamics. Her team is addressing, from microscopic principles, novel applications in chemical dynamics, molecular-level electronics, thermal energy management and optoelectronics. Recent work is focused on the discovery of noise processes in atomic scale devices and development of nanoscale quantum machines that utilize quantum effects for operation

Professor Segal holds the **Canada Research Chair in Theoretical Chemistry**. She has recently been appointed **Interim Director of CQIQC, the Centre for Quantum Information and Quantum Control**.

Return to U of T RESEARCHERS

Ali Sheikholeslami


	University Affiliations: Electrical & Computer Eng'g Electronics Group Fujitsu Co-Creation Laboratory at the University of Toronto
	Website: Ali Sheikholeslami
	Keywords: Quantum Computing Digital Annealer High-speed signalling Memory Design

Ali Sheikholeslami and his collaborators at Fujitsu Labs created the world's first "Digital Annealer" – an important leap forward in quantum-inspired computing at higher temperatures than the near-absolute-zero required by true quantum computers. As a result of the 20-year partnership, Fujitsu Labs have built a research centre on the UofT campus, locating the digital annealer technology here. His research also studies analog and digital integrated circuits, high-speed signalling, and VLSI memory design.

Professor Sheikholeslami is currently the **Academic/Laboratory Head of the Fujitsu Co-creation Laboratory at the University of Toronto**

Return to U of T RESEARCHERS


John Sipe

	University Affiliations: Physics Quantum Optics Group
	Website: John Sipe
	Keywords: Quantum Optics Condensed Matter Physics Quantum Physics Quantum Information processing Photonics

John Sipe is a theorist specializing in quantum optics and condensed matter physics. His research focuses on the interaction of light (having no mass) with matter (having mass). This work is key to understanding behaviour central to implementation of quantum information processing and quantum computing.

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Aephraim Steinberg


	University Affiliations: Physics CQIQC Quantum Optics Group
	Website: Aephraim Steinberg
	Keywords: Quantum Physics Quantum Information processing Photonics Quantum Optics Entanglement theory Quantum Cryptography

Aephraim Steinberg and his team study fundamental quantum-mechanical phenomena, particularly quantum information processing. He also investigates control and characterization of systems ranging from laser-cooled atoms to individual photons. Current research interests include Bose-Einstein condensates and atomic tunneling, quantum information and quantum foundations with entangled photons; and light/matter interfaces at the quantum level.

Professor Steinberg holds the rank of **University Professor**, accorded only to the top scholars at UofT. He is also **Co-Director of the CIFAR program in Quantum Information Science**.

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Joseph Thywissen


	University Affiliations: Physics CQIQC Quantum Optics Group Ultracold Atoms Group
	Website: Joseph Thywissen
	Keywords: Photonics Quantum Optics Quantum Physics Quantum Simulation Ultracold Atoms

Joseph Thywissen studies ultracold atomic gases, investigating a variety of quantum mechanical condensed matter and atomic physics problems. His research group works with novel laser cooling techniques, quantum simulation, and quantum information. The team is also currently exploring Bose-Einstein Condensates.

Professor Thywissen is a Fellow of the **American Physical Society**.

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Sorin Voinigescu

	University Affiliations: Electrical & Computer Eng'rg Electronics Group
	Website: Sorin Voinigescu
	Keywords: Quantum Computing Silicon Computing

Sorin Voinigescu's research and teaching interests focus on nano-scale and atomic-scale devices, and their application in integrated circuits and systems-on-a-chip at frequencies beyond 500GHz, as well as silicon-based quantum computing. His current work aims to provide the benefits of quantum computing at a less resource-intensive cost by developing silicon-based monolithic quantum processor architectures within commercial large volume silicon foundry technologies.

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Amar Vutha


	University Affiliations: Physics Quantum Optics Group
	Website: Amar Vutha
	Keywords: Photonics Quantum Optics Quantum Physics Quantum Simulation Ultracold Atoms

Amar Vutha and his team measure atoms and molecules, looking for cracks in the structure of physical laws. This leads to research impacting new kinds of atomic clocks, searching for the electron electric dipole moment, and testing quantum electrodynamics using hydrogen. His work on improving accuracy and portability of atomic clocks will have implications for enhanced detection of gravity waves. He investigates the shape of certain atomic nuclei, and has also contributed to recent work on ascertaining the radius of the proton.

Professor Vutha currently holds the **Canada Research Chair in Precision Atomic and Molecular Physics (Tier II)**.

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Nathan Wiebe

	University Affiliations: Computer Science Physics CQIQC
	Website: Nathan Wiebe
	Keywords: Quantum Computing Quantum Algorithms AI/ML Quantum Simulation

Nathan Wiebe's research focuses on quantum algorithm development, in particular, on quantum methods for machine learning and simulation of physical systems. He has developed the first quantum algorithms for deep learning, and pioneered the use of particle filters for characterizing quantum devices. This research blends the growing field of quantum computing algorithms with UofT's global leadership in the field of AI and Machine Learning.

Professor Wiebe has recently joined UofT's faculty, in the Department of Computer Science; and is aligned with CQIQC, the centre of quantum studies at the university.

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SELECT TECHNOLOGY OPPORTUNITIES

U of T has flexible IP terms available to sponsoring partners. U of T's interest in IP developed through this research is "Inventors' Choice" where the inventors have the option to manage IP themselves, or to transfer IP to the university for management/commercialization (via the Innovations & Partnerships Office).

For all U of T technologies currently available for licensing, visit <http://uoft.me/tech-ops>

Quantum-Safe Communication

<https://research.utoronto.ca/technology-opportunities/db/quantum-safe-communication>

This technology includes a state-of-the-art encryption solution that leverages quantum technologies: Quantum Key Infrastructure (QKI). QKI Provides quantum-safe communication implementable with today's technologies; Eliminates all threats of classical and quantum computational attacks; Is cost-effective, ready today, and has strong demand in many different verticals; and can be used to secure communications (for in-transit data) or secure data encryption and authorization (for at-rest data), including use cases in VPN, cloud data, and mobile communication.

Shield Crypto Systems: GPU Implementation of RLWE Homomorphic Encryption with Secure Search and Spam-Filter Applications

<https://research.utoronto.ca/technology-opportunities/db/shield-crypto-systems-gpu-implementation-rlwe-homomorphic-encryption>

This technology is an optimized version of the Ring-Learning-With-Errors (RLWE) Fully Homomorphic Encryption (FHE) system. This proprietary system maintains encrypted data privacy of communications while still allowing cloud operations to be carried out on the encrypted data, such as key word searching and filtering. This technology is of interest to banks, credit card, and online payment processors, the intelligence establishment, and to large IT companies with a presence in cloud computing.

Infera AI: Platform for Digital Twins and Better Decision Making

<https://research.utoronto.ca/technology-opportunities/db/infera-ai-platform-digital-twins-and-better-decision-making>

A software platform that leverages statistical inference and machine learning to make more informed decisions. Through a novel combination of deep Bayesian learning and Bayesian analytics, the platform delivers accurate prediction statistics for robust, quantifiable, and interpretable analytics to scenarios that were previously too expensive or too slow.

Deep Learning Performance and Energy Optimization Techniques

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While algorithmic improvements will allow Deep Learning to evolve, much hinges on hardware's ability to keep delivering ever higher performance and data processing storage and processing capability.

This invention is a set of techniques that are valued-based methods for reducing the number of computations that need to be performed when executing Deep Learning Algorithms and do not require intervention from the Machine Learning expert.

By exploiting ineffectual computations, weight sparsity, precision variability, and bit content, the accelerator designs transparently reduce the amount of work that needs to be performed by neural networks. The methods lead to the design of performance-, energy-, and/or cost-optimized computing engines for various applications domains.

All work with out-of-the-box Deep Learning networks and rely on value properties exhibited by typical models such as value- and bit-sparsity and data type need variability, and reward model optimizations.