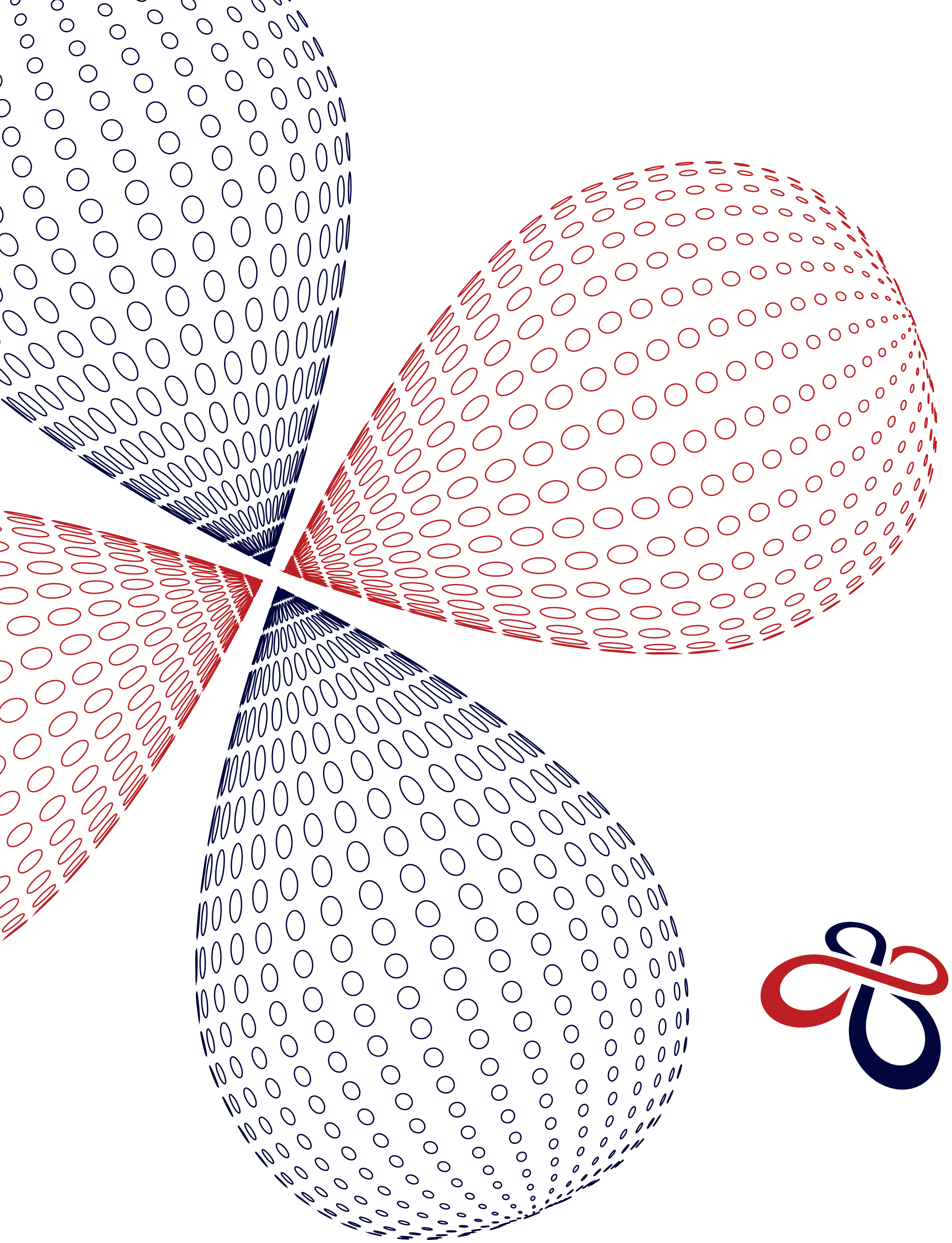

Stewart Blusson
Quantum Matter Institute
THE UNIVERSITY OF BRITISH COLUMBIA

ANNUAL REPORT 2018

Quantum Materials by Design

Creating the building blocks for future technologies that will transform the world

Mission

SBQMI fosters the discovery, understanding, and control of quantum materials and related novel materials and devices. We train the professionals who will translate this intellectual capital into economic benefits for Canada, and transfer the discoveries to industry to create next-generation technologies.

Vision

SBQMI aims to emerge at the forefront of its international peers in the field of quantum materials and devices, and aspires to nucleate an ecosystem of companies developing future technologies.

A macroscopic demonstration of a quantum effect is the magnetic levitating track, in which a high-temperature superconductor floats over a magnetic track. Once it is set in motion, and as long as it is kept colder than the transition temperature, the superconductor will float indefinitely.

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Our Funders

SBQMI is deeply indebted to the generous support of our funders, partners, and sponsors. Our research is made possible thanks in particular to the following individuals and organizations:

Stewart and Marilyn Blusson
University of British Columbia
Canada First Research Excellence Fund (CFREF)
Canada Foundation for Innovation (CFI)
British Columbia Knowledge Development Fund (BCKDF)
Natural Sciences and Engineering Research Council of Canada (NSERC)
Canada Research Chairs Program (CRC)
Canadian Institute for Advanced Research (CIFAR)
The Gordon and Betty Moore Foundation

We wish to express our sincere gratitude and appreciation for their support as their contributions have enabled SBQMI to exponentially accelerate research excellence and technology translation.

History

May 2010
Quantum Matter Institute (QMI) is Established Under the leadership of George A. Sawatzky

A group of faculty members at UBC establishes the Quantum Matter Institute (QMI). The group aims to break through boundaries around quantum material research through the collaborative effort of a multidisciplinary team that brings together physicists, chemists, and material scientists — a team of theoreticians, experimentalists, and engineers working closely together.

February 2012
QMI Broadens its International Presence

George Sawatzky, Director of QMI, and Bernhard Keimer, Director of the Max Planck Institute for Solid State Research in Stuttgart, lead the creation of the Max Planck-UBC Centre for Quantum Materials. It is the only international Max Planck Centre focused on quantum materials research and one of the few Max Planck partnerships outside of Germany.

January 2014
QMI's International Partnership Expands

QMI and UBC sign a Memorandum of Understanding with the Max Planck Society and the University of Tokyo to expand the Centre for Quantum Materials to also include the University of Tokyo.

January 2015
New Scientific Direction

Andrea Damascelli succeeds George Sawatzky as the new Director of the Quantum Matter Institute and joins Bernhard Keimer as co-director of the Max Planck-UBC Centre for Quantum Materials. His vision is to continue building an institute that will propel Canada to the forefront of quantum materials science and technology.

July 2015
QMI Wins Support to Begin its Transformative Growth

QMI receives a $66.5 million investment from the Government of Canada via the Canada First Research Excellence Fund (CFREF) to support its program, "Quantum Materials and Future Technologies." The award allows QMI to become Canada's quantum materials science and technology institute, with a mission to broaden research, foster learning, and strengthen translational efforts.

March 2016
QMI Becomes Stewart Blusson Quantum Matter Institute (SBQMI)

Vancouver-based diamond pioneer and philanthropist Stewart Blusson and his wife Marilyn donate $11M to quantum materials research at UBC, enabling the institute to further broaden and deepen its research capabilities. In recognition of the gift, the Stewart Blusson Quantum Matter Institute (SBQMI) has been named in honour of the geology alumnus (BSc '60).

April 2017
Max Planck-UBC-UTokyo Centre for Quantum Materials

A signing ceremony in Tokyo formalizes a 2014 MOU to engage in a 3-way partnership involving the University of Tokyo, the Max Planck Society, and UBC, opening new possibilities for scientific collaboration through workshops, conferences, joint research projects, and student exchanges.

May 2017
New Building Opens

After moving into its new, purpose-designed building, SBQMI expands its materials synthesis, characterization, and device development capabilities and embarks on a major expansion and upgrade of its nanofabrication facilities, electron microscopy, and lithography infrastructure.

June 2018
First Canadian Graduate Quantum Conference

Jointly hosted by the Canada First Excellence Research Fund (CFREF) institutes — SBQMI, Institute Quantique (IQ) at the Université de Sherbrooke, and the Transformative Quantum Technologies (TQT) program at the University of Waterloo — this 3-day conference showcases research from all three quantum research based institutes to foster early-career collaborations.

July 2018
Official Opening of SBQMI's Building Extension

The new 20,000-square-foot wing, with its state-of-the-art laboratory space and equipment, including vibration-free facilities for microscopy experiments down to the subatomic scale, gives SBQMI the resources needed to break into new frontiers of quantum materials research.

October 2018
Joint PhD Program Established

An MOU for a joint PhD program offered by the University of British Columbia and the University of Stuttgart is signed, with the Max Planck Society involved as a third partner in the agreement. The program is a natural extension of the Max Planck-UBC-UTokyo Centre for Quantum Materials. The agreement cements a collaborative and collegial relationship between SBQMI and the Max Planck Society of Germany, which has resulted in accelerated research excellence since the Centre was founded in 2012.

November 2018
"Grand Challenges" Call for Proposals Launched

Taking a crucial step towards our future by strategically investing in key research priorities, we launch the "Grand Challenges" call for proposals. Building upon the uniqueness of SBQMI's approach, the proposals are meant to identify bold ideas that will define SBQMI's research agenda for the next decade.

Evolution

Founded in 2010, SBQMI is an internationally-recognized multidisciplinary research institute at UBC with faculty members from physics, chemistry, and electrical and computer engineering, and expertise spanning theory, experiment, and device development in quantum materials.

This reputation has allowed SBQMI to form strong partnerships with renowned research institutes such as the Max Planck Society, the University of Tokyo, TRIUMF, the Canadian Light Source, the Canadian Centre for Electron Microscopy, and two other CFREF-funded institutes at the University of Waterloo and Université de Sherbrooke.

In 2018, SBQMI focused its resources on creating distinctive scientific opportunities through initiatives such as the "Grand Challenges" call for proposals launched in November. The submitted proposals will be developed into "flagship ideas" that will further rationalize and define our research themes. Successful proposals are expected to leverage SBQMI's expertise and state-of-the-art infrastructure, while contributing to our scientific identity as we design materials with ideal properties to serve as building blocks for future high-performance technologies. The funded projects will help formulate SBQMI's visionary research agenda for the next decade.

With the official opening of the building extension in July, SBQMI has been able to pursue several comprehensive renovation projects and lab upgrades, enhancing its capacity for materials research and development – from fundamental theoretical design all the way to device fabrication.

This year SBQMI established its first industry consortium with the inaugural meeting taking place next year. Focused on advancing the fabrication of silicon photonics devices, the industry consortium illustrates how SBQMI continues to support and grow its fundamental research program, while expanding into device development and technology translation, with the goal of nucleating a quantum technology hub in the international port city of Vancouver, BC.

MESSAGE FROM OUR SCIENTIFIC DIRECTOR

2018 was a year of growth and evolution for SBQMI — a year that entrenched our strategic and unique approach to research as well as institutional development. New faculty members Meigan Aronson, Steve Dierker, and Alannah Hallas, as well as our new Chief Operating Officer, Vis Naidoo, joined us, among others. We also welcomed two new affiliate members to the Institute: Kenji Kojima from TRIUMF and Robert Green from the University of Saskatchewan and the Canadian Light Source, bringing the total to 25 faculty members.

Although our team grew considerably, we lost a key team member: our former Managing Director, Sheila Moynihan, retired in early 2018. Sheila led our early organizational growth and development, and worked tirelessly to build SBQMI's culture and values. She recognized early on that SBQMI's excellence was not only determined by a group of faculty members sharing scientific endeavours and facilities, but rather, our shared goal was for SBQMI to be known for its scientific excellence and for bringing together a diverse team of scientists, students, and professional staff united by curiosity and a collective desire to further knowledge. On behalf of SBQMI, I want to express my deepest gratitude to Sheila for helping us build that early and critical institutional capacity — one of the key components enabling the growth SBQMI is experiencing today.

I am also very proud of our progress in embedding equity, diversity, and inclusion within our culture. This year, SBQMI was among the top three finalists for a BC Workplace Inclusion award. It was an honour to be recognized for our ongoing efforts in making science more diverse and inclusive. We also officially launched our Quantum Pathways program with the goal of encouraging young women and other underrepresented groups to pursue careers in science and engineering. We believe that developing and implementing programs like Quantum Pathways, to promote diversity and equity in science, is not just the right thing to do — it also significantly increases research outcomes and impact.

Our fruitful partnership with the Max Planck Society continues to expand and in 2018, we launched a joint PhD program with the University of Stuttgart in Germany. The program is an organic extension of the long-term collegial relationship between us. By combining these three prestigious institutions, students within the program will receive training opportunities unequaled anywhere else in the world.

Taking a crucial step towards our future by strategically investing in key research priorities, we launched the "Grand Challenges" call for proposals at the end of 2018. Emphasizing the uniqueness of SBQMI's approach, the proposals are meant to describe bold ideas that will define SBQMI's research effort for the next decade, and propel us on a clear trajectory towards world leadership. The thorough review process is already underway, and funding decisions will be announced in mid-2019.

Reflecting on where we were only 3 years ago, I am inspired by SBQMI's achievements during such a short period of time. There is still work to be done, but I look forward to the year ahead with enthusiasm and a deep appreciation for the talent and commitment of SBQMI's people. They are the ones who have made this growth possible!

Andrea Damascelli
Scientific Director

114 Students

41 QuEST Students

36 Postdoctoral Fellows

2 Affiliate Members

25 Faculty

5 Canada Research Chairs

16 Admin Staff

32 Scientific & Technical Staff

7 CIFAR Fellows

Our goal is to ensure that SBQMI comprises the professional personnel necessary to build a world-class institute while prioritizing the development of programs that support equity, diversity, and inclusion. In 2018, female representation among students was 24%, above the 20% reported by the American Institute of Physics in 2017. Likewise, 49% of our students and 56% of our postdoctoral fellows identified themselves as visible minorities.

Our Research Themes

What's in a theme? Research themes help to frame approaches, concepts, and understanding of quantum phenomena. They can help guide discussion in a complex dialogue that can have many different entry points. Because SBQMI evolved out of collaborations among scientists with diverse backgrounds, cultures, and expertise, in 2017, we invested in the articulation of SBQMI's Quantum Materials by Design research strategy, and identified five thematic areas. With our approach and identity evolving and maturing, in 2018, two of the five original research themes were merged under the advisement of our International Scientific Advisory Board (ISAB).

I

Atomic Level Design of Quantum Materials

This area explores materials in which strong local atomic interactions play a dominant role in determining electronic behavior and physical properties. Combining multi-scale modelling and calculations with highly advanced experimental characterization techniques enables rational design of novel quantum materials.

II

Emergent Electronic Phenomena at Interfaces

Heterostructures of atomically smooth interfaces of quantum materials exhibit emergent properties that do not exist in bulk. This extends the capacity for the rational atomic-level design of complex structures with tunable properties, creating a bridge from materials to devices, functionalities, and applications.

III

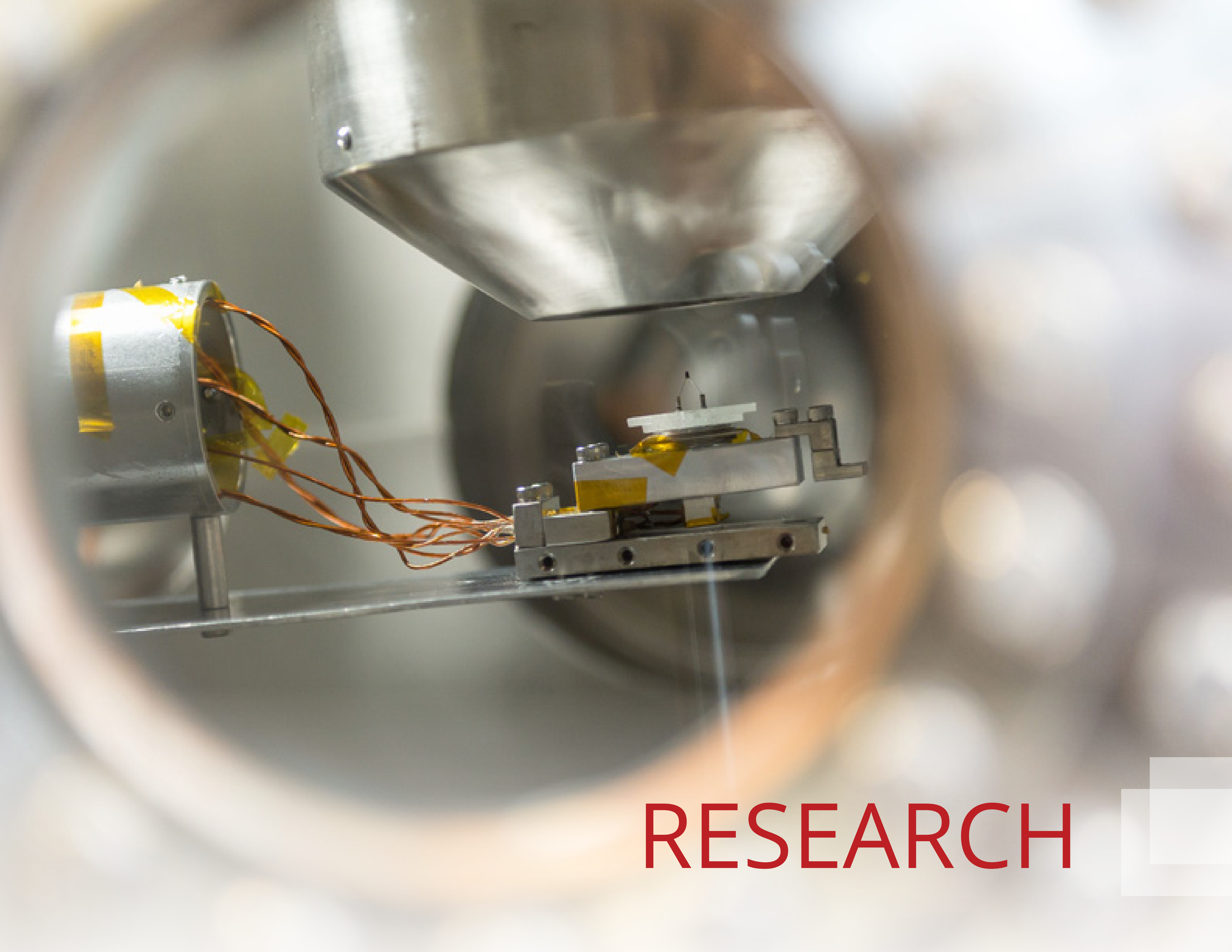
Topologically-Protected Quantum States

Materials with topologically-protected conducting or superconducting surface states exhibit many exotic phenomena. Topological protection of quantum states offers the potential to create a new class of quantum electronic devices that can leapfrog current efforts towards realizing quantum computing.

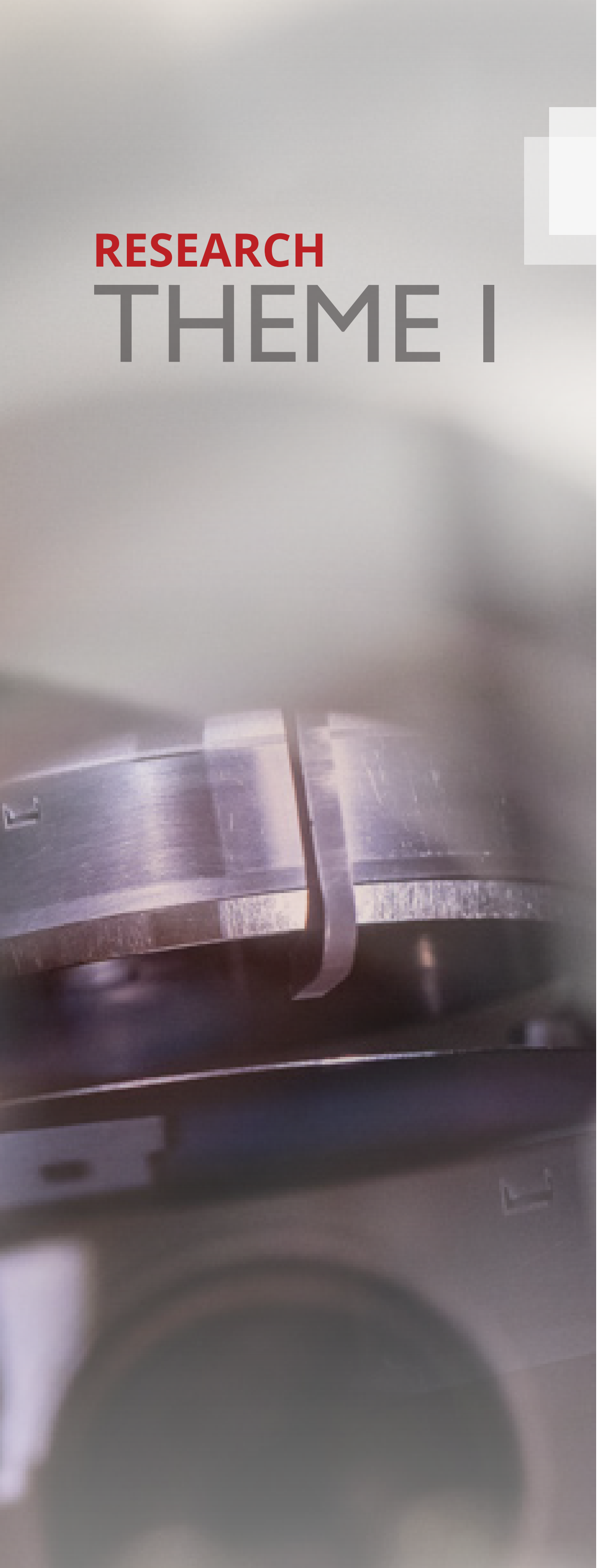
IV

Photonic Manipulation of Quantum States

This theme develops coherent light sources and photonic techniques to control spin, valley, and charge degrees of freedom in 2D van der Waals materials, oxide superconductors, and silicon photonic circuits, to explore unique approaches in quantum computing and discover optically driven states of matter.



RESEARCH



RESEARCH
THEME I

Atomic-Level Design of Novel Quantum Materials

SBQMI researchers are currently investigating a wide variety of materials that exhibit novel quantum behaviors. Approaches in this theme often combine multi-scale theoretical calculations with specialized characterization techniques to enable the deliberate design of new materials. Building on last year's achievements, in 2018 we worked on two new approaches.

First, we reconceptualized the possible reasons for superconductivity in monolayer iron selenide (FeSe). The work, led by Fengmiao Li and George Sawatzky, provides strong theoretical and experimental evidence that the replica bands observed in the high temperature iron-based superconductors (FeSC), such as FeSe, originate from extrinsic photoelectron energy loss rather than intrinsic coupling between the FeSe electrons and SrTiO3 phonons, as previously reported. In their study, Li and Sawatzky found that the time-dependent electric field generated by the fast-moving photoelectrons near the sample surface excites the SrTiO3 phonon resulting in the observable replica band in the ARPES experiments. Further photon-energy-dependent ARPES studies are underway with SBQMI's Zou and Damascelli groups to verify their theory. Published in Physical Review Letters, this work has quickly become impactful, and George Sawatzky was invited to deliver a presentation on this research at the 2019 APS March Meeting.

Next, a team of physicists from UBC — including SBQMI's Mona Berciu — and the Indian Institution of Technology identified a new possible approach to achieving high-temperature superconductivity by binding electrons to form tight, but very light, pairs that flow without resistance.

In electrical wires, electrons collide with metal ions and defects, producing heat and restricting the amount of current a conductor can carry. At very low temperatures, however, vibrations from the ions can bind electrons into Cooper pairs which flow without resistance. The result is a conventional superconductor. This binding is only stable at very low cryogenic temperatures however, limiting practical implementation.

The team studied the strong-coupling limit of Cooper pairs. "This traditional theory of electron-lattice coupling finds that the polaron and bipolaron masses increase quickly with increased electron-vibration coupling," says UBC theoretical physicist John Sous, first author of the study published in Physical Review Letters. "These very heavy particles aren't favourable for superconductivity, because the electrons must flow with ease to become superconducting."

In their study, the team shows that the mass increase does not occur if the vibrations modify the electrons' kinetic energy and not their potential energy. "These pairs can be very light because the lattice vibrations help the electrons to move together," says John Sous. "This points to a new direction in the search for vibration-mediated high-Tc superconductivity." Next, the team plans to study the validity of this mechanism in specific materials and under different conditions.

F. Li, G.A. Sawatzky.
Electron Phonon Coupling versus Photoelectron Energy Loss at the Origin of Replica Bands in Photoemission of FeSe on SrTiO3.
Phys. Rev. Lett. **120**, 237001 (2018).

J. Sous, M. Chakraborty, R.V. Krems, M. Berciu.
Light Bipolarons Stabilized by Peierls Electron Phonon Coupling.
Phys. Rev. Lett. **121**, 247001 (2018).

RESEARCH
THEME II

Emergent Electronic Phenomena at Interfaces

Researchers around the globe are currently working to harness the power of quantum materials and develop new transformative quantum devices. To accomplish this, researchers must develop a comprehensive understanding of complex quantum materials and how to control their functional properties. SBQMI researchers working under this theme investigate 2D electronic systems as a platform to realize quantum states. This lays the foundation for rational atomic-level design of complex structures with tunable properties, and creates a bridge from fundamental materials systems to the controllable functionality needed to build devices for a multitude of applications. One important development this year was the study of complex magnetic order in nickelate thin films published in Nature Physics.

The international team, which included researchers from SBQMI and Max Planck Institute (MPI) for Solid State Research in Stuttgart, demonstrated control over quantum material properties when they engineered nanoscale magnetism in ultra-thin films of nickel-oxide-based materials. The material, called a perovskite rare earth nickelate, is known to have a unique form of magnetism consisting of nanoscale spirals of atomic magnetic moments.

Led by Eva Benckiser and Bernhard Keimer, researchers at MPI grew the nickelate materials on a substrate having a particular crystal orientation, and synthesized a series of ultra-thin samples ranging from roughly 10 nm thick down to 1.5 nm. The UBC and MPI teams then conducted x-ray scattering experiments at the Canadian Light Source on the REIXS Beamline led by George Sawatzky and Robert Green, to study the magnetic properties of these ultra-thin materials. By applying a novel method of analysis to the scattering data, the researchers found that while the thicker samples exhibited the nanoscale spirals already known to exist, the thinnest films had no spirals and all the magnetic moments were forced to align in planes.

The team then developed a theoretical model to describe this strong and unexpected crossover in the magnetic behaviour, providing a toolkit for future studies to engineer similar magnetic crossover in other materials. Additionally, the results suggest that spiral and non-spiral states are very close in energy for films of appropriate thickness, and that researchers may be able to switch between these states using external stimuli. Future magnetic quantum devices could be constructed by taking advantage of this magnetic switching between spiral and non-spiral states.

M. Hepting, R.J. Green, Z. Zhong, M. Bluschke, Y.E. Suyolcu, S. Macke, A. Frano, S. Catalano, M. Gibert, R. Sutarto, F. He, G. Cristiani, G. Logvenov, Y. Wang, P.A. van Aken, P. Hansmann, M. Le Tacon, J.M. Triscone, G.A. Sawatzky, B. Keimer, E. Benckiser.
Complex magnetic order in nickelate slabs.
Nat. Phys. **14**, 1097 (2018).

RESEARCH
THEME III

Topologically Protected Quantum States

SBQMI researchers are playing a key role in modelling and designing topological materials with strong interactions. Robust topological protection of quantum states is predicted to be key in the creation of a revolutionary new class of quantum devices that are fundamentally more advanced than conventional electronics and with the potential to exponentially accelerate efforts towards realizing quantum computing.

Dongsheng Wang, Ian Affleck, and Robert Raussendorf asked the question: How can quantum information be protected from decoherence while being processed? Currently, software solutions exist as long as the quantum mechanical noise is kept below a critical value — limiting the use of the software to only certain applications.

In 2018, the team constructed quantum codes based on so-called SU(N)-symmetric valence-bond solids, protected by an energy gap. These codes have unusual transversal encoded gates, provided by a global and topologically protected twist operation.

The first step towards quantum fault-tolerance is to choose a type of quantum encoding, but this choice should be made in consideration of the road ahead. Many things beyond the issue of memory need to be worked out in order to compute fault-tolerantly. To date, essentially only a single family of quantum codes is known that meets a range of requirements: stabilizer codes. This code family is based on the principle that all quantum code words are eigenstates of Pauli observables. To appreciate the structural likeness among these codes, imagine all languages of this day were based on Sanskrit.

Thus, one may ask whether completely different kinds of quantum codes exist. While primarily a question of fundamental interest, it has a practical angle too. Stabilizer codes solve most tasks well, but they tend to incur a large operational overhead in their implementation. This motivates the search for new types of quantum codes, leading to different methods and architectures of fault-tolerant quantum computation.

By demonstrating fundamental features of valence-bond solids and symmetry-protected topological order for quantum error correction and quantum memory, which can also be generalized to other valence-bond solids or crystals, Affleck and Raussendorf presented a family of such alternative quantum codes. A comparison to stabilizer codes would be premature, but research has shown that the new codes do well in one particular discipline: they implement large and previously undemonstrated sets of transversal encoded gates, simplifying computation on encoded quantum data.

D.S. Wang, I. Affleck, R. Raussendorf.
Topological Qubits from Valence Bond Solids.
Phys. Rev. Lett. **120**, 200503 (2018).

Photonic Manipulation of Quantum States

Coherent light waves can be exploited to read out or manipulate quantum states of matter with high fidelity. SBQMI researchers are developing a variety of novel light sources and photonic techniques to control spin, valley, and charge degrees of freedom in 2D van der Waals materials, oxide superconductors, and silicon photonic circuits. This year, using an ultrafast laser source funded by the Gordon and Betty Moore Foundation, SBQMI researchers deepened the current understanding of the superconducting phase transition in cuprates.

Scientists have long debated the key ingredient that enables the cuprates to become superconducting at such high temperatures: Does superconductivity emerge when electrons bind together in pairs, known as Cooper pairs, or when those pairs establish macroscopic phase coherence? Thanks to very recent advances in pulsed-laser sources, the SBQMI team lead by David Jones and Andrea Damascelli was able to take a new look at this longstanding, fundamental question.

The research indicates that the presence of an attractive “glue” binding electrons into pairs is necessary but not sufficient to stabilize the superconducting state. Rather, the Cooper pairs must behave coherently as a whole to establish a line of communication, with a single macroscopic quantum phase.

“Broadly speaking, you can imagine phase coherence akin to a large ensemble of arrows all aligned in the same direction,” said Fabio Boschini, lead author of the study and a postdoctoral fellow at the SBQMI. “When the Cooper pairs, sketched as arrows, point in random directions, phase coherence is lost.”

Graphic work by postdoctoral research fellow Christopher Gutiérrez who modelled the cooper pairs in the 3-D graphic and animation software, Blender. The change in coloration from the centre suggest the different states in superconductivity.

The phase coherence emerges on a time scale of few hundreds of femtoseconds (one femtosecond equals one quadrillionth of a second). Leveraging the pulsed laser sources and facilities at SBQMI’s new UBC-Moore Centre for Ultrafast Quantum Matter, researchers established a new investigative technique to “watch” what happens to the material’s electrons during those ultrafast timescales. The effort revealed the key role of phase coherence in driving the transition into the superconducting state of copper oxides.

“Thanks to very recent advances in pulsed-laser sources we are only just beginning to visualize the dynamic properties of quantum materials,” said Andrea Damascelli, leader of the research team and the Scientific Director of the SBQMI. “By applying these pioneering techniques, our research team aims to reveal the elusive mysteries of high-temperature superconductivity and other fascinating phenomena of quantum matter.”

F. Boschini, E.H. da Silva Neto, E. Razzoli, M. Zonno, S. Peli, R.P. Day, M. Michiardi, M. Schneider, B. Zwartsenberg, P. Nigge, R.D. Zhong, J. Schneeloch, G.D. Gu, S. Zhdanovich, A.K. Mills, G. Levy, D.J. Jones, C. Giannetti, A. Damascelli.
Collapse of superconductivity in cuprates via ultrafast quenching of phase coherence.
Nat. Mater. **17**, 416 (2018).

GRAND CHALLENGES

How can quantum physics research address global challenges?

In November 2018, SBQMI launched a “Grand Challenges” call for proposals open to all institute members. The call was framed around addressing a grand challenge currently facing Canadians and the world. Proposals leveraging SBQMI’s expertise and state-of-the-art infrastructure, involving collaborative work across multiple SBQMI groups, and using approaches under one or more of our four research themes, were particularly encouraged.

Building upon the uniqueness of SBQMI’s approach, the proposals are meant to identify bold ideas that will define SBQMI’s research agenda for the next decade. The range of conceptualization and innovation in the submitted proposals is impressive, and an exhaustive review process is underway. The successful proposals will be announced next year.

(Left to right) Andrea Damascelli, Stewart and Marilyn Blusson, Santa Ono, and George Sawatzky at opening of Stewart Blusson Quantum Matter Institute

Stewart Blusson Quantum Matter Institute exterior. Design by PUBLIC Architecture + Communication. Photo: Paul Joseph

Grand Opening of Stewart Blusson QMI Building

On July 4, UBC honoured Stewart and Marilyn Blusson for their support of a major expansion to the Vancouver campus' Brimacombe Building, home of the Stewart Blusson Quantum Matter Institute. The new 20,000-square-foot wing, with its state-of-the-art laboratory space and equipment, including vibration-free facilities for microscopy experiments down to the subatomic scale, gives the Stewart Blusson QMI team the resources needed to break into new frontiers.

UBC President Santa J. Ono was joined by the Blussons to unveil a plaque as a tribute to their support. "The research happening today in the field of quantum physics is already changing the world," said Prof. Ono. "And with the incredible support of Stewart and Marilyn Blusson, UBC will continue to be at the penetrating cutting edge of quantum physics for many years to come."

"This facility is absolutely essential for our team's research," said Andrea Damascelli, Scientific Director of the Stewart Blusson QMI. "Before, we had too many experiments that couldn't move forward without the proper facilities. The groundbreaking work of researchers with the institute—now all housed under the same roof—will be accelerated, thanks to the increased new capacity. We're most grateful for Stewart and Marilyn's unprecedented support to make this all possible."

Stewart Blusson is a geologist, businessman and philanthropist who co-discovered Canada's largest diamond mine, triggering billions in new exploration and deep crustal research. He is one of UBC's most distinguished alumni, and he and his wife, Marilyn, are leading university donors. In 1998, they gave $50 million—the largest ever donation to the university—which greatly expanded UBC's capacity to pursue basic research and innovation. They built on their generosity with the $11 million investment in the Quantum Matter Institute, which was named for Stewart in 2016.

Since its inception in 2010, the Stewart Blusson QMI has been recognized for world-class research, which has enabled the UBC Faculty of Science to attract a number of talented quantum physicists.

"This institute is bringing the next generation of top researchers to Canada and to UBC," said Stewart Blusson. "We're thrilled that this new facility will enable the kind of fundamental research that is so important for advancing modern science and technology. This is just the beginning."

SBQMI would like to express sincere appreciation for the generous support and donation of Stewart and Marilyn Blusson.

INFRASTRUCTURE

Infrastructure

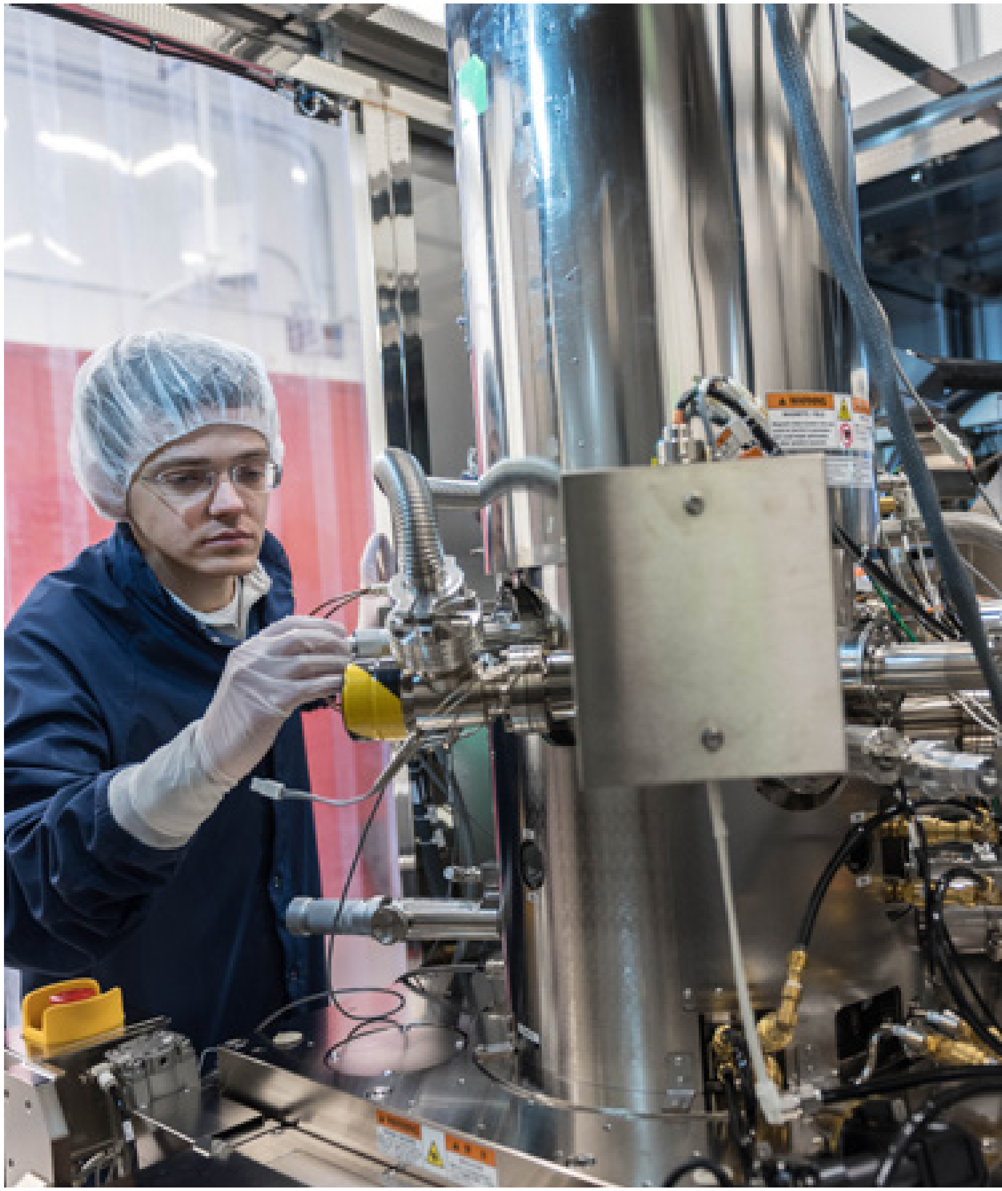
Quantum materials research examines the broad range of quantum properties and requires substantial investment in infrastructure and facilities. More recently, SBQMI has invested in the areas of device fabrication and materials synthesis: from the purchase of an electron beam lithography (EBL) machine, to a comprehensive Nanofabrication Facility upgrade, to a fully-equipped Machine Shop capable of handling SBQMI's custom fabrication needs.

In 2018, the expansion of our research programs resulted in the development of a high magnetic field lab spearheaded by Joshua Folk, a new facility for investigating nanophotonics and 2D materials with Ziliang Ye, and a twin-chamber molecular-beam epitaxy (MBE) apparatus in Ke Zou's lab for the growth of transition-metal oxides and chalcogenides and the in-situ study of their electronic structure by ARPES (angle-resolved photoemission spectroscopy). An EBL tool that enables high-precision chip-writing at the nanoscale was commissioned in a dedicated cleanroom—free of vibrations and electromagnetic noise. At the same time, under Sarah Burke's and Doug Bonn's leadership, work on a 4-probe scanning tunneling microscopy (STM) instrument, and a combined ARPES-STM system, is underway in two state-of-the-art vibration- and acoustic-noise-free laboratory spaces.

Nanofabrication Facility

The newly renovated Nanofabrication Facility, operated by five dedicated engineers and managed by Director Kostis Michelakis, will enhance SBQMI's ability to conduct world-class research. This state-of-the-art infrastructure and associated expertise will also be made available to industry partners to provide advanced fabrication services. Indeed, the Nanofabrication Facility is also the cornerstone of the SiEPICfab industry consortium recently established under Lukas Chrostowski's leadership.

In Phase 1 of the facility upgrade, we installed and commissioned a state-of-the-art JEOL JBX-8100FS electron-beam lithography tool that enables device fabrication at the nanoscale, where quantum properties of materials primarily manifest themselves. The device uses an intense, well-formed, and focused beam to directly write features of a few nanometers in size across wafers up to 8 inches, and is the first instrument of its kind to be installed in Canada.

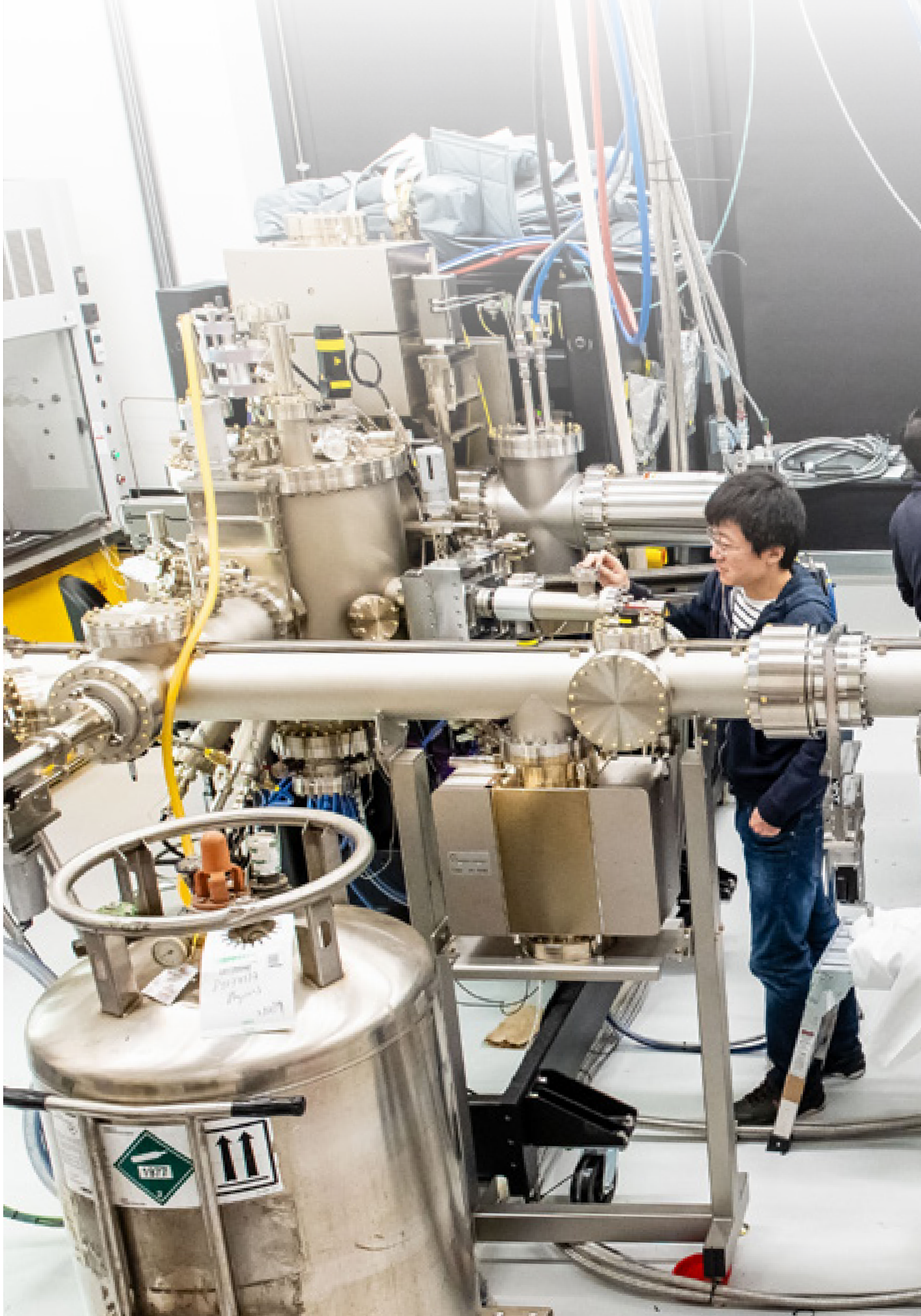


Dual-chamber MBE Lab

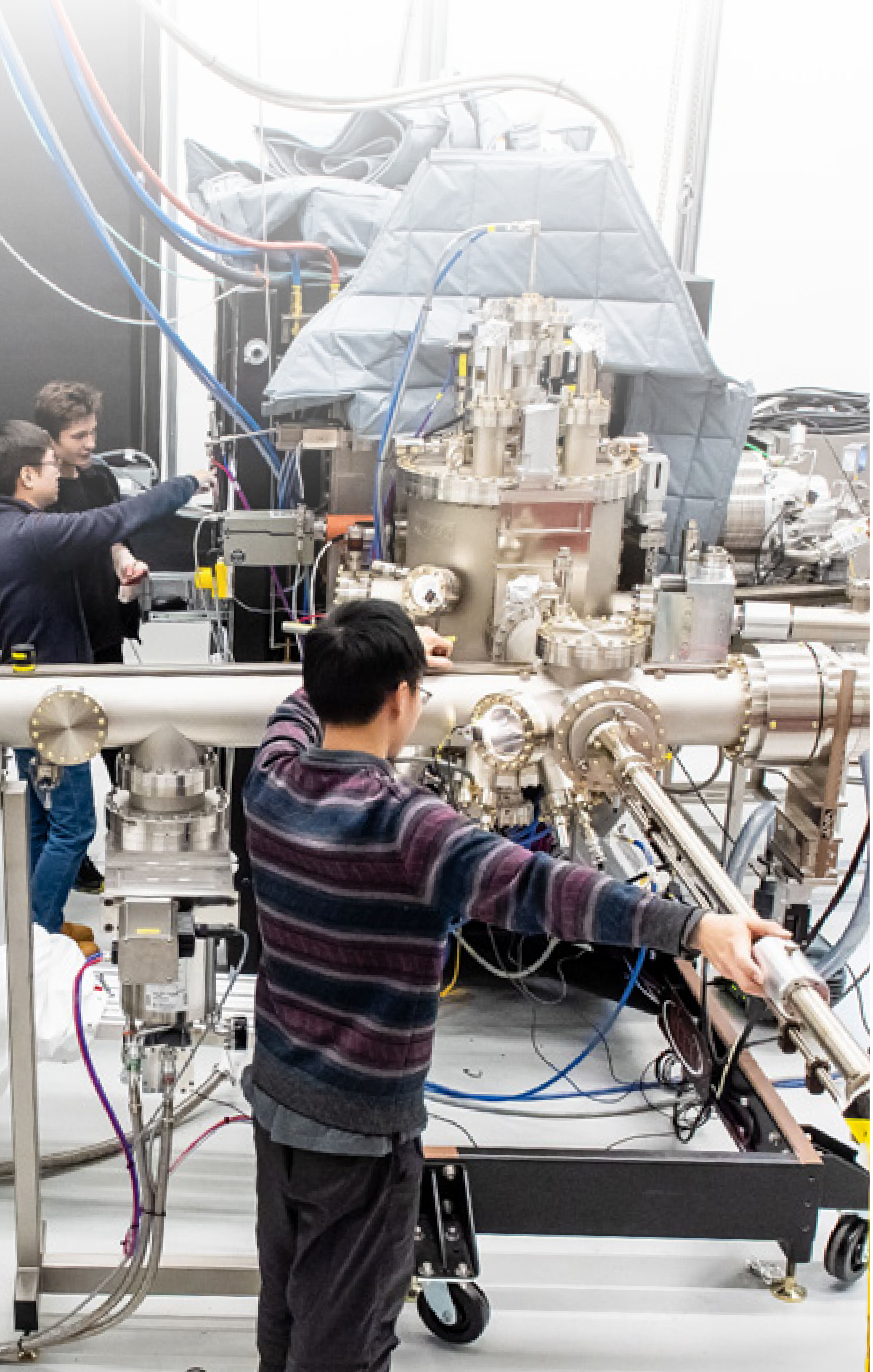
In the last several decades, research on materials and devices has been supporting the rapid economic growth of Canada and industrial innovations, particularly owing to semiconductor-based technologies. More recently, atomic-thick two-dimensional (2D) material systems, such as graphene, metal chalcogenides, and complex oxides, have become a new playground for physicists and material scientists to search for new functionalities beyond those offered by conventional metals and semiconductors.

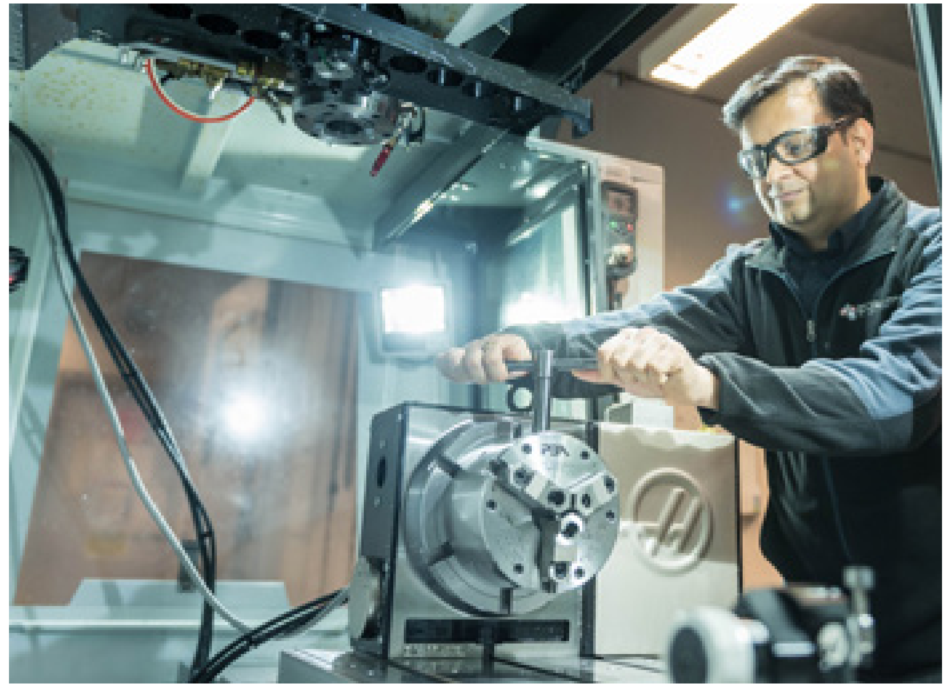
As one of the most advanced synthesis techniques, MBE allows the growth of materials layer-by-layer in an ultra-high-vacuum environment, and the control of the composition of individual atomic layers. The elimination of defects in the synthesized materials is essential for the expression of intrinsic functional properties. In 2D systems and heterostructures, the quantum confinement and interface effects can lead to substantial modifications in electronic and magnetic properties. A prominent example of such interface effects is the greatly enhanced superconducting transition temperature of monolayer FeSe on $SrTiO_3$.

Under Ke Zou's leadership, we pursue scientific and technological breakthroughs exploiting the high tunability of 2D quantum materials. We developed state-of-the-art instrumentation combining a dual-chamber MBE for the growth of transition-metal oxides and chalcogenides—with ARPES—to study the electronic structure of air-sensitive materials in situ. We will further integrate the MBE+ARPES system with nanofabrication techniques, to probe and control the properties of quantum materials and devices.



The MBE Lab featuring a double-chamber-MBE+ARPES system, for the growth and in situ study of transition-metal oxides and dichalcogenides.



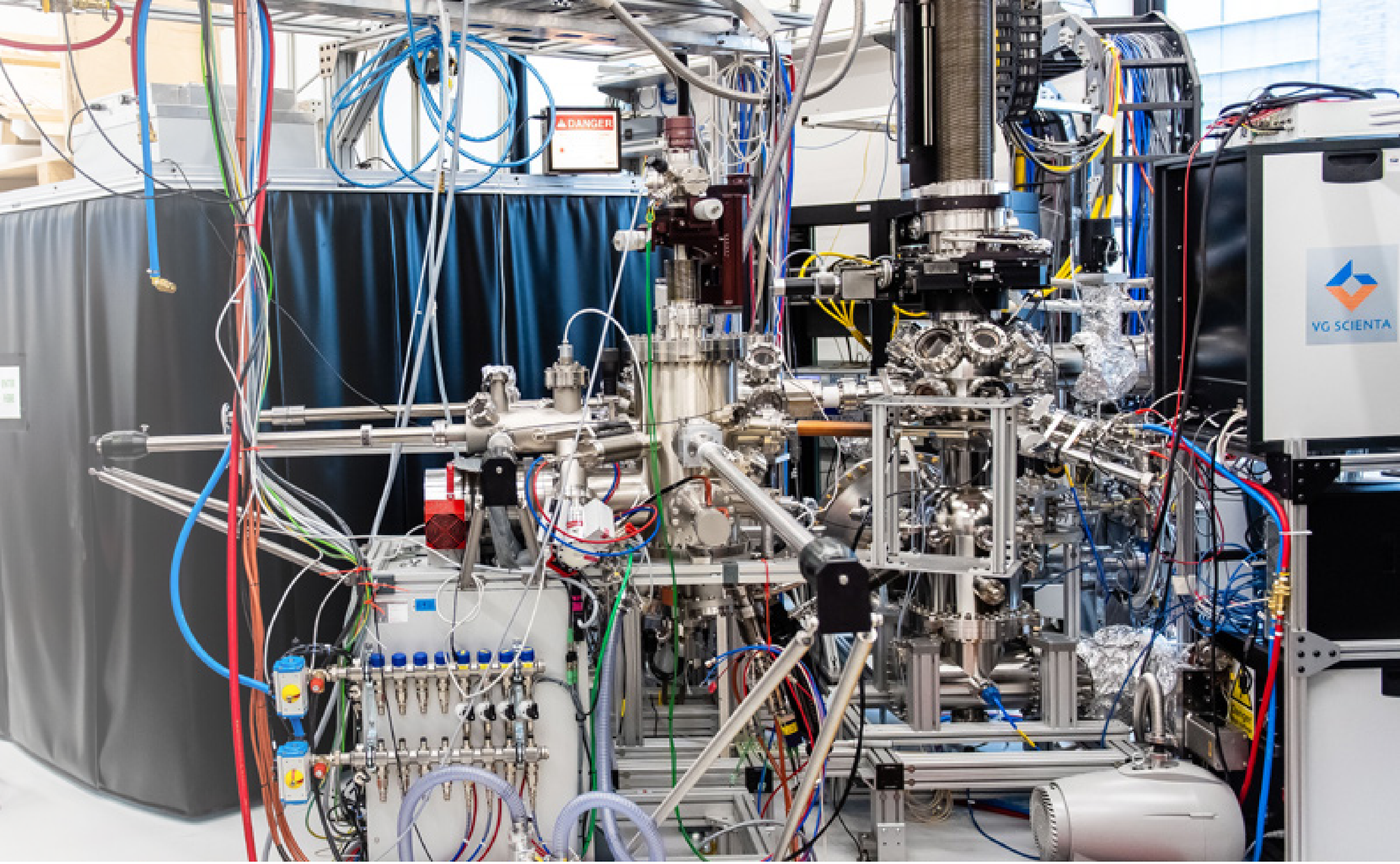


Machinists Harish Gautam and Dilyar Arkin (not pictured) monitor and support the development of custom-made tools and components in the Machine Shop.

Machine Shop

Innovation often emerges out of necessity. Specialized lab work makes it essential for researchers to develop customized tools, components, and parts to advance their research. The Machine Shop is part of the integrated fabrication suite available to SBQMI researchers and offers a wide range of services. It is equipped with CNC mills, lathes, and will soon house a high-precision 3D printer.

Additionally, graduate students and other HQP have access to a small dedicated student workshop—within the Machine Shop and under the supervision of professional staff—to develop the tailored components and parts needed to complete their projects.



"This combination of state-of-the-art tools and approaches enables us to conduct experiments that condensed matter physicists around the world have yearned to perform, but which have remained out of reach with existing instrumentation. Fine-grained measurements of the electronic structure at subatomic and ultrafast scales will be key to disentangling relevant electronic interactions within novel quantum materials, and unleashing their full potential for future technologies."

- Andrea Damascelli

The Beast: Low-temperature Scanning Tunneling Microscopy Lab

In a state-of-the-art vibration-free facility, an ultra-low temperature scanning tunneling microscope is being set up. Research Associate James Day is demonstrating the depth of the supportive platform.

EXPLORING THE SCIENCE

Research institutes have a vital role to play in educating the public about new advances and sharing the wonders of scientific discoveries.

Education and Outreach

In order to foster public curiosity in quantum materials research and engagement with tomorrow's young scientists, SBQMI works in concert with various UBC programs, affiliated institutes, and local school districts. SBQMI members have long been active in science outreach activities throughout Greater Vancouver, with many of our scientific staff regularly participating in school demonstrations. We actively seek and support opportunities for students to join these activities as volunteers or presenters, as these experiences encourage the development of their science communication and presentation skills. In this section, we present examples of some of these outreach initiatives.

Experience Science Day

Each year, 150-200 elementary school students from the Vancouver Downtown East Side visit the UBC Vancouver campus to participate in hands-on activities in a variety of science topics. Launched in 2010, the Physics & Astronomy Outreach Program hosts this UBC event with support from SBQMI, Math, Computer Science, Michael Smith Laboratories, Let's Talk Science, Beaty Biodiversity Museum, and Pacific Museum of Earth.

Science Rendezvous with UBC

Science Rendezvous is an annual festival held across Canada showcasing the "Art in Science." In 2018, SBQMI participated in the UBC day-long event with activities that followed the theme of "Full S.T.E.A.M. Ahead!" This theme emphasized an interdisciplinary approach to research and innovation in science, technology, engineering, art, and math. One of the most popular activities was an SBQMI-led demonstration of a magnetic levitating track. The demonstration and open house attracted nearly 1,000 visitors to the Institute.

Bringing Quantum into Classrooms with UBC Geering Up

Teachers are experts at connecting lessons to everyday life, and bringing their classrooms into the world. Engineering is about applying science to everyday life, connecting theory and practice. When teachers and engineers are brought together, an exciting program of possibilities can be developed to encourage early interest in the sciences.

Represented by graduate student, Ketty Na, SBQMI joined UBC Geering Up to deliver an introduction to quantum physics workshop to K-12 educational professionals from the Greater Vancouver area with the goal of supporting classroom science activities for grades 4 to 7. Workshop participants left equipped with ideas, inspiration, and teaching toolkits for developing and running spectroscopy demonstrations.

Katarina Smith from UBC Geering Up and Ketty Na from SBQMI before a professional development workshop with teachers looking to expand their repertoire of science experiments to teach concepts from quantum physics.

SBQMI's Operations Manager, Pinder Dosanjh, prepares for a magnetic levitation track demonstration

Equity, Diversity and Inclusion (EDI)

One reason for encouraging EDI in any workplace is that diversity makes us "smarter," giving us access to resources and perspectives that we might not normally encounter if we were to limit recruitment to established pools. SBQMI has been proactive in this endeavour by encouraging applicants from a wide range of backgrounds, and through its network of national and international partners has been fortunate to attract students, postdocs and faculty from diverse cultures. What follows are demonstrable examples of our commitment to improving the status of women and underrepresented minorities in the sciences.

SBQMI Recognized as a Top Three Finalist for an UnTapped Workplace Inclusion Award

In 2018, SBQMI was among the top three finalists for the 2018 BC Workplace Inclusion Award, as selected by UnTapped — an organization that brings together hundreds of BC employers for topical discussions of common recruitment challenges and solutions in regards to underrepresented groups including women, visible minorities and people with disabilities. Forty organizations were nominated in the small business category of "Workplace Diversity & Inclusion Champion."

The UnTapped Gala celebrates BC businesses and individuals who have demonstrated a commitment to foster workplace diversity and inclusion. Tapping into new talent pools is a top priority for BC businesses, and the demand for skilled workers across all industry sectors and professions continues to grow; yet, many employers find themselves confronting labour shortages — affecting their growth capacity and hindering competitiveness. Successful companies are developing strategies for engaging non-traditional talent pools within marginalized communities such as indigenous peoples, candidates with disabilities, recent immigrants, women, youth, and mature workers.

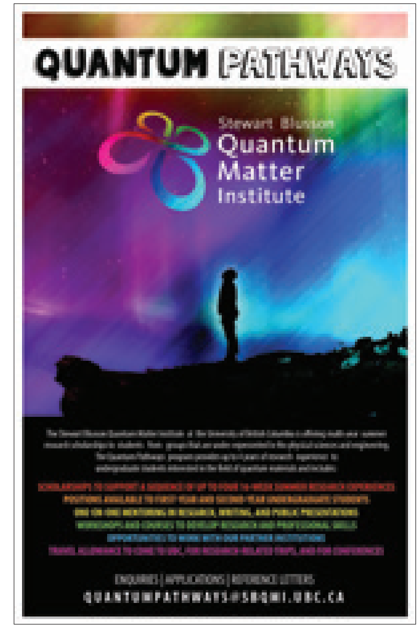
SBQMI is committed to promoting diversity and inclusion amongst its students, faculty, and staff, and is proud to receive this recognition. As a research institute and learning center, SBQMI strives to attract a diverse world-class talent pool, and create outreach opportunities that specifically encourage women and other underrepresented groups to pursue careers in science and engineering.

Quantum Pathways

In 2018, SBQMI launched a multi-year summer research scholarship program for women and other underrepresented groups who are undertaking studies in the physical sciences and engineering. The Quantum Pathways program provides up to 4 years of summer research experience in SBQMI to undergraduate students, providing them with training and hands-on experience in quantum materials.

Program highlights:

- Undergraduate scholarships to support a sequence of 16-week summer research positions, over four years
- One-to-one mentoring in research, writing, public presentations, and career preparation
- Workshops and coursework to develop professional skills
- Opportunities to work with our international partner institutions
- Travel allowance for attending research and conferences



QuIWI and Bridging Indigenous Ways of Knowing with Western Ways of Doing Research

In April 2018, thanks in part to funding from Westcoast Women in Engineering, Science and Technology (WWEST) and eng•cite, we launched a one-week outreach program for indigenous female high school students from the Greater Vancouver area. Working closely with the Vancouver School District and the North Vancouver School District to select participating students, our innovative program — Quantum Indigenous Women Initiative (QuIWI) — aims to inspire a new generation of scientists.

The students worked closely with several of our scientific groups by engaging directly in laboratory work. Participants were also given dedicated tours of Science World at Telus World of Science, TRIUMF (Canada's national laboratory for particle and nuclear physics), and the Museum of Anthropology at UBC - renowned for its display of world arts and cultures, with a distinct emphasis on First Nations peoples and other cultural communities of British Columbia.

The inaugural week began with a public panel hosted at Science World on "Bridging Indigenous Ways of Knowing with Western Ways of Doing Research." Panelists included influential indigenous community leaders as well as SBQMI's Scientific Director, Andrea Damascelli. The event was highly successful and brought awareness of indigenous ways of knowing to the SBQMI community and the public at large, while demonstrating SBQMI's spirit of inclusivity and respect.

Conferences, Training Programs and Signature Events

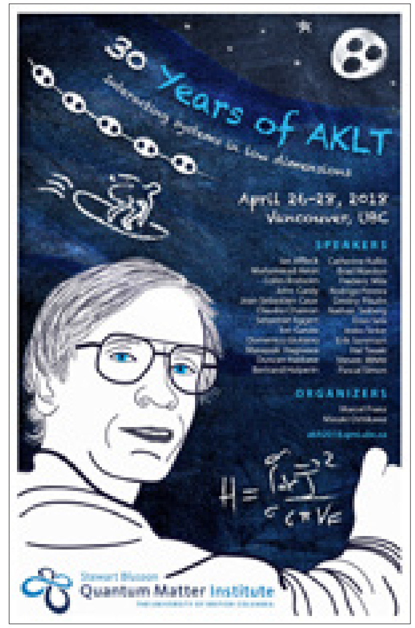
Another component of SBQMI's commitment to our community is centred around knowledge exchange through conferences, workshops, and brainstorming sessions. Through the Condensed Matter Seminar series, visiting scholars are invited to present one-hour talks to SBQMI's students, postdocs, faculty, and staff. In 2018, the series saw participants from Harvard, MIT, the Max Planck Institute for Solid State Research in Stuttgart, the Weizmann Institute of Science, the University of Illinois, and Stanford University, to name a few.

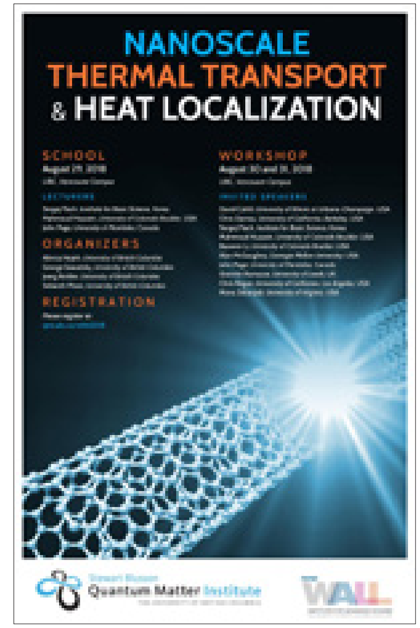
Faculty, students, postdocs, and staff are also actively involved in organizing and participating in brainstorming sessions and workshops on specific topics, which bring together researchers from different institutions and disciplines. Our signature events in 2018 included an August school and workshop on Nanoscale Thermal Transport & Heat Localization, which brought world experts together to discuss recent progress and combine different perspectives for tackling open questions on this topic. Another signature event was a three-day symposium marking the 30th anniversary of the Affleck-Kennedy-Lieb-Tasaki (AKLT) model, which is an exactly solvable model for quantum spins in one dimension. Thirty years ago, this model would go on to illustrate and foreshadow many key properties of low-dimensional interacting systems that are being explored today.

First Annual Canadian Graduate Quantum Conference

SBQMI hosted the first annual Canadian Graduate Quantum Conference in June 2018. This three-day graduate conference was jointly organized by the three Canada First Excellence Research Fund (CFREF) recipients in quantum science and technology: SBQMI at UBC, Institute Quantique at the Université de Sherbrooke, and Transformative Quantum Technologies at the University of Waterloo.

Through poster sessions, student talks, lab tours, networking sessions, and special keynote speaker presentations, the conference provided a detailed survey of the research taking place across Canada. Open to all students and postdoctoral fellows completing quantum research in Canada, the event offered graduate students the opportunity to learn about current research initiatives in Canada, while fostering early-career networking between academic institutions and also with industry partners.





Quantum Electronic Science and Technology (QuEST) Program

SBQMI's core student training program is QuEST, an integrated study program combining access to world-class researchers and facilities, with opportunities to develop professional skills both locally and internationally. QuEST is an enriched graduate program aimed at increasing the quantity and quality of graduate students in quantum material research. Its goal is to engage students in an international research network and connect these future thinkers and entrepreneurs with academic and industry partners.

Programs and Careers

SBQMI develops programs and workshops for undergraduate and graduate students, as well as postdocs, including experimental and technical training, mentoring, career panels, internships, and various outreach programs aimed at high schools and underrepresented groups such as indigenous peoples, women, visible minorities and LGBTQ groups.

STUDENTS AND ALUMNI

Students

SBQMI's value as a learning institute is its ability to offer students a multicultural, multidisciplinary, hands-on environment that encourages collaboration across groups to build a culture of rapport and critical engagement. Students are given the opportunity to engage with international partners and industry collaborators to explore career options. A collegial atmosphere encourages students to develop research, planning, communication, and collaborative skills through participation in committees, talks, and conference presentations. Students are supported in their efforts to lead local outreach activities in schools and with indigenous communities.

I came to SBQMI from my home city of Sichuan because it is a very advanced quantum material research institute. With Mark's group, I have learned how to conduct a project, how to research, and how to write articles. SBQMI is one of the most advanced institutes in this field in the world. Lectures and seminars have opened my mind to research in biology and physics with which I had never had contact before.

Yuanyuan Cao, Postdoctoral Fellow in the Mark MacLachlan Group

I came to SBQMI because of the scope of its activities on both the theoretical and experimental side. It is the wonderful cooperation between physicists, chemists, engineers, and even entrepreneurs that really got me interested in the program.

Stepan Fomichev is part of the Mona Berciu Group. Stepan will present the results of his work on rare-earth nickelates, obtained in collaboration with Max Planck Institute member Giniyat Khaliullin, at the American Physical Society's 2019 March Meeting.

When you're looking for a place to do your postgraduate studies, your research is a priority. At UBC, SBQMI offers a unique environment. It enables cutting-edge research, while fostering a wonderfully collaborative community.

Alexandra Tully is a graduate student working with David Jones and Sarah Burke, and an active member of SBQMI's Student Committee.

When you go on beamtime you're working on a team... where everyone is in it together, and supporting each other, and learning from each other as well.

Cissy Suen is a graduate student in the joint PhD program, a collaborative undertaking with the Max Planck Society and the University of Stuttgart. She is co-supervised by Bernhard Keimer at MPI Stuttgart and Andrea Damascelli at SBQMI.

ALUMNI INTERVIEW WITH RICCARDO COMIN

Now a full-time Assistant Professor at MIT, Riccardo Comin is an alumnus of the Stewart Blusson Quantum Matter Institute (SBQMI), where he received his PhD in 2013 under Andrea Damascelli's supervision. In January 2018, he joined SBQMI's Lukas Chrostowski in a career panel hosted at UBC, and through the Condensed Matter Seminar series presented his group's most recent findings on nanoscale charge and spin texture in quantum solids.

Curiousity as a driver of new techniques and research approaches

Thanks to a UBC 4-year graduate fellowship (4YF), Riccardo was able to pursue his PhD studies at SBQMI. It was a life decision involving a range of challenges, from learning a new language, and adapting to a different environment, to the difficulty of maintaining connections with family and friends back home. However, he has no regrets about making the move: "The environment here is unique. You sometimes hear about the world's ranking of universities in broad categories, such as science or physics, but if one were to do a specific ranking of best places for quantum materials, UBC would no doubt be among the top 5 on the global scene."

Riccardo was present in the early 2010s when the idea of an institute dedicated to the study of quantum materials research was realized. Commenting on the cross-pollination between theory and experiments that has always been engraved in the core philosophy of SBQMI thanks to the leadership of scientists like founding Director George Sawatzky — one of the few people in the world who can embrace both aspects — Riccardo explains: "theories of the quantum many body problem are very complex. To uncover the exotic properties of quantum solids, it is essential for theorists and experimentalists to work together."

In regards to SBQMI's recent expansion in the range of lab and approaches, as well as technical and scientific staff, under the direction of Andrea Damascelli, Riccardo remarks, "It's because the more you find out, the more you want to discover. And to know more, you need more techniques. You need higher energy resolution, higher levels of brightness, lower temperatures. You need new facilities, new probes, new approaches. And then come new ideas and expanded knowledge."

And Riccardo concludes: "The Institute creates an interdisciplinary and highly collaborative environment that is coherently focused on an intriguing set of problems. It's a privilege to work in such a special context, where we are given the opportunity to apply our passion for science and follow our intellectual curiosity. It's the kind of place where you fall in love with quantum materials, that's what SBQMI is, and UBC is one of the world's leading environments for its research."

Joint CFREF Projects Announced

Three of Canada's most recognized centres in quantum-related research are collaborating on five new joint research projects. The three centres are all recipients of funding from the Canada First Research Excellence Fund (CFREF): SBQMI at UBC, Institut Quantique (IQ) at the Université de Sherbrooke, and Transformative Quantum Technologies (TQT) program at the University of Waterloo. Each of these five quantum research projects looks to accelerate breakthrough science by connecting expertise among the institutions over the next 2 years.

"There are amazing opportunities at the interfaces of research efforts," said David Cory, principal investigator of TQT. "These joint research projects build on the complementarity of the three quantum CFREF programs, extending the reach of their accomplishments and speeding development."

Final proposals were selected based on scientific significance with results expected within 2 years. Headed by collaborative networks of investigators among the three centres, each proposal makes use of knowledge, technical resources, and infrastructure unique to each centre.

The breadth and range of investigative approaches highlights the potential for advanced research among collaborating institutions across Canada. The model offered by this joint institutional effort is potentially one that could be used to map networks of resources among quantum institutions around the world.

"I am most excited about these new collaborative efforts," said Andrea Damascelli, Scientific Director at SBQMI. "Bringing together our strengths will advance Canada's position as a global leader in quantum materials and technologies."

Alexandre Blais, Scientific Director at IQ agrees: "We're cementing Canada's place on the world stage. Working together on breakthrough quantum science benefits not only the scientific outcomes but also the training of the quantum technology leaders for Canada and the world."

Building upon this first inter-institutional effort, the three CFREF-funded centres plan to further their collaboration on future endeavours.

The current list of the first round of joint projects is given below:

(1) Quantum computational resources in the presence of symmetry
This joint IQ, SBQMI and TQT proposal involves an approach to improve fault tolerance in quantum computation in order to improve its computational power and robustness.
Researchers: David Poulin (IQ), Robert Raussendorf (SBQMI), Joseph Emerson (TQT)

(2) Novel high-speed SPAD arrays for quantum communication
CMOS single-photon detectors will be investigated in an innovative approach to quantum detector and quantum receiver technology in this joint IQ and TQT proposal.
Researchers: Thomas Jennewein (TQT), Serge Charlebois (IQ), Jean-François Pratte (IQ)

(3) Combined momentum and real-space photoelectric probes of dimensionality-tuned Weyl semimetals
This joint TQT and SBQMI proposal aims to bridge the divide between quantum materials and quantum devices to harness topological protection for future technologies.
Researchers: Adam Wei Tsen (TQT), Christopher Gutierrez (SBQMI), Andrea Damascelli (SBQMI)

(4) Industrially relevant spin-3/2 hybrid quantum devices
In this joint proposal from IQ and SBQMI, a silicon prototype hybrid quantum device will be developed that could offer electrical control and longer coherence times for viable commercial technologies.
Researchers: Joe Salfi (SBQMI), Eva Dupont-Ferrier (IQ), Michel Pioro-Ladrière (IQ),

(5) Planckian dissipation in strange metals
This joint submission from IQ and SBQMI will investigate quantum materials for their "strange metal" behavior, which is qualitatively different from that of conventional metals and is believed to bear direct relation to unconventional superconductivity.
Researchers: Louis Taillefer (IQ), Fabio Boschini (SBQMI), Andrea Damascelli (SBQMI)

Our International Partnerships

Enhancing our global connectedness and international research engagement is a fundamental requirement to sustain and enhance our role as leaders in quantum materials research. The deep international partnerships formed thanks to SBQMI's extreme proclivity to collaborate has accelerated scientific progress and brought diverse cultural and scientific perspectives together.

Joint PhD Program

Last October, the president of the Max Planck Society, Dr. Martin Stratmann, the President of the University of Stuttgart, Dr. Wolfram Ressel, and the President of the University of British Columbia (UBC), Professor Santa Ono, signed a Memorandum of Understanding to establish a joint PhD degree program.

"This agreement combines the excellent education and training opportunities of the International Max Planck Research School for Condensed Matter Science (IMPRS-CMS) and the long-standing research collaborative of the Max Planck-UBC-UTokyo Centre for Quantum Materials," states Dr. Bernhard Keimer, co-director of the centre.

Since 2010, the Centre has created a forum for scientific exchange and collaboration, which has enabled important discoveries in quantum materials research. Through student mobility agreements, young scientists are given opportunities to experience the spirit of international collaboration and to contribute to a rapidly evolving research frontier.

A central mission is to establish research opportunities at different career stages. Initiatives hosted through the Centre offer flexible appointments, ranging from a few months as a visiting scientist to a few years as a postdoctoral fellow or a PhD student. Openings for a number of top-tier Max Planck-UBC-UTokyo Fellowships offer candidates the chance to conduct research in an international setting, while additional learning opportunities for students are created through joint summer and winter schools. In December 2018, the Centre hosted a winter school at the Hongo Campus of the University of Tokyo.

German Ministry Visit

In recognition of the deep collaborative research effort ongoing under the aegis of the Max Planck-UBC-UTokyo Centre for Quantum Materials, in October 2018 SBQMI received a delegation led by German Federal Minister for Education and Research, Anja Karliczek, and composed of members from the Federal Ministry of Education and Research, the Bundestag Committee on Education, the Research and Technology Assessment, and the German Consulate in Vancouver. The delegation toured SBQMI facilities, TRIUMF, and the National Research Council of Canada offices located at UBC.

UPCOMING INTERNATIONAL EVENTS

While focusing its energy on expanding the reputation of its scientific program, in 2018 SBQMI made the deliberate decision to pursue opportunities to host international events and bring top international experts to BC to share their expertise. As a result, SBQMI successfully won competitive bids to host two prominent conferences forthcoming in 2020 and 2021. Both of these conferences are prestigious because of their distinguished reputations and the calibre of specialized expertise among participating delegates.

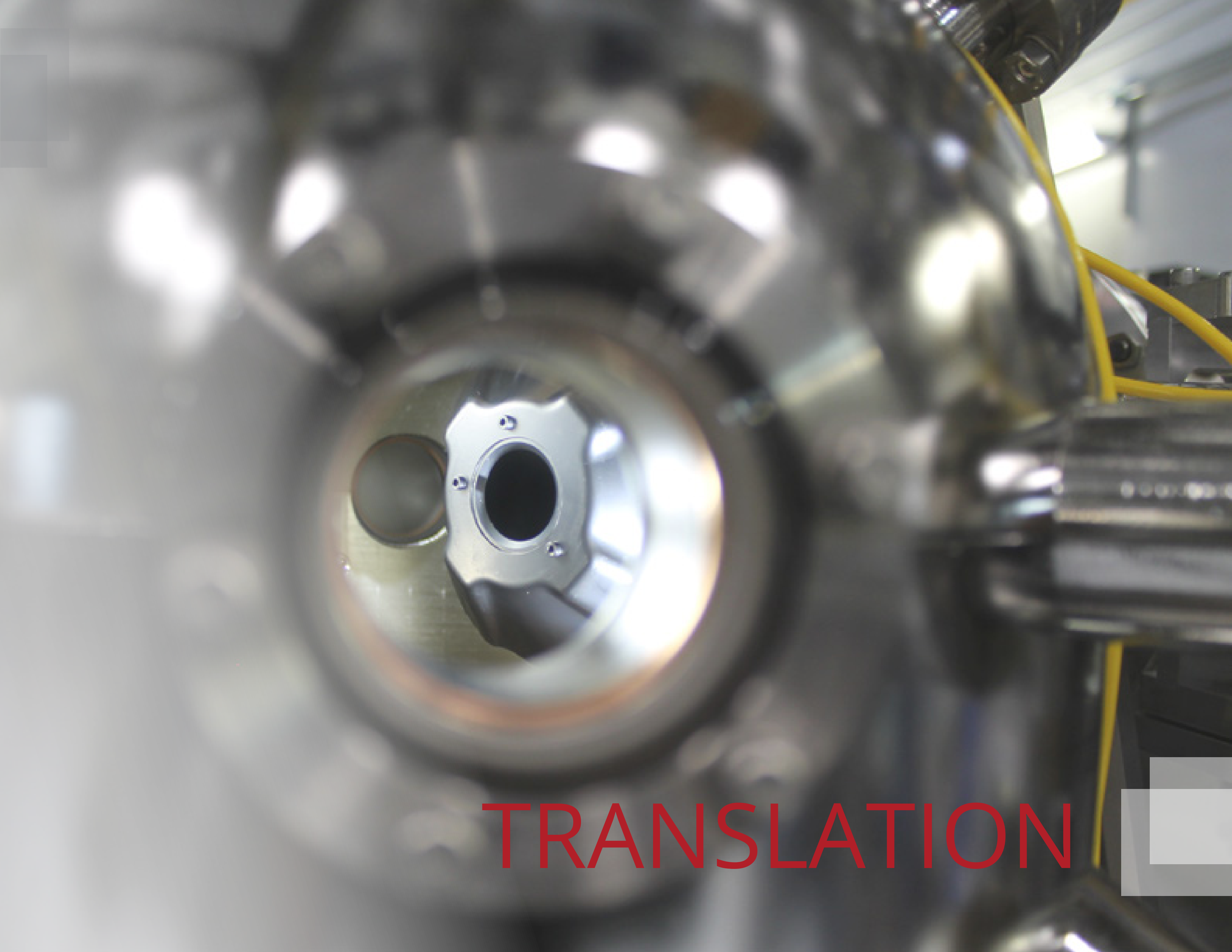
2020 International Conference on Nanoscience and Technology (ICN+T)

In summer 2020, SBQMI will host the International Conference on Nanoscience and Technology (ICN+T). The conference attracts over 500 international attendees with leading edge expertise in Scanning Probe Microscopy instrumentation and use. ICN+T brings together leading academic scientists, researchers and scholars to exchange and share their experiences and research results on all aspects of Nanoscience and Technology, providing an interdisciplinary platform for scientists, practitioners and educators to present and discuss the most recent innovations, trends, and concerns.

2021 International Conference on Materials and Mechanisms of Superconductivity (M^2S)

SBQMI will host the 2021 M^2S 2018 conference, an international event on superconductors and mechanisms of superconductivity held every three years. Since 1988, the conference has taken place in Palo Alto (1989), Kanazawa (1991), Grenoble (1994), Beijing (1997), Houston (2000), Rio de Janeiro (2003), Dresden (2006), Tokyo (2009), Washington (2012) and Geneva (2015). The aim is to provide a platform for members of the international superconductivity community to report their latest results, exchange information and foster collaborations. The conference is dedicated to all aspects of basic superconductivity research in materials, mechanisms and phenomena of superconductivity, and its applications.

Hosting these events will enable SBQMI to showcase Canadian quantum materials research and create a value-adding global network centred around the international port city of Vancouver.



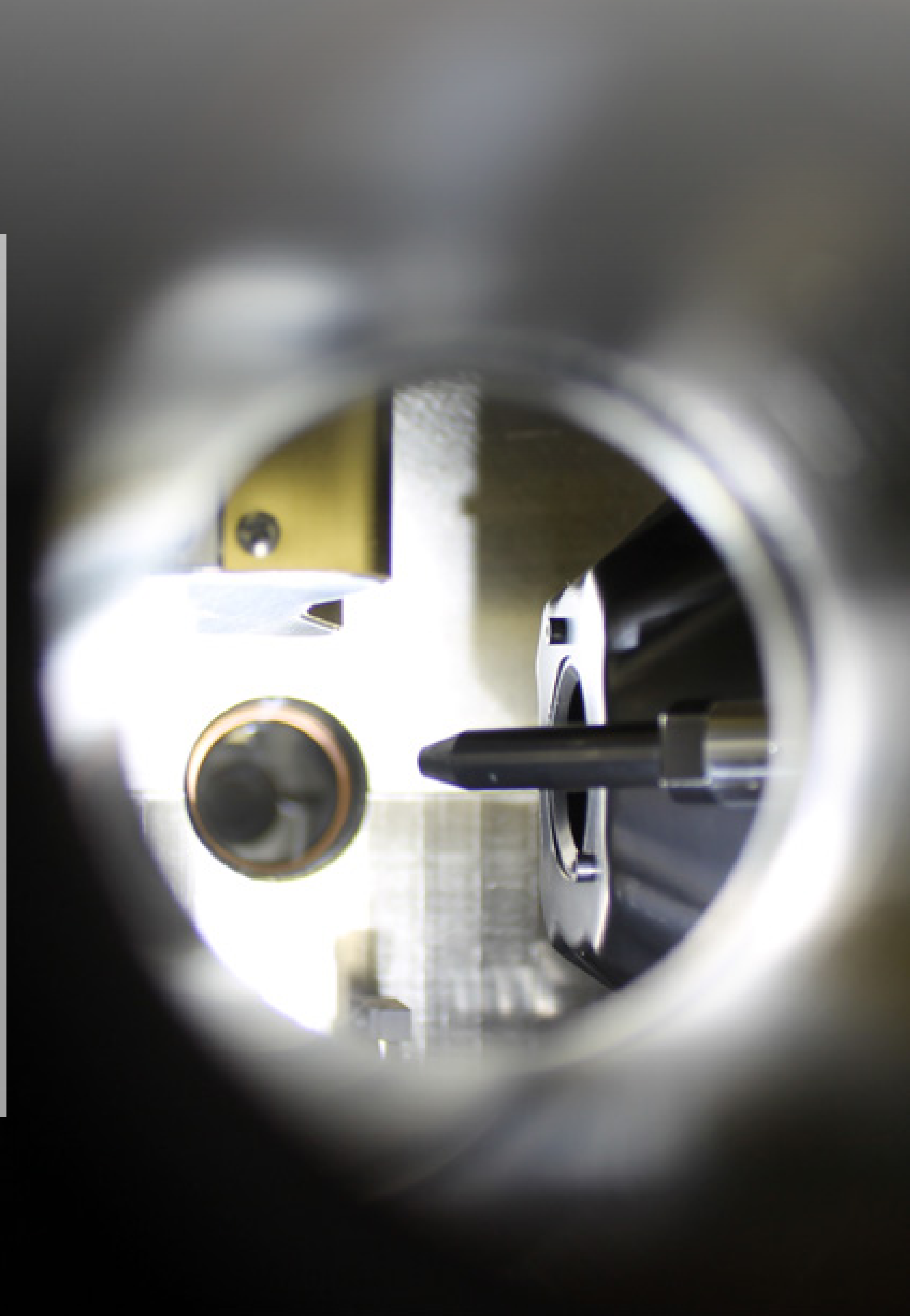
TRANSLATION

Translation

Research at SBQMI has the potential to spark breakthroughs with applications in quantum computing, telecommunications, clean energy, health and much more. But for this value to flow from the laboratory to the wider world, tangible progress must be communicated and transferred to industry. With funding from CFREF, and thanks to a dedicated Business Development team led by Executive Director Karl Jessen, SBQMI has been able to leverage local, national, and global connections to enhance the impact of our research, and accelerate the translation of our quantum materials research.

DARPA

SBQMI's George Sawatzky and his team are providing theory and modelling support for the development of an electronic switch potentially capable of replicating neuron/synapse functionality with the goal of enabling true neuromorphic computing. This three-year project titled "Synapses and Neurons Using Correlated Electron Devices (SyNCED)" is being supported with funding from the US Defense Advanced Research Projects Agency (DARPA), and undertaken with industry partner, Applied Materials, a US-based leader in material engineering solutions used in innovative chip and display technology.



SiEPICfab: the Canadian Silicon Photonics Foundry

In 2018, under Lukas Chrostowski's leadership, we established our first formal industry consortium: SiEPICfab.

The consortium is an organic extension of the SiEPIC research training program that has roots dating back to 2007, and was funded via an NSERC-CREATE grant between 2012 and 2018. The training program has offered 20 workshops to date, and taught more than 315 students from 34 different universities. In fact, it was in part in response to the slow turnaround times and the high cost of international foundries, experienced by SiEPIC researchers, that the SiEPICfab consortium was formed.

SiEPICfab's goal is to fabricate and demonstrate novel photonic devices and functions for emerging applications, such as quantum computing, 5G wireless communications, chip-scale switching networks, and Internet of Things (IoT) technology.

In the short-term, SiEPICfab will advance the fabrication of silicon photonic devices and photonic integrated circuits. By making leading-edge silicon photonic manufacturing accessible to Canadian and international academic and industry partners, SiEPICfab will help fast-track the development of rapid prototyping and device fabrication for users.

A longer-term goal is to support a premier ecosystem of companies involved in silicon photonics product development and photonics-based quantum devices in Canada.

Currently, the consortium consists of several companies and three universities, including Université Laval, McGill University, and the University of British Columbia. The founding industry partners involved in the modelling, design, fabrication and testing of silicon photonics are:

1. Aeponyx
2. Applied Nanotools
3. Ciena Canada
4. GenISys
5. Huawei Technologies Canada
6. Keysight Technologies
7. Lumerical
8. Luxmux
9. Qoherence Instruments

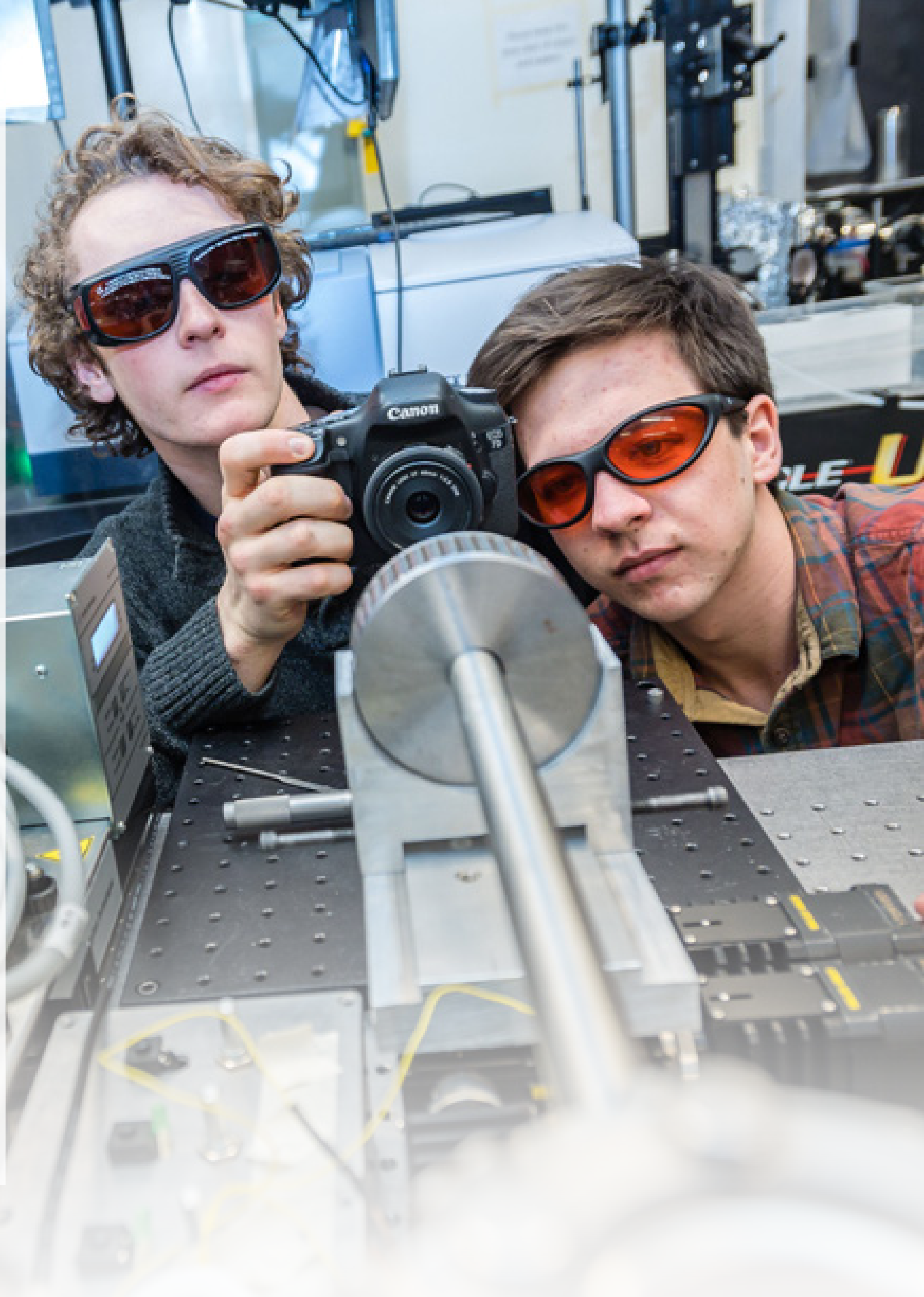
An AweSEM™ Undertaking

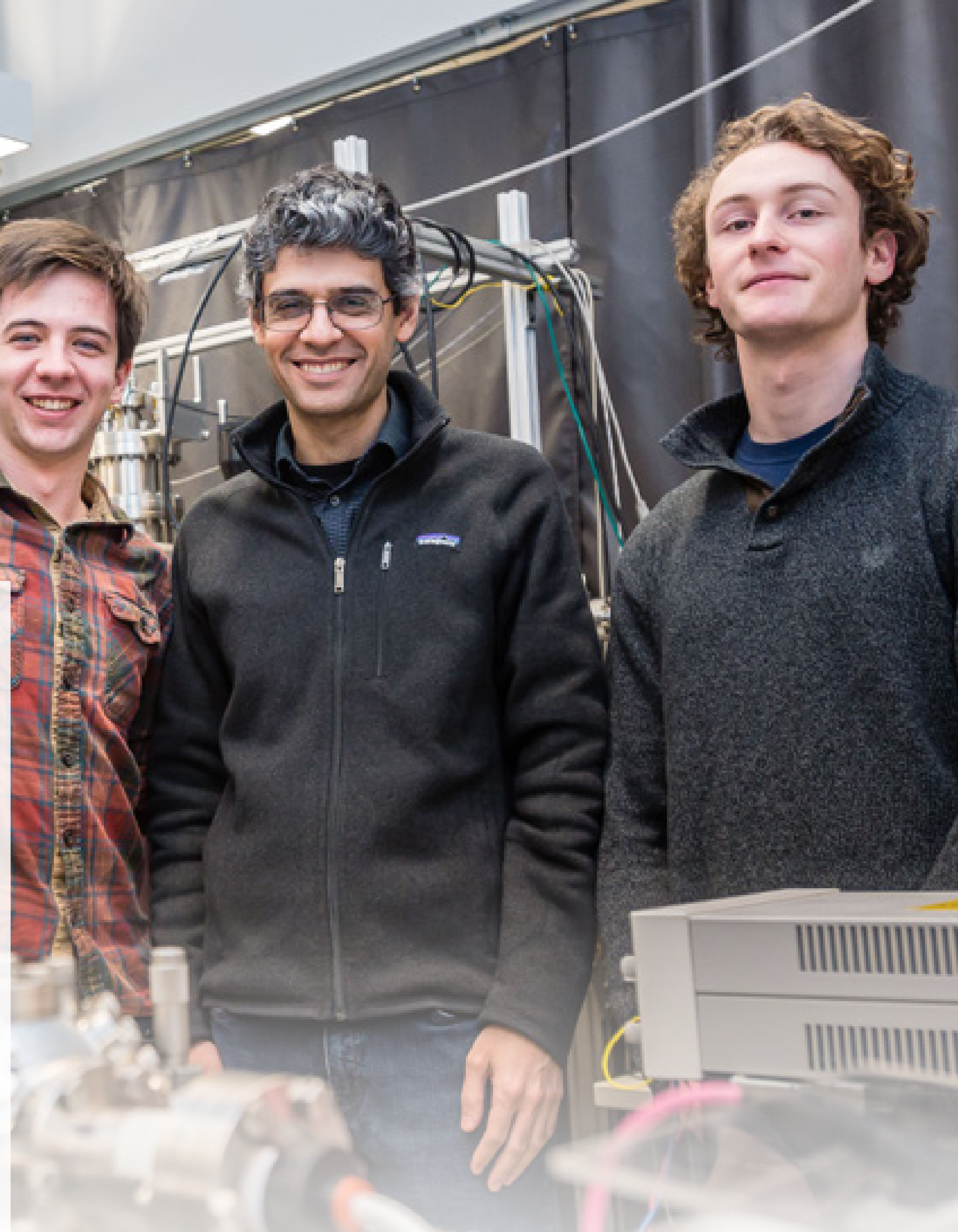
The scanning electron microscope (SEM) has become one of the most widely used instruments in advanced scientific laboratories because of its lifelike images with tremendous depth of focus, huge range of magnification and better resolution than a light microscope. However, access to this form of high-resolution imaging is severely limited due to the associated complexity and high cost. SEMs are too expensive for, say, high school students, low-income healthcare clinics, and many small companies in the business of micromanufacturing.

With a goal of improving access to high resolution imaging technology, Alireza Nojeh's group is developing AweSEM™, an inexpensive and portable SEM. It is a high-resolution imaging instrument that creates an image by bombarding a sample with an electron beam and analyzing the resulting backscattered and secondary electrons. This type of high-resolution imaging reveals important information about biological, inorganic, and manufactured materials. Other electron microscopes in the market can cost well over $100,000 and are expensive to maintain. They are also large, difficult to master, and require specialized specimen preparation.

Projected to sell for less than 1/100th of an average tabletop SEM, AweSEM™ aims to have 50 nm resolution and battery operation for enhanced portability. Currently, the group is focused on developing and optimizing the cathode, which is an optically-stimulated carbon nanotube forest. By focusing a low power laser on the forest, a "heat trap" effect produces localized heating to thermionic emission temperatures. The localized heating effect results in a small electron emission area, allowing for simplified electron optics using a permanent magnetic lens to demagnify the beam.

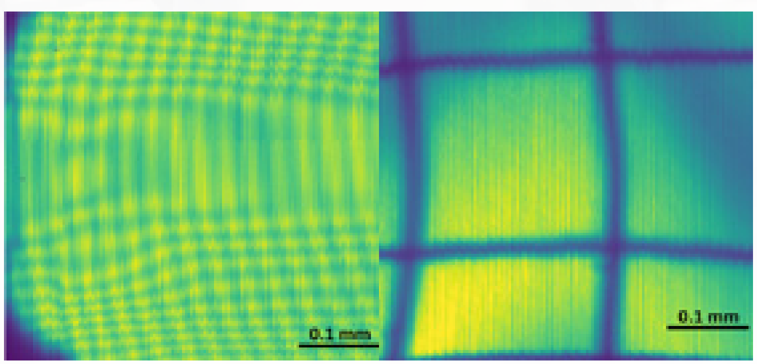
With applications not just in life science (medical, pharmaceutical, forensics, biology) or education, but also in material science (semiconductors, geology, metallurgy, nanotechnology, industrial manufacturing), researchers are developing AweSEM™ to be a robust instrument with the potential to revolutionize industries seeking an affordable and portable solution to high-resolution imaging.





First AweSEM™ Images

Below are the first images taken with the AweSEM™ prototype. They show scanning transmission images taken with the sample held at atmospheric pressure. The detector is a photodiode with the glass taken off and a mechanically-scanned stage was used. In this case, the image has been generated by software which collects and displays a signal generated by the transmitted electrons hitting the photodiode. The steel mesh shown here provides a sense of scale. The resolution is on the order of a few tens of micrometers. The group hopes to improve this resolution down to 1 micrometer in the near future.



AweSEM™ group members shown here left to right are Casimir Kuzyk, Gabriel Robinson-Leith, Alireza Nojeh and Alexander Dimitrakopoulos.

Quantum Information Science Research at SBQMI

Quantum computers are expected to spur the development of new scientific insights and breakthroughs in medicine, environmental sciences, resource management, infrastructure planning, and materials development — anything that requires a great deal of classical computational power is expected to benefit from advances in quantum information science (QIS) research.

At SBQMI, a major QIS research thrust involves enabling a universal fault-tolerant quantum computer based on silicon donor qubits developed at SFU by Mike Thewalt and Stephanie Simmons. SBQMI researchers will interconnect these qubits using photonic waveguides developed in the groups of Jeff Young and Lukas Chrostowski. The quantum computer architecture into which these components are integrated is being designed by Robert Raussendorf's group at SBQMI.

In 2018, part of the underlying enabling research on quantum key distribution for this project was supported by Lumerical and Applied Nanotools — two Canadian companies. A research contract between the Jeff Young group and Lumerical was also undertaken for the analysis of quantum optical circuits to distribute quantum keys.

Events in Quantum Information Science and Computing

Since 2013, SBQMI has supported workshops and conferences in the emerging area of quantum information and computation. These workshops have provided essential venues for the development and communication of theory and analysis in QIS. Following this path, in January 2018, a workshop on Active Silicon Photonics was developed and presented through the SiEPIC research training program.

Intellectual Property and Patents

SBQMI supports faculty members in their application for device patents. Below are examples of patents with implications for industry development in optical telecommunications and health that were issued this past year.

Phase-sweeping Photonic Switch

Ray Chung, Zeqin Lu, Hasitha Jayatilleka, Mohammed Wadah Altaha, Sudip Shekhar, Shahriar Mirabbasi, Lukas Chrostowski

A photonic switch that enables a light path to work in a manner similar to a network router in order to intelligently direct information within a network. The patent for this device includes a method and apparatus for monitoring and feedback control of a photonic switch that involves the use of a time-varying phase shift.

Optical Switch

Dritan Celo, Lukas Chrostowski, Eric Bernier, Yun Wang

Quantum physics offers new ways to enhance the performance of optical-communication systems. This device is an optical device that transmits and converts electrical signals into an optical form in order to place the resulting signal into an optical fibre.

Low-cost Electron Microscope

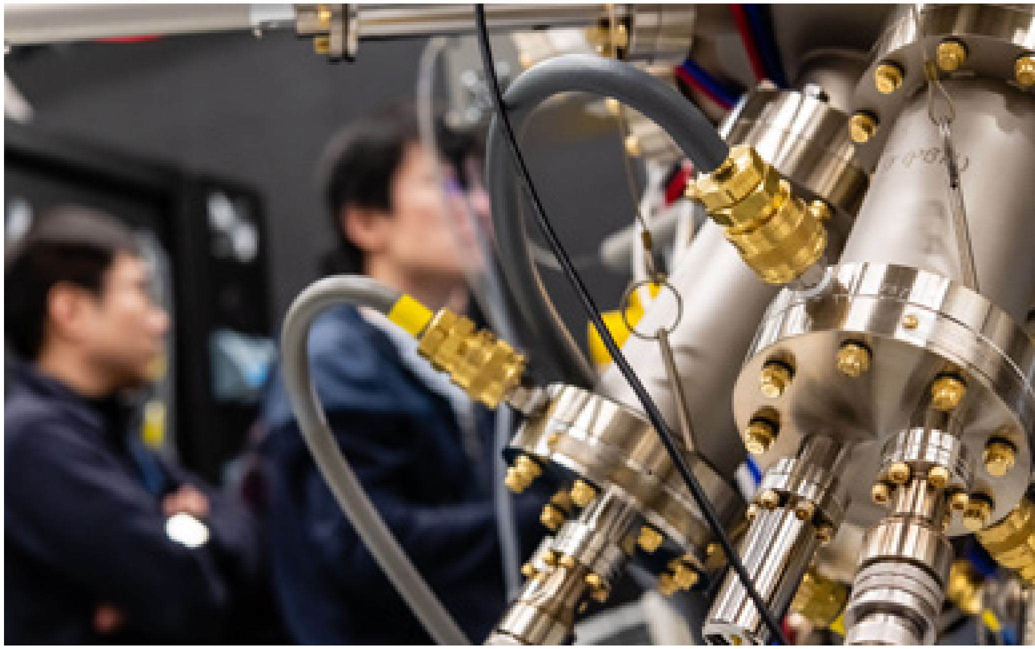
Alireza Nojeh and collaborators

Shining a low-powered laser on a readily-available carbon nanomaterial causes highly-localized heating and the subsequent emission of electrons. These electrons can be used to generate images in a manner analogous to an electron microscope, but with greatly reduced energy requirements. Scanning images using a mechanically-manipulated stage or by point projection removes the need for the electron beam to be scanned electromagnetically during operation, thereby simplifying the overall design. Other design features, including a permanently-sealed vacuum and remote image processing software, further develops the potential for a portable and inexpensive scanning electron microscope.

Palladium Membrane Reactor

Curtis Berlinguette, Rebecca Sherbo, Aiko Kurimoto

A thin palladium foil as the cathode of an electrochemical cell can be used to mediate the cost-efficient upgrading of small molecule starting materials using benign reagents and under mild conditions. The system takes advantage of the unique material properties of palladium as selectively permeable to hydrogen atoms to cleanly and selectively convert alkynes to either alkenes or alkanes using water as the only reagent. By replacing water with heavy water (D2O) in the electrochemical compartment of the cell, the UBC team discovered that this system could be used to generate deuterated reagents that are of relevance to a new class of pharmaceuticals with improved metabolic properties.



PRINCIPAL INVESTIGATORS

New Faculty

SBQMI welcomed three new faculty members in 2018, including UBC's Dean of Science Meigan Aronson, Steve Dierker, and Alannah Hallas who — though she will not officially assume her role until mid-2019 — has already engaged in preparations for her Quantum Materials Design Lab that will focus on single crystal growth.

In addition, two new affiliate members also joined SBQMI, Robert Green (Assistant Professor at the University of Saskatchewan and Associate at the Canadian Light Source), and Kenji Kojima (tenured Research Scientist at TRIUMF).

The addition of these new members is particularly exciting owing to their diverse expertise in areas such as thin films and single crystal growth, quantum devices, as well as optical and electron microscopy, enabling the Institute to roll out the next phase in its development: expansion of its scientific effort along the path from *Quantum Materials by Design* to quantum-material-based devices and applications.

MEIGAN ARONSON

Meigan Aronson is currently Dean of the Faculty of Science at UBC and Full Professor in the Physics and Astronomy Department. Meigan received her Ph.D. in Physics in 1988 from the University of Illinois, Urbana-Champaign. Following her graduate work, she held a postdoctoral assistant position with the Condensed Matter and Thermal Physics Group at Los Alamos National Laboratory and was a visiting scientist at Natuurkundig Laboratorium at the Universiteit van Amsterdam in The Netherlands. She commenced her professional research and teaching career in 1990 at the University of Michigan as an Assistant Professor of Physics and earned promotion to Professor in 2002. At Michigan, she also served as Associate Dean for Natural Sciences in the College of Literature, Science and Arts (2004-2006). Meigan has also been a Professor of Physics at Stony Brook University and concurrently the Group Leader of the correlated electron materials group in the Condensed Matter Physics and Materials Science Department at Brookhaven National Laboratory.

Meigan brings a strong commitment to research, teaching, and learning. She has an extensive publication record, and has been honoured with a number of fellowships, including from the American Physical Society and, most recently this year, the Neutron Scattering Society of America. She is passionate about mentoring students and postdoctoral fellows, and has a deep commitment to diversity and improving the success of students and faculty.

STEVE DIERKER

Steve Dierker is a Professor in the Department of Physics and Astronomy at UBC and a principal investigator at SBQMI. Following his graduate work at the University of Illinois, he took up a scientific staff position at AT&T Bell Laboratories in Murray Hill from 1983-1990. From 1990-2006, he was a tenured faculty member in the Physics Department and the Applied Physics Program at the University of Michigan. In 2001 he went on leave to become the Director of the National Synchrotron Light Source at Brookhaven National Laboratory (BNL), where he stayed until 2015. While at BNL, he led efforts to develop the scientific case, technical specifications, and secured government support for the National Synchrotron Light Source II (NSLS-II) and was then Project Director for the $912 million NSLS-II Project. He also founded, and was the Associate Laboratory Director for, the Photon Sciences Directorate at BNL. From 2015-2018, Dr. Dierker was a Professor in the Department of Physics and Astronomy at Texas A&M University. He is a Fellow of the American Association for the Advancement of Science.

Dr. Dierker's research interests are concerned primarily with the study of the collective dynamics of condensed matter systems and their dependence on reduced dimensionality, strong interactions, disorder, and mesoscale structure. He is working to establish the Quantum Materials Electron Microscopy Center at SBQMI as well as an optical spectroscopy laboratory.

ALANNAH
HALLAS

Alannah Hallas will be an Assistant Professor in the Department of Physics and Astronomy at UBC and will be joining SBQMI to head the Quantum Materials Design Lab. Before coming to UBC, Alannah completed her PhD in physics as a Vanier Scholar at McMaster University and was the Smalley Postdoctoral Fellow at Rice University. Having worked in both physics and chemistry departments, Alannah is passionate about taking an interdisciplinary approach to the study of quantum materials.

ROBERT
GREEN

Robert Green is an affiliate faculty member at SBQMI. He began this role in September 2017 as a joint appointment upon becoming an Assistant Professor at the University of Saskatchewan. Prior to this, Robert was a Max Planck-UBC-UTokyo Centre for Quantum Materials Postdoctoral Research Fellow at SBQMI (2013- 2017), and then an SBQMI's Research Associate (2017). He has BSc degrees in both Engineering Physics and Computer Science, and a PhD in Physics from the University of Saskatchewan. Robert's focus is the study of quantum materials using synchrotron experiments, which he performs primarily at the Canadian Light Source in Saskatoon.

KENJI
KOJIMA

Kenji Kojima joined the Centre for Molecular and Materials Science (CMMS) at TRIUMF as a Research Scientist, in August 2018. Concurrently, he also joined the SBQMI as an affiliated faculty member. Previously, he was a postdoc with Professor Tomo Uemura at Columbia University after acquiring his Ph.D. from the University of Tokyo in 1996. He then joined Professor Uchida's group investigating high-Tc superconductivity at the University of Tokyo as a Research Associate. Kenji then became Associate Professor in the Muon Science Laboratory at the High Energy Accelerator Research Organization (KEK) in Japan. His long-term interest is in various types of quantum materials, using muon and unstable nuclei as a tool-kit to solve their mysteries. He has published multiple papers in Nature Physics, Scientific Reports, and Physical Review journals.

Awards and Recognitions

This year SBQMI faculty members continued to receive accolades in recognition of both their research and service achievements. They include:

Mona Berciu

American Physical Society (APS) Outstanding Referee — an honour that recognizes a select group of scientists whose efforts in peer review have contributed to keeping the standards of the journal at exceptionally high levels.

Doug Bonn

Global Highly Cited Researchers 2018 List by Clarivate Analytics (Top 1% of citations) — the list recognizes world-class researchers selected for their exceptional research performance, demonstrated by multiple highly cited papers that rank in the top 1%.

Andrea Damascelli

2018 CAP/DCMMP Brockhouse Medal from the Canadian Association of Physicists — the medal recognizes outstanding experimental or theoretical contributions to condensed matter physics with a focus on the excellence of the research accomplishments.

Fellow of the Royal Society of Canada (RSC) — Fellows of the RSC are peer-elected and considered the best in their field. It is Canada's highest honour for "distinguished men and women who have made remarkable contributions in the arts, humanities and sciences."

Marcel Franz

Research shortlisted for a Physics World 2018 Breakthrough of the Year — in this shortlisted publication, Marcel Franz, working with teams from the US, UK, and Israel, uses theoretical calculations to demonstrate that a material as simple as a graphene flake can be utilized to create a quantum hologram replicating the trademark characteristics of a black hole.

Joerg Rottler

Friedrich Wilhelm Bessel Research Award from the Alexander von Humboldt Foundation — the award recognizes outstanding research records and those expected to have "a seminal influence in their discipline beyond their immediate field of work."

Ziliang Ye

Canada Research Chair (CRC) Tier II in Condensed Matter Physics — the CRC national program invests "$265 million per year to attract and retain the world's most accomplished and promising minds."

SBQMI's Professor Emeritus Walter Hardy was also listed on the global Highly Cited Researchers 2018 List by Clarivate Analytics. While officially retired, the cryogenic atomic hydrogen maser on which Hardy worked — and which once maintained a world record for being the most accurate atomic clock — remains at the SBQMI building.

IAN AFFLECK

Research Focus

One method which we have applied with great success is conformal field theory. While its original development was motivated by string theory, we have applied it to quantum spin chains, quantum wires, and various types of quantum impurity problems including the Kondo effect and junctions of quantum wires. We also use the renormalization group, which straddles high energy and condensed matter physics, and have frequently applied large scale numerical techniques to these problems, especially the Density Matrix Renormalization Group. Our collaborators include Steven White
at UC Irvine and Frederic Mila at École Polytechnique Fédérale de Lausanne.

Current Projects

- Self-interacting Majorana modes (the Majorana-Hubbard model)
- A Majorana mode interacting with a multi-channel Luttinger liquid
- Quantum spin chains with SU(n) symmetry
- Phase diagram of the generalized Kitaev spin chain model
- Gapless phases in integer spin chains
- Observing impurity entropy in the multi-channel Kondo effect (in collaboration with Joshua Folk)

Career Highlights

PhD Harvard University 1976 – 1979
Asst. Professor Princeton University 1981 – 1987
Professor UBC 1987 – present

2018 Graduates

Samuel Gozel (EPFL), Tarun Tummuru, Kyle Wamer

Postdoctoral Fellows

Pedro Lopes, Wang Yang

Research Associate

Alberto Nocera

Selected Publications

I. Affleck, J.B. Marson. *Large-n limit of the Heisenberg-Hubbard model: implications for high-Tc superconductors.* Phys. Rev. B **37**, 3774 (1988).

I. Affleck, A. Rahmani, D. Pikulin. *Majorana-Hubbard model on the square lattice.* Phys. Rev. B **96**, 125121 (2018).

D. Wang, I. Affleck, R. Raussendorf. *Topological Qubits from Valence Bond Solids.* Phys. Rev. Lett. **120**, 200503 (2018).

MONA BERCIU

Research Focus

Our main interest is in the development of variational approximations that are quantitatively accurate yet computationally efficient, and can be used to explore the properties of some models of strongly-correlated systems in a wide region of the parameter space. Such studies supplement numerical exact studies, which are usually extremely time consuming and have limitations in terms of system size, temperature range, etc. Our main focus so far has been on few-particle properties in the extremely underdoped limit of insulators at zero temperature, but we are now attempting to expand our expertise to cover finite temperatures and finite particle densities.

Current Projects

- Effective magnon-mediated interactions between holes doped in a cuprate parent layer
- Effective phonon-mediated interactions between particles in systems with Peierls-type electron-phonon coupling
- Melting of a bipolaron crystal as a model for insulator-to-metal transition in BaBiO3 and in rare earth nickelates
- Properties of polarons at finite temperatures

Career Highlights

PhD University of Toronto 1995 – 1999
Postdoc. Fellow Princeton University 2000 – 2002
Research Assoc. Princeton University 2001 – 2002
Asst. Professor UBC 2002 – 2007
Assoc. Professor UBC 2007 – 2012
Professor UBC 2012 – present

2018 Graduates

Nathan Cheng (MSc), Tao Fang (Msc), John Sous (PhD)

Graduate Students

Nathan Cheng, Tao Fang, Stepan Fomichev, John Sous, Oliver Yam

Postdoctoral Fellows

Mi Jiang, Mirko Möller, Krzysztof Bieniasz

Selected Publications

H. Ebrahimnejad, G.A. Sawatzky, M. Berciu. *The dynamics of a doped hole in cuprates is not controlled by spin fluctuations.* Nat. Phys. **10**, 951 (2014).

S. Johnston, A. Mukherjee, I. Elfimov, M. Berciu, G.A. Sawatzky. *Charge disproportionation without charge transfer in the rare-earth nickelates as a possible mechanism for the metal-insulator transition.* Phys. Rev. Lett. **112**, 106404 (2014).

J. Sous, M. Chakraborty, R.V. Krems, M. Berciu. *Light bipolarons stabilize by Peierls electron-phonon coupling.* Phys. Rev. Lett. **121**, 247001 (2018).

CURTIS BERLINGUETTE

Research Focus
Our research program specializes in the development and study of advanced materials for use in clean energy conversion and storage schemes, including CO2 utilization technologies, dynamic windows and next-generation solar cells.

Current Projects
- CO2 electrolysis
- High throughput and autonomous clean energy materals discovery
- Solution processed dynamic glass
- Organic charge transfer materials for next-generation solar cells
- Pairing electrolysis with hydrogenation in a palladium membrane reactor

Career Highlights
PhD Texas A&M University 2000 – 2004
Postdoc. Fellow Harvard University 2004 – 2006
Asst. Professor UCalgary 2006 – 2011
Assoc. Professor UCalgary 2011 – 2013
Assoc. Professor UBC 2013 – 2017
Professor UBC 2017 – present

2018 Graduates
Kevan Dettelbach (PhD), Tengfei Li (PhD)

Graduate Students
Valerie Chiykowski, Roxanna Delima, Rebecka Forward, Arthur Fink, Ken Hu, Aoxue Huang, Ryan Jansonius, Alec Ji, Dorian Joulie, Yechan Kim, Cameron Kellett, Yohan Ko, Caroline Krzyszkowski, Eric Lees, Nicholas Loo, Ben MacLeod, Thomas Morrissey, Ben Mowbray, Fraser Parlane, Shaoxuan Ren, Angelica Reyes, Danielle Salvatore, Rebecca Sherbo, Danika Wheeler

Postdoctoral Fellows
Yang Cao, Pierre Chapuis, Wei Cheng, Kevan Dettelbach, Maxwell Goldman, Jingfu He, Noah Johnson, Aiko Kurimoto, Changli Li, Tengfei Li, Raphaell Moreira, Marta Moreno, Carolyn Virca

Research Associates
Jacky Chau, David Dvorak, Ted Haley, Brian Lam, Phil Schauer

Selected Publications
T. Li, T. Kasahara, J. He, K.E. Dettelbach, G.M. Sammis, C.P. Berlinguette. *Photoelectrochemical oxidation of organic substrates in organic media.* Nat. Commun. **8**, 390 (2017).

R.D.L. Smith, M.S. Prevot, R. Fagan, Z. Zhang, P.A. Sedach, M.K.J. Siu, C.P. Berlinguette. *Photochemical route for accessing amorphous metal-oxide materials for heterogeneous water oxidation catalysis.* Science **340**, 60 (2013).

D.M. Weekes, D.A. Salvatore, A. Reyes, A. Huang, C.P. Berlinguette. *Electrolytic CO2 reduction in a flow cell.* Acc. Chem. Res. **51**, 910 (2018).

DOUG BONN

Research Focus
We synthesize ultraclean samples of quantum materials, particularly high temperature superconductors, by bulk single crystal and film growth. These samples are then used for microwave spectroscopy, which reveals the low frequency conductivity spectrum, and scanning tunnelling spectroscopy, which provides spectroscopic capabilities at low temperatures on a nanoscale.

Current Projects
- Quasiparticle interference in Fe-based superconductors
- Microwave spectroscopy of long-lived quasiparticles in Fe-based superconductors and hydrodynamic electronic materials
- Quasiparticle interference in Weyl semimetal ZrSiTe
- Development of ultra-low temperature STM with in situ MBE
- Vapour-transport growth of chalcogenides

Career Highlights
PhD McMaster University 1983 – 1989
Postdoc. Fellow UBC 1989 – 1991
Research Assoc. UBC 1992 – 1994
Asst. Professor UBC 1994 – 1997
Assoc. Professor UBC 1997 – 2000
Professor UBC 2000 – present

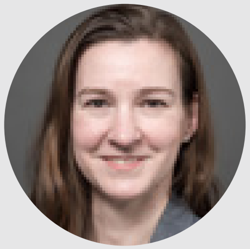
Graduate Students
Jeff Bale, Graham Baker, Aaron Kraft, Brandon Stuart

Postdoctoral Fellows
Mohamed Oudah, Seokhwan Choi

Research Associates
James Day, Jisun Kim

Selected Publications
D.A. Bonn, K. Zhang, R. Liang, D.J. Baar, D.C. Morgan, P. Dosanjh, T.L. Duty, A. MacFarlane, G.D. Morris, J.H. Brewer, W.N. Hardy, C. Kallin, A.J. Berlinsky. *Microwave measurements of the quasiparticle scattering time in Y Ba2Cu3O6.95.* Phys. Rev. B **47**, 11314 (1993).

N. Doiron-Leyraud, C. Proust, D. LeBoeuf, J. Levallois, J.B. Bonnemaison, R. Liang, D.A. Bonn, W.N. Hardy, L. Taillefer. *Quantum oscillations and the Fermi surface in an underdoped high temperature superconductor.* Nature **447**, 565 (2007).



SARAH BURKE

Research Focus
My research interests broadly encompass the study of electronic processes where nanoscale structure influences or reveals the underlying physics. Using scanning probe microscopy (SPM) techniques, my group investigates materials for organic electronics and optoelectronics, graphene and other carbon-based nanomaterials, and other materials where a nanoscale view offers the potential for new understanding.

Current Projects
- Energetic landscapes of organic heterojunctions
- Interaction between light and organic semiconductors on a single molecule level using SPM
- Quasiparticle interference: understanding interactions with defects and mapping electronic properties of novel 2D materials
- Dynamics of charge separation in organic solar cells using time- and angle-resolved photoemission spectroscopy
- Molecular imaging of heterogeneous catalysis in action

Career Highlights
PhD McGill University 2005 – 2009
Postdoc. Fellow UC Berkeley 2009 – 2010
Asst. Professor UBC 2010 – 2017
Assoc. Professor UBC 2017 – present

Graduate Students
Graham Baker, Miriam DeJong, Amy Qu, Brandon Stuart, Gary Tom, Alexandra Tully

Postdoctoral Fellows
Seokhwan Choi, Erik Mårsell, Giang Nguyen

Research Associates
James Day, Jisun Kim

Selected Publications
K.A. Cochrane, A. Schiffrin, T.S. Roussy, M. Capsoni, S.A. Burke. *Pronounced polarization-induced energy level shifts at boundaries of organic semi-conductor nanostructures.* Nat. Commun. **6**, (2015).

S. Chi, R. Aluru, S. Grothe, A. Kreisel, U.R. Singh, B.M. Andersen, W.N. Hardy, R. Liang, D.A. Bonn, S.A. Burke, and P. Wahl. *Imaging the real space structure of the spin fluctuations in an iron-based superconductor.* Nat. Commun. **8**, 15996 (2017).

A. Schiffrin, M. Capsoni, G. Farahi, C.G. Wang, C. Krull, M. Castelli, T. Roussy, K.A. Cochrane, Y. Yin, N.V. Medhekar, M. Fuhrer, A.Q. Shaw, W. Ji, S.A. Burke. *Designing Optoelectronic Properties by On-Surface Synthesis: Formation and Electronic Structure of an Iron–Terpyridine Macromolecular Complex.* ACS Nano **12**, 7 (2018).

LUKAS CHROSTOWSKI

Research Focus
Our main research interests are in the applications of silicon photonics, including optical communications, biosensors, and quantum information. Using the relatively mature silicon photonics technology, and very mature CMOS electronics technology, we are developing a quantum information platform.

Current Projects
- Tunable photonic crystal for cavity quantum electrodynamics (with Jeff Young)
- Single photon sources (with Jeff Young)
- Semiconductor laser stabilization using CMOS electronics
- Silicon photonic biosensors

Career Highlights
PhD UC Berkeley 1998 – 2004
Postdoc. Fellow UC Berkeley 2004 – 2005
Asst. Professor UBC 2005 – 2010
Assoc. Professor UBC 2010 – 2015
Professor UBC 2015 – present

2018 Graduates
Anthony Park, MSc

Graduate Students
Abdelraman Afifi, Rui Cheng, Ya Han, Jaspreet Jhoja, Stephen Lin Enxiao Luan, Minglei Ma, Hossam Shoman, Becky Lin, Donald Witt, Connor Mosquera, Mohammed Shemis, Adan Azem, Adam Darcie, Mohammed Mirsharifi

Postdoctoral Fellows
Jingda Wu, Alireza Samani

Selected Publications
L. Chrostowski, M. Hochberg. *Silicon photonics design: from devices to systems.* Cambridge University Press (2015).

X. Wang, W. Shi, H. Yun, S. Grist, N.A.F. Jaeger, L. Chrostowski. *Narrow-band waveguide Bragg gratings on SOI wafers with CMOS-compatible fabrication process.* Opt. Express. **20**, 15547 (2012).

ANDREA DAMASCELLI

Research Focus

Our group develops and utilizes angle-resolved photoemission spectroscopy (ARPES) and its time- and spin- resolved variants, as well as resonant x-ray scattering (RXS), to push the limits of these techniques and gain a deeper understanding of quantum materials and new phases of matter. Leveraging facilities established at SBQMI and the Quantum Materials Spectroscopy Centre at the Canadian Light Source, we pursue the engineering of the electronic structures of these materials through in situ adatom deposition, strain, and the optical coherent control of electronic states via pulsed laser excitations.

Current Projects

- Non-equilibrium dynamics of quantum materials
- Coherent control and spectroscopy of quantum materials
- Spin-orbit coupling and unconventional superconductivity
- New avenues in charge and spin manipulation at surfaces
- 2D van der Waals materials and oxide heterostructures

Career Highlights

PhD University of Groningen 1994 – 1999
Postdoc. Fellow Stanford University 1999 – 2002
Asst. Professor UBC 2002 – 2007
Assoc. Professor UBC 2007 – 2013
Professor UBC 2013 – present
Scientific Director, SBQMI 2015 – present

Graduate Students

Ryan Day, Ketty Na, Pascal Nigge, Amy Qu, Alexander Sheyerman, Marta Zonno, Berend Zwartsenberg, Cissy Suen (Joint PhD), Sydney Dufresne

Postdoctoral Fellows

Fabio Boschini, Christopher Gutiérrez, Sean Kung, Matteo Michiardi, Elia Razzoli, Danilo Kuen

Research Associates

Ilya Elfimov, Giorgio Levy, Arthur Mills, Sergey Zhdanovich

Scientific Engineers

Michael Schneider, Douglas Wong

Selected Publications

F. Boschini, E.H. da Silva Neto, E. Razzoli, M. Zonno, S. Peli, R. P. Day, M. Michiardi, M. Schneider, B. Zwartsenberg, P. Nigge, R.D. Zhong, J. Schneeloch, G.D. Gu, S. Zhdanovich, A.K. Mills, G. Levy, D.J. Jones, C. Giannetti, A. Damascelli. *Collapse of high-Tc superconductivity via ultrafast quenching of the phase coherence.* Nat. Mater. **17**, 416 (2018).

R. Comin, A. Frano, M.M. Yee, Y. Yoshida, H. Eisaki, E. Shierle, E. Weschke, R. Sutarto, F. He, A. Soumyanarayanan, Y. He, M. Le Tacon, I.S. Elfimov, J.E. Hoffman, B. Keimer, G.A. Sawatzky, A. Damascelli. *Charge ordering driven by Fermi-arc instability in underdoped cuprates.* Science **343**, 6169 (2014).

A. Damascelli, Z. Hussain, Z.X. Shen. *Angle-resolved photoemission studies of the cuprate superconductors.* Rev. Mod. Phys. **75**, 473 (2003).

JOSHUA FOLK

Research Focus

We perform ultra-low temperature electronic measurements, often at high magnetic fields, of devices defined by micro- and nanolithography, and controlled by various electrostatic gates. Materials used for these devices range from conventional semiconductors, such as GaAs, to 2D materials such as graphene or dichalcogenides, to strongly correlated 2D materials such as strontium vanadate.

Current Projects

- Vanderwaals heterostructures
- Non-abelian electronic states
- Mesoscopic physics

Career Highlights

PhD Stanford University 1998 – 2003
Postdoc. Fellow MIT 2003 – 2004
Postdoc. Researcher Delft Technical University 2005
Asst. Professor UBC 2005 – 2010
Assoc. Professor UBC 2010 – present

Graduate Students

Tim Child, Christian Olsen, Ebrahim Sajadi, Aswin Vishnuradhan

Postdoctoral Fellow

Nik Hartman

Research Associate

Silvia Lüscher

Selected Publications

N. Hartman, C. Olsen, S. Lüscher, M. Samani, S. Fallahi, G.C. Gardner, M. Manfra, J. Folk. *Direct entropy measurement in a mesoscopic quantum system.* Nat. Phys. **14**, 1083 (2018).

M. Kjaergaard, F. Nichele, H.J. Suominen, M.P. Nowak, M. Wimmer, A.R. Akhmerov, J.A. Folk, K. Flensberg, J. Shabani, C.J. Palmstrom, C.M. Marcus. *Quantized conductance doubling and hard gap in a two-dimensional semiconductor-superconductor heterostructure.* Nat. Commun. **7**, 12841 (2016).

E. Sajadi, T. Palomaki, Z. Fei, W. Zhao, P. Bement, C. Olsen, S. Luescher, X. Xu, J.A. Folk, D.H. Cobden. *Gate-induced superconductivity in a monolayer topological insulator.* Science **362**, 922 (2018).

MARCEL FRANZ

Research Focus
We formulate and study simple models of solids that are relevant to topological insulators, topological superconductors, Dirac and Weyl semimetals, and other topological or otherwise exotic states of quantum matter. The key criteria driving our research are: (i) cutting edge theoretical developments and (ii) relevance to real systems as studied by our experimental colleagues.

Current Projects
- Quantum holography in a graphene flake with an irregular boundary
- Antichiral edge states in a modified Haldane nanoribbon
- Quantum oscillations and Dirac-Landau levels in Weyl superconductors
- Diagnosing quantum chaos without reversing the flow of time
- Black Hole on a Chip: Proposal for a Physical Realization of the Sachdev-Ye-Kitaev model in a Solid-State System

Career Highlights
PhD University of Rochester 1992 – 1994
Postdoc. Fellow McMaster University 1994 – 1996
Postdoc. Fellow Johns Hopkins University 1996 – 2000
Asst. Professor UBC 2000 – 2005
Assoc. Professor UBC 2005 – 2010
Professor UBC 2010 – present

Graduate Students
Oguzhan Can, Anffany Chen, Rafael Haenel, Étienne Lantagne-Hurtubise, Chengshu Li, Tianyu Liu, Vedangi Pathak

Postdoctoral Fellows
Sharmishta Sahoo, Xiao-Xiao Zhang, Stephan Plugge, Pedro Lopes

Selected Publications
A. Chen, R. Ilan, F. de Juan, D. I. Pikulin, M. Franz. *Quantum Holography in a Graphene Flake with an Irregular Boundary.* Phys. Rev. Lett. **121**, 036403 (2018).

E. Lantagne-Hurtubise, C. Li, M. Franz. *Family of Sachdev-Ye-Kitaev models motivated by experimental considerations.* Phys. Rev. B **97**, 235124 (2018).

M.M. Moeller, G.A. Sawatzky, M. Franz, M. Berciu. *Type-II Dirac semimetal stabilized by electron-phonon coupling.* Nat. Commun. **8**, 2267 (2017).

DAVID JONES

Research Focus
The research pursued in my group lies at the convergence of condensed matter physics and ultrafast photonics and spectroscopy. It encompasses the development of new and customized femtosecond laser sources and accompanying spectroscopic techniques and employing them in tandem to unravel properties of quantum materials when they are at equilibrium as well as when they are in excited states. Ultimately, we seek to implement photonic manipulation and control of quantum states/phases within solids.

Current Projects
- Femtosecond XUV for TR-ARPES over the full Brillioun zone
- k-space optical tweezers
- Flexible VUV femtosecond lasers sources for time-resolved photoemission
- Spatio-temporal characterization of interfacial charge separation in organic photovoltaics
- Multi-dimensional spectroscopy techniques for studying coherences in solids

Career Highlights
PhD MIT 1994 – 1999
Research Assoc. NIST Boulder Labs 1998 – 2000
Research Assoc. CU Boulder 2001 – 2003
Asst. Professor UBC 2004 – 2010
Associate Professor 2010 – present

2018 Graduates
Emily Altiere, Aurelien Pelissier

Graduate Students
Matthias Bohlen, Aghigh Jalehdoost, Ketty Na, Alexander Sheyerman, Max Warner, Shadab Ahamed, Alexandra Tully

Postdoctoral Fellows
Fabio Boschini, Erik Mårsell, Hao Chen

Research Associates
Arthur Mills, Sergey Zhdanovich

Visiting Scientist
Edmund Kelleher

Scientific Engineer
Evgeny Ostroumov

Selected Publications
D.J. Jones, S.A. Diddams, J.K. Ranka, A. Stentz, R.S. Windeler, J.L. Hall, S.T. Cundiff. *Carrier-envelope phase control of femtosecond mode-locked lasers and direct optical frequency synthesis.* Science **288**, 635 (2000).

A.K. Mills, T.J. Hammond, M.H.C. Lam, D.J. Jones. *XUV frequency combs via femtosecond enhancement cavities.* J. Phys. B **45**, 14 (2012).

M.X. Na, A.K. Mills, F. Boschini, M. Michiardi, B. Nosarzewski, R.P. Day, E. Razzoli, A. Sheyerman, M. Schneider, G. Levy, S. Zhdanovich, T.P. Devereaux, A.F. Kemper, D.J. Jones, A. Damascelli. *Direct determination of mode-projected electron-phonon coupling in the time-domain.* (Submitted 2018).

ROB KIEFL

Research Focus

We are using muon spin rotation and beta-detected NMR to study magnetic and electronic properties of oxides and their interfaces. We also have a program to investigate magneto electrics and nanoparticles. We are exploring exotic states of a positive muon in magnetic materials in which the muon can behave as a magnetic monopole or form a bound state with a polaron.

Current Projects

- Magnetic properties of oxide interfaces and their near surface region
- Novel magnetic and chemical properties of nanoparticles
- Lithium diffusion studies in battery electrode materials
- Local magnetoelectric effects studied with beta-NMR and muon spin rotation

Career Highlights

PhD UBC 1978 – 1982
Research Assoc. TRIUMF 1982
Postdoc. Fellow Physics Institute, University of Zurich 1982 – 1984
Research Scientist TRIUMF 1984 – 1987
Research Fellow UBC 1987 – 1990
Asst. Professor UBC 1990 – 1992
Assoc. Professor UBC 1992 – 1995
Professor UBC 1995 – present

Graduate Students

Aris Chatzichristos, Martin Dehn, Derek Fujimoto, Victoria Karner, Ryan McFadden

Selected Publications

D.L. Cortie, T. Buck, M.H. Dehn, V.L. Karner, R.F. Kiefl, C.D.P. Levy, R.M.L. McFadden, G.D. Morris, I. McKenzie, M.R. Pearson, X.L. Wang, W.A. MacFarlane. *beta-NMR investigation of the depth dependent magnetic properties of an antiferromagnetic surface.* Phys. Rev. Letts. **116**, 106103 (2016).

H. Saadaoui, Z. Salman, H. Luetkens, T. Prokscha, A. Suter, W.A. MacFarlane, Y. Jiang, K. Jin, R.L. Greene, E. Morenzoni, R.F. Kiefl. *The Phase Diagram in Electron-Doped La2-xCexCuO4.* Nat. Commun. **6**, 6041 (2015).

J.E. Sonier, J.H. Brewer, R.F. Kiefl. *μSR studies of the vortex state in type-II superconductors.* Rev. Mod. Phys. **72**, 769 (2000).

ANDREW MACFARLANE

Research Focus

Using radioactive beta-detected NMR, we study the electromagnetic properties in electronic materials in the form of single crystals, thin films and multilayers. Our main probe is the short-lived isotope 8Li. Using this probe we also study molecular dynamics and lithium ionic mobility in thin films and near interfaces. We develop the techniques and apply them to interesting materials problems which are difficult or impossible to address with more conventional techniques.

Current Projects

- Metallic and magnetic properties of LaNiO3 thin films
- Spin relaxation in topological insulators
- Indirect relaxation in magnetic heterostructures
- Spin relaxation as a probe of Li+ ionic mobility in solids and near interfaces
- 31Mg, a new beta NMR probe

Career Highlights

PhD UBC 1992 – 1997
Postdoc. Fellow Laboratoire de Physique des Solides, Université Paris-Sud 1997 – 1999
Postdoc. Fellow University of Toronto 1999 – 2001
Research Assoc. TRIUMF 2001 – 2002
Asst. Professor UBC 2002 – 2008
Assoc. Professor UBC 2008 – present

Graduate Students

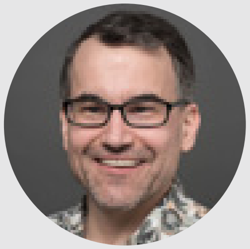
Luca Egoriti, Derek Fujimoto, Victoria Karner, Ryan McFadden, John Ticknor

Selected Publications

D.L. Cortie, T. Buck, M.H. Dehn, R.F. Kiefl, C.D.P. Levy, R.M.L. McFadden, G.D. Morris, M.R. Pearson, Z. Salman, Y. Maeno, W.A. MacFarlane. *Spin fluctuations in the exotic metallic state of Sr2RuO4 studied with β-NMR.* Phys. Rev. B **91**, 241113(R) (2015).

R.M.L. McFadden, T.J. Buck, A. Chatzichristos, C. Chen, K.H. Chow, D.L. Cortie, M.H. Dehn, V.L. Karner, D.Koumoulis, C.D. Philip Levy, C. Li, I. McKenzie, R.Merkle, G.D. Morris, M.R. Pearson, Z. Salman, D. Samuelis, M. Stachura, J. Xiao, J. Maier, R.F. Kiefl, W.A. MacFarlane. *Microscopic Dynamics of Li+ in Rutile TiO2 Revealed by 8Li β-Detected Nuclear Magnetic Resonance.* Chem. Mater. **29** (23), 10187 (2017).

W.A. MacFarlane, Q. Song, N.J.C. Ingle, K.H. Chow, M. Egilmez, I. Fan, M.D. Hossain, R.F. Kiefl, C.D.P. Levy, G.D. Morris, T.J. Parolin, M.R. Pearson, H. Saadaoui, Z. Salman, D. Wang. *β-detected NMR spin relaxation in a thin film heterostructure of ferromagnetic EuO*. Phys. Rev. B **92**, 064409 (2015).



MARK MACLACHLAN

Research Focus
Our group members synthesize new molecules (especially macrocycles) and study their self-assembly under different conditions. We also develop new photonic materials using liquid crystalline templates, especially derived from cellulose and chitin. Finally, we explore a variety of new nanostructured materials for different applications.

Current Projects
- Flexible photonic materials from cellulose nanocrystals for stimuli-responsive applications (e.g., pressure sensors)
- Stimuli-responsive gelation
- Nanostructured catalysts for low temperature methane oxidation
- Supramolecular compounds for stimuli-driven molecular delivery
- Molecular cluster templating inside shape-persistent macrocycles

Career Highlights
PhD University of Toronto 1995 – 1999
Postdoc. Fellow MIT 1999 – 2001
Asst. Professor UBC 2001 – 2007
Assoc. Professor UBC 2007 – 2011
Professor UBC 2011 – present

2018 Graduates
Veronica Carta (PhD), Peixi Wang (PhD)

Graduate Students
Mohammad Chaudhry, Francesco D'Acierno, Yiling Dai, Madhureeta Das Gupta, Lev Lewis, Jeanette Loos, Andy Tran, Chris Walters, Yitao Xu

Postdoctoral Fellows
Charlotte Boott, Yuanyuan Cao, Arash Momeni, Miguel Angel Soto Muñoz, Peixi Wang, Gosuke Washino

Research Associate
Thanh-Dinh Nguyen

Selected Publications
K.E. Shopsowitz, H. Qi, W.Y. Hamad, M.J. MacLachlan. *Free-standing mesoporous silica films with tunable chiral nematic structures.* Nature **468**, 422 (2010).

N.G. White, M.J. MacLachlan. *Anion-templated hexagonal nanotubes.* Chem. Sci. **6**, 6245-6249 (2015).

ALIREZA NOJEH

Research Focus
Our research activities centre on the study of the interaction of light with nanostructures leading to highly localized heating and thermal electron emission. Our work involves device design, micro and nanofabrication in the cleanroom, nanostructure growth and deposition, electron and scanning-probe microscopy, building experimental apparatus such as high- or ultra-high vacuum systems, electronic characterization and sensitive instrumentation, and working with lasers and optics. We complement our experimental efforts with modelling and simulation using methods ranging from continuum modelling (such as finite-element analysis) to classical molecular dynamics to first-principles, quantum-mechanical techniques such as the Hartree-Fock theory, configuration-interaction, perturbation theory and the density-functional theory.

Current Projects
- Heat localization in carbon nanotubes
- Thermionic energy conversion
- Compact, inexpensive electron microscope

Career Highlights
PhD Stanford University 2006
Asst. Professor UBC 2006 – 2011
Assoc. Professor UBC 2011 – 2016
Professor UBC 2016 – present

Graduate Students
Aashish Bhardwaj, Daniel Bruns, Mike Chang, Mokter Mahmud Chowdhury, Mohab Hassan, Casimir Kuzyk, Ehsanur Rahman, Kevin Voon

Undergraduate Student
Gabriel Robinson-Leith

Postdoctoral Fellows
Faezeh Mohammadbeigi, Shreyas Patankar

Research Associate
Harrison Fan

Selected Publications
M. Chang, H. D. E. Fan, M. M. Chowdhury, G. A. Sawatzky, A. Nojeh. *Heat localization through reduced dimensionality.* Phys. Rev. B **98**, 155422 (2018).

A. Nojeh, G.A. Sawatzky, L.A. Whitehead. *Graphene-based bidirectional radiative thermal transfer method for heat engines.* Appl. Opt. **58**, 2028 (2019).

P. Yaghoobi, M. Vahdani Moghaddam, A. Nojeh. *"Heat trap": light-induced localized heating and thermionic electron emission from carbon nanotube arrays.* Solid State Commun. **151**, 1105 (2011).

ROBERT RAUSSENDORF

Research Focus
The work in my group focuses on the theory of quantum computation, such as quantum computer architecture, the relation of quantum computation to foundations of quantum mechanics such as quantum contextuality, and the relation of quantum computation to condensed matter physics, e.g., symmetry-protected topological order.

Current Projects
- Quantum computational phases of matter (measurement-based quantum computation in SPTordered phases)
- Quantum computer architecture with matter qubits coupled by photons
- The role of contextuality for quantum computation

Career Highlights
PhD University of Munich (LMU) 1999 – 2003
Postdoc. Fellow Caltech 2003 – 2006
Postdoc. Fellow Perimeter Institute for Theoretical Physics 2006 – 2007
Asst. professor UBC 2008 – 2013
Assoc. Professor UBC 2013 – present

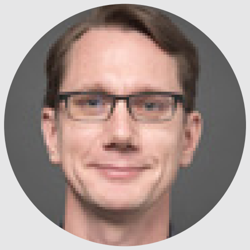
Graduate Students
Poya Hagnehgahdar, Oleg Kabernik, Hendrik Poulsen Nautrup (U Innsbruck), Arman Zaribafiyan

Postdoctoral Fellows
Cihan Okay, Dongsheng Wang

Selected Publications
R. Raussendorf, C. Okay, D. Wang, D.T. Stephen, H.P. Nautrup. *Computationally universal phase of quantum matter.* Phys. Rev. Lett. **122**, 090501.

R. Raussendorf, J. Harrington. *Fault-tolerant quantum computation with high threshold in two dimensions.* Phys. Rev. Lett. **98**, 190504 (2007).

R. Raussendorf, H.J. Briegel. *A one-way quantum computer.* Phys. Rev.Lett. **86**, 5188 (2001).



JOERG ROTTLER

Research Focus
With state-of-the-art computational techniques ranging from density functional theory (DFT) at the quantum level, molecular dynamics and Monte Carlo simulations on the atomic level, to field theoretic (phase field) methods on the mesoscale, the group studies a diverse set of materials that include polymers, disordered solids, and nanomaterials. Computer simulations facilitate the discovery of emergent phenomena, test theories and generic trends, and reveal quantities that are difficult or impossible to obtain in experiments, thus providing essential input into the design of new functional materials.

Current Projects
- Near-surface relaxation in amorphous polystyrene films via molecular simulations and beta-NMR measurements
- Nanoscale phononics and the origin of the heat-trap effect in carbon nanotubes
- Statistical physics of driven disordered solids
- Molecular simulations of polyelectrolyte gel sensors and diodes
- Tuning morphology and thermal transport of smart polymer blends by macromolecular engineering

Career Highlights
Ph.D. Johns Hopkins University 2003
Chercheur Associé E.S.P.C.I. (Paris) 2003
Research Assoc. Princeton University 2003 – 2005
Asst. Professor UBC 2005 – 2010
Assoc. Professor UBC 2010 – 2016
Professor UBC 2016 – present

Graduate Students
Daniel Bruns, Derek Fujimoto, Vasiliy Triandafilidi (co-supervised with CHBE)

Postdoctoral Fellow
Céline Ruscher

Research Associate
Debashish Mukherji

Selected Publications
M. Greenwood, N. Provatas, J. Rottler. *Free energy functionals for efficient phase field crystal modeling of structural phase transformations.* Phys. Rev. Lett. **105**, 045702 (2010).

A. Nicolas, J.L. Barrat, J. Rottler. *Effect of inertia on the steady state shear rheology of amorphous solids.* Phys. Rev. Lett. **116**, 058303 (2016).

J. Rottler, M.O. Robbins. *Shear yielding of amorphous glassy solids: Effect of temperature and strain rate.* Phys. Rev. E. **68**, 011507 (2003).

GEORGE SAWATZKY

Research Focus
We use a combination of advanced experimental and theoretical methods in studies of quantum materials exhibiting interesting and not well-understood physical properties. We also develop new experimental spectroscopic methods such as various forms of x-ray spectroscopies that can provide detailed information concerning the electronic, atomic, and magnetic structure of materials and material interfaces. The development of resonant x-ray reflectometry is one of the most recent highly successful developments. On the theory side, we use and develop further density function band theory methods as well as many body exact diagonalization methods to study the electronic structure of materials and material interfaces.

Current Projects
- High oxidation state oxides and negative charge transfer gap materials like BaBiO3
- Bond disproportionation and dynamical charge fluctuations in the perovskite rare-earth nickelates
- Electron-magnon-phonon coupling and their role in high Tc superconductors and topology
- Resonant soft Xray reflectometry and the study of buried interfaces in heterostructures
- Controlled physical properties by interface engineering

Career Highlights
PhD University of Manitoba 1969
Postdoc. Fellow Groningen University 1969 – 1971
Assoc. Professor Groningen University 1971 – 1979
Professor Groningen University 1979 – 2001
Professor UBC 2002 – present

Graduate Students
Shadi Balandeh, Arash Khazraie, Kevin Voon, Oliver Yam

Research Associates
Ilya Elfimov, Harrison Fan

Selected Publications
V.I. Anisimov, I.V. Solovyev, M.A. Korotin, M.T. Czyżyk, G.A. Sawatzky. *Density-functional theory and NiO photoemission spectra.* Phys. Rev. B **48**, 16929 (1993).

F. Li, G.A. Sawatzky. *Electron Phonon Coupling versus Photoelectron Energy Loss at the Origin of Replica Bands in Photoemission of FeSe on SrTiO3.* Phys. Rev. Lett. **120**, 237001 (2018).

R.W. Lof, M.A. van Veenendaal, H.T. Jonkman, G.A. Sawatzky. *Band gap, excitons and Coulomb interactions of solid C60*. Phys. Rev. Lett. **68**, 3924 (1992).

ZILIANG YE

Research Focus
We are developing a research program to study the atomically thin van der Waals (vdW) materials and heterostructures, with emphasis on their light-matter interaction, spin-valley degrees of freedom, correlated effects, and topological phenomena. We are building an ultrafast and nearfield optical spectroscopy lab which can measure the material's properties with femtosecond temporal resolution and nanometer spatial resolution. Our current focus is on resolving the impact of Moire superlattice on the excitonic property in transition metal dichalcogenide heterostructures. At the same time we are also actively exploring the idea of controlling the electronic structure of quantum materials using intense structured light.

Current Projects
- Resolving intra- and interlayer excitons in Moire superlattice within transition metal dichalcogenide heterostructures
- Developing next-generation photo-induced force spectroscopy and nearfield optical imaging techniques
- Creating steady Floquet states in low-dimensional materials and studying their open quantum properties

Career Highlights
PhD University of California, Berkeley 2013
Postdoc. Fellow University of California, Berkeley 2013
Postdoc. Fellow Columbia and Stanford University 2014 – 2017
Asst. Professor UBC 2017 – present

Graduate Students
Eddie Ji, Dongyang Yang

Undergraduate Students
Quentin Guillet, Amritabha Guha, Hirsh Kamakari, Stanley Lim

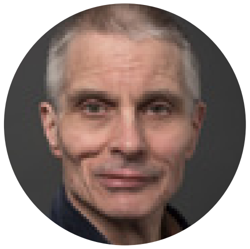
Former Interns
Dong He, Lianghui Peng, Haonan Zhao

Selected Publications
Z. Ye, T. Cao, K. O'Brien, H. Zhu, X. Yin, Y. Wang, S.G. Louie, X. Zhang, *Probing excitonic dark states in single-layer tungsten disulphide.* Nature **513**, 214 (2014)

Z. Ye, D. Sun, T.F. Heinz. *Optical manipulation of valley pseudospin.* Nat. Phys. **13**, 26 (2017).

Z. Ye, L. Waldecker, E.Y. Ma, D. Rhodes, A. Antony, B. Kim, X. Zhang, M. Deng, Y. Jiang, Z. Lu, D. Smirnov, K. Watanabe, T. Taniguchi, J. Hone, T.F. Heinz. *Efficient generation of neutral and charged biexcitons in encapsulated WSe2 monolayers.* Nat. Commun. **9**, 3718 (2018)

X. Yin, Z. Ye, D.A. Chenet, Y. Ye, K. O'Brien, J.C. Hone, X. Zhang. *Edge nonlinear optics on a MoS2 atomic monolayer.* Science **344**, 6183 (2014).



JEFF YOUNG

Research Focus
Our group uses electrodynamic models and simulation tools to design compact nanophotonic components in silicon-on-insulator wafers to control the flow of light over a range of infrared wavelengths. Examples include single photon detectors, non-classical light sources, and high quality factor, low mode volume nanophotonic cavities for achieving strong-coupling with dipole transitions within quantum oscillators located in the nanocavities. We also carry out a combination of in-house and external nanofabrication and post-processing (electron beam and optical lithography, plasma etching, metal deposition etc.) tasks to realize our designs in silicon slab waveguides. We then carry out optical spectroscopic characterization of the fabricated circuits.

Current Projects
- Developing a micro electro-mechanical based means of tuning photonic crystal microcavity resonance frequencies while maintaining high quality factors and low mode volumes
- Developing practical single photon sources in the silicon photonic circuit platform
- Designing quantum information processing strategies/architectures that are particularly suited to the photon-mediated coupling of chalcogenide impurities in silicon
- Further developing our integrated single photon superconducting nanowire detectors to work over a broader range of frequencies
- Developing novel coherent light sources for carrying out high resolution spectroscopy in the mid IR

Career Highlights
PhD University of Toronto 1983
Assoc. Professor UBC 1992 – 1996
Professor UBC 1996 – present

2018 Graduates
Ellen Schelew (PhD), Xiruo Yan (MSc)

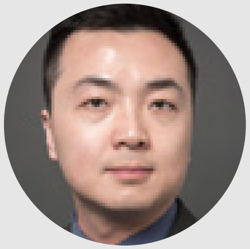
Graduates *Co-supervised with Lukas Chrostowski*
Xiruo Yan (PhD), Mohammad Mirsharifi (PhD), Sebastian Gitt (MSc), Donald Witt (MASc), Adan Azem (PhD)

Postdoctoral Fellows *Co-supervised with Lukas Chrostowski*
Jingda Wu, Alireza Samani, Mohsen Akhlaghi

Selected Publications
M.K. Akhlaghi, E. Schelew, J.F. Young. *Waveguide integrated superconducting single-photon detectors implemented as near-perfect absorbers of coherent radiation.* Nat. Commun. **6**, 8233 (2015).

C.A. Foell, K.A. Abel, F.C.J.M. van Veggel, J.F. Young. *Kinetic analysis of the temperature dependence of PbSe colloidal quantum dot photoluminescence: Effects of synthesis process and oxygen exposure.* Phys. Rev. B **89** (2014).

S. Hughes, L. Ramunno, J.F. Young, J.E. Sipe. *Extrinsic optical scattering loss in photonic crystal waveguides: Role of fabrication disorder and photon group velocity.* Phys. Rev. Lett. **94**, 033903 (2005).



KE ZOU

Research Focus
Our research interests are in the growth and studies of complex oxide and chalcogenide films, and electrical and magnetotransport studies of complex, nanoscale graphene devices by molecular beam epitaxy (MBE) growth. Our research will integrate molecular beam epitaxy synthesis with nanostructure fabrication and characterization techniques for physical and electronic structures, to explore and control the generated properties in new materials and in new forms of materials, such as in heterostructures and gated field effect transistors.

Current Projects
- MBE and device fabrication to create thin films, heterostructures, and transistors of 2D crystals
- Synthesis and characterization of 2D material systems

Career Highlights
PhD Pennsylvannia State University 2012
Postdoc. Fellow Yale University 2012 – 2018
Asst. Professor UBC 2018 – present

Graduate Students
Ryan Roemer, Hyungki Shin

Postdoctoral Fellow
Chong Liu

Undergraduate Students
Aly Abouzaid, James Shaw

Research Associates
Bruce A. Davidson, Fengmiao Li

Selected Publications
K. Zou, X. Hong, D. Keefer, J. Zhu. *Deposition of high-quality HfO2 on graphene and the effect of remote oxide phonon scattering.* Phys. Rev. Lett. **105**, 126601 (2010).

K. Zou, F. Zhang, C. Clapp, A.H. MacDonald, J. Zhu. *Transport studies of dual-gated ABA- and ABC- trilayer graphene: band gap opening and band structure tuning in very large perpendicular electric field.* Nano Lett. **13**, 369 (2013).

K. Zou, S. Ismail-Beigi, K. Kisslinger, X. Shen, D. Su, F.J. Walker, C.H. Ahn. *LaTiO3/KTaO3 interfaces: a new 2D electron gas system.* APL Mater. **3**, 036104 (2015).

INTERNATIONAL SCIENTIFIC ADVISORY BOARD (ISAB)

We are fortunate to have the support and advice of a group of world-renowned scientists who meet with us annually to review our work, provide us with feedback, and advise us on future directions. The International Scientific Advisory Board complements SBQMI's multidisciplinary approach, with its balance of expertise in theoretical, experimental, and applied research, and representation of different scientific disciplines with strong links to academia and industry.

DR. LESLEY COHEN

CHAIR OF THE BOARD

Consul for Faculty of Natural Sciences & Education Office
Professor, Department of Physics, Faculty of Natural Sciences, Imperial College London

Lesley Cohen is a Professor of Experimental Solid State Physics at Imperial College London and Editor in Chief of Applied Physics Letters. She received the inaugural Imperial College Julia Higgins Award for her contributions to the promotion and support of women in science, and remains committed to equality and diversity within STEM. Her recent research work focuses on superconducting spintronics, chiral antiferromagnetism, nanostructured honeycomb artificial spin ices and quantum interference effects in organic self-assembled molecules.

DR. J.C. SEAMUS DAVIS

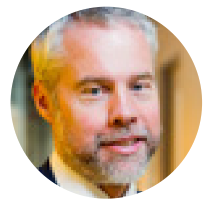
Professor of Physics, Oxford University
Senior Fellow Wadham College, Oxford University
Professor of Quantum Physics, University of College Cork
J.G. White Distinguished Professor Emeritus, Cornell University

Seamus Davis is a Professor of Physics at Oxford University and a Professor of Quantum Physics at the University of College Cork. He undertakes a wide range of experimental low-temperature research into the fundamental macroscopic quantum physics of superconductors, superfluids, supersolids, heavy-fermions, topological insulators and superconductors, magnetic spin and monopole quantum liquids, as well as developing new techniques for visualization and measurement of complex quantum matter.

DR. GEORGE CRABTREE

Distinguished Fellow, Argonne National Laboratory
Distinguished Professor of Physics, Electrical and Mechanical Engineering, University of Illinois at Chicago
Director of the Joint Center for Energy Storage Research (JCESR)

George Crabtree is Professor of Physics at University of Illinois-Chicago, Distinguished Fellow of Argonne National Laboratory and Director of the Joint Center for Energy Storage Research (JCESR). He has testified before the U.S. Congress on the hydrogen economy, meeting sustainable energy challenges, and energy storage.



DR. BENJAMIN EGGLETON

Professor of Physics, University of Sydney,
Director, The University of Sydney Nano Institute
Co-Director, NSW Smart Sensing Network (NSSN)

Benjamin Eggleton is a Professor of Physics at the University of Sydney and recently appointed Director of the University of Sydney Nano Institute. He is a Fellow of the Australian Academy of Science (AA), the Australian Academy of Technology and Engineering (ATSE), the Optical Society of America and IEEE. He was previously an ARC Laureate Fellow, and has twice been an ARC Federation Fellow. His research links fundamental science to applied science and spans physics and engineering with pioneering contributions in the areas of nonlinear optics and all-optical signal processing.

DR. ANTOINE
GEORGES

CCQ Director, Flatiron Institute
Professor of Physics, Collège de France

Antoine Georges is one of the co-inventors of dynamical mean field theory, for which he shared the 2006 Europhysics Condensed Matter Prize. This theory has deeply transformed our understanding of these materials and our ability to explain, calculate and predict their physical properties. He also received the 2007 Silver Medal of the CNRS, the 2014 Hamburg Prize for Theoretical Physics as well as a major Synergy Grant from the European Research Council. He is a member of the French Academy of Sciences.

DR. STUART
PARKIN

Director at the Max Planck Institute of Microstructure Physics,
IBM Fellow,
Consulting Professor Dept. of Applied Physics, Stanford University

Stuart Parkin is a Professor at the Institute of Physics of the Martin-Luther-University at Halle-Wittenberg where he develops and shapes the field of material sciences, and applied spintronics specifically. Considered a pioneer in the science and application of spintronic materials, he has made crucial discoveries in the behavior of thin-film magnetic structures leading to the increased data density and capacity of hard drives.

DR. R. STANLEY
WILLIAMS

Professor and holder of the Hewlett Packard Enterprise Company Chair
Department of Electrical and Computer Engineering,
Texas A & M University

R. Stanley Williams is the Director of the Hewlett Packard Enterprise Center for Computer Architecture Research at Texas A&M University. For the past 40 years, his primary scientific research has been in the areas of solid-state chemistry and physics, and their applications to technology. This has taken him on a journey that began with surface science; expanded to electronic, photonic and ionic nanotechnologies; and now encompasses computation, chaos, complexity and neuroarchitectonics. In 2008, a team of researchers he led announced that they had built and demonstrated the first intentional memristor, the fourth fundamental nonlinear electronic circuit element predicted by Prof. Leon Chua in 1971. Williams has received recognition for business, scientific and academic achievement, including being named one of the top 10 visionaries in the field of electronics by EETimes, the 2014 IEEE Outstanding Engineering Manager Award, the 2009 EE Times Innovator of the Year ACE Award, the 2007 Glenn T. Seaborg Medal for contributions to Chemistry, the 2004 Herman Bloch Medal for Industrial Research, and the 2000 Julius Springer Award for Applied Physics. He has published over 460 peer reviewed papers and been awarded more than 220 US patents.

2018 PUBLICATIONS

E. Altiere, E. Miller, T. Hayamizu, D. Jones, K. Madison, T. Momose. *High-resolution two-photon spectroscopy of a 5 p(5) 6 p ←5 p(6) transition of xenon*. Phys. Rev. A **97**, 012507 (2018).

G. Beaulieu-Houle, N. White, M. MacLachlan. *Coordination Polymers from Functionalized Bipyrimidine Ligands and Silver(I) Salts*. Cryst. Growth Des. **18**, 2210 (2018).

J. Bermejo-Vega, D. Hangleiter, M. Schwarz, R. Raussendorf, J. Eisert. *Architectures for Quantum Simulation Showing a Quantum Speedup*. Phys. Rev. X **8**, 021010 (2018).

H. Beygi, S. Sajjadi, A. Babakhani, J. Young, F. van Veggel. *Solution phase surface functionalization of PbS nanoparticles with organic ligands for single-step deposition of p-type layer of quantum dot solar cells*. Appl. Surf. Sci. **459**, 562 (2018).

H. Beygi, S. Sajjadi, A. Babakhani, J. Young, F. van Veggel. *Surface chemistry of as-synthesized and air-oxidized PbS quantum dots*. Appl. Surf. Sci. **457**, 1 (2018).

W. Bogaerts, L. Chrostowski. *Silicon Photonics Circuit Design: Methods, Tools and Challenges*. Laser Photon. Rev. **12**, 1700237 (2018).

F. Boschini, E. Neto, E. Razzoli, M. Zonno, S. Peli, R. Day, M. Michiardi, M. Schneider, B. Zwartsenberg, P. Nigge, R. Zhong, J. Schneeloch, G. Gu, S. Zhdanovich, A. Mills, G. Levy, D. Jones, C. Giannetti, A. Damascelli. *Collapse of superconductivity in cuprates via ultrafast quenching of phase coherence*. Nat. Mater. **17**, 416 (2018).

M. Brass, C. Enss, L. Gastaldo, R. Green, M. Haverkort. *Ab initio calculation of the calorimetric electron-capture spectrum of Ho-163: Intra-atomic decay into bound states*. Phys. Rev. C **97**, 054620 (2018).

Y. Cao, W. Hamad, M. MacLachlan. *Broadband Circular Polarizing Film Based on Chiral Nematic Liquid Crystals*. Adv. Opt. Mater. **6**, 1800412 (2018).

V. Carta, S. Mehr, M. MacLachlan. *Controlling Ligand Exchange through Macrocyclization*. Inorg. Chem. **57**, 3243 (2018).

M. Chang, H. Fan, M. Chowdhury, G. Sawatzky, A. Nojeh. *Heat localization through reduced dimensionality*. Phys. Rev. B **98**, 155422 (2018).

M. Chaudhry, F. Lelj, M. MacLachlan. *Expanded campestarene hosts for tetra- and dinuclear uranyl(vi) complexes*. Chem. Commun. **54**, 11869 (2018).

A. Chen, R. Ilan, F. de Juan, D. Pikulin, M. Franz. *Quantum Holography in a Graphene Flake with an Irregular Boundary*. Phys. Rev. Lett. **121**, 036403 (2018).

K. Chen, P. Schauer, B. Patrick, C. Berlinguette. *Correlating cobalt redox couples to photovoltage in the dye-sensitized solar cell*. Dalton Trans. **47**, 11942 (2018).

R. Cheng, L. Chrostowski. *Multichannel photonic Hilbert transformers based on complex modulated integrated Bragg gratings*. Opt. Lett. **43**, 1031 (2018).

W. Cheng, J. He, K. Dettelbach, N. Johnson, R. Sherbo, C. Berlinguette. *Photodeposited Amorphous Oxide Films for Electrochromic Windows*. Chem **4**, 821 (2018).

W. Cheng, M. Moreno-Gonzalez, K. Hu, C. Krzyszkowski, D. Dvorak, D. Weekes, B. Tam, C. Berlinguette. *Solution-Deposited Solid-State Electrochromic Windows*. iScience **10**, 80 (2018).

V. Chiykowski, Y. Cao, H. Tan, D. Tabor, E. Sargent, A. Aspuru-Guzik, C. Berlinguette. *Precise Control of Thermal and Redox Properties of Organic Hole-Transport Materials*. Angew. Chem.-Int. Edit. **57**, 15529 (2018).

M. Chowdhury, H. Fan, M. Chang, K. Dridi, K. Voon, G. Sawatzky, A. Nojeh. *The role of lateral confinement in the localized heating of thermionic emitters based on carbon nanotube forests*. 2018 31st International Vacuum Nanoelectronics Conference (IVNC) (2018).

F. Cilento, G. Manzoni, A. Sterzi, S. Peli, A. Ronchi, A. Crepaldi, F. Boschini, C. Cacho, R. Chapman, E. Springate, H. Eisaki, M. Greven, M. Berciu, A. Kemper, A. Damascelli, M. Capone, C. Giannetti, F. Parmigiani. *Dynamics of correlation-frozen antinodal quasiparticles in superconducting cuprates*. Sci. Adv. **4**, EAAR1998 (2018).

K. Cochrane, T. Roussy, B. Yuan, G. Tom, E. Marsell, S. Burke. *Molecularly Resolved Electronic Landscapes of Differing-Acceptor-Donor Interface Geometries*. J. Phys. Chem. C **122**, 8437 (2018).

E. Colomes, M. Franz. *Antichiral Edge States in a Modified Haldane Nanoribbon*. Phys. Rev. Lett. **120**, 086603 (2018).

T. Croft, E. Blackburn, J. Kulda, R. Liang, D. Bonn, W. Hardy, S. Hayden. *Reply to "Comment on 'No evidence for orbital loop currents in charge-ordered YBa2Cu3O6+x from polarized neutron diffraction."'* Phys. Rev. B **98**, 016502 (2018).

O. Cyr-Choiniere, R. Daou, F. Laliberte, C. Collignon, S. Badoux, D. LeBoeuf, J. Chang, B. Ramshaw, D. Bonn, W. Hardy, R. Liang, J. Yan, J. Cheng, J. Zhou, J. Goodenough, S. Pyon, T. Takayama, H. Takagi, N. Doiron-Leyraud, L. Taillefer. *Pseudogap temperature T* of cuprate superconductors from the Nernst effect*. Phys. Rev. B **97**, 064502 (2018).

O. Cyr-Choiniere, D. LeBoeuf, S. Badoux, S. Dufour-Beausejour, D. Bonn, W. Hardy, R. Liang, D. Graf, N. Doiron-Leyraud, L. Taillefer. *Sensitivity of T-c to pressure and magnetic field in the cuprate superconductor YBa2Cu3Oy: Evidence of charge-order suppression by pressure.* Phys. Rev. B **98**, 064513 (2018).

O. Dagdeviren, S. Mandal, K. Zou, C. Zhou, G. Simon, F. Walker, C. Ahn, U. Schwarz, S. Ismail-Beigi, E. Altman I. *Suppression of the spectral weight of topological surface states on the nanoscale via local symmetry breaking*. Phys. Rev. Mater. **2**, 114205 (2018).

Y. Dai, V. Kumar, C. Zhu, M. MacLachlan, K. Smith, M. Wolf. *Mesoporous Silica-Supported Nanostructured PdO/CeO2 Catalysts for Low-Temperature Methane Oxidation*. ACS Appl. Mater. Interfaces **10**, 477 (2018).

E. da Silva Neto, M. Minola, B. Yu, W. Tabis, M. Bluschke, D. Unruh, H. Suzuki, Y. Li, G. Yu, D. Betto, K. Kummer, F. Yakhou, N. Brookes, M. Le Tacon, M. Greven, B. Keimer, A. Damascelli. *Coupling between dynamic magnetic and charge-order correlations in the cuprate superconductor Nd2-xCexCuO4*. Phys. Rev. B **98**, 161114 (2018).

R. Day, G. Levy, M. Michiardi, B. Zwartsenberg, M. Zonno, F. Ji, E. Razzoli, F. Boschini, S. Chi, R. Liang, P. Das, I. Vobornik, J. Fujii, W. Hardy, D. Bonn, I. Elfimov, A. Damascelli. *Influence of Spin-Orbit Coupling in Iron-Based Superconductors*. Phys. Rev. Lett. **121**, 076401 (2018).

M. Dehn, D. Arseneau, T. Buck, D. Cortie, D. Fleming, S. King, W. MacFarlane, A. McDonagh, R. McFadden, D. Mitchell, R. Kiefl. *Nature of magnetism in thiol-capped gold nanoparticles investigated with Muon spin rotation*. Appl. Phys. Lett. **112**, 053105 (2018).

K. Dettelbach, D. Salvatore, A. Bottomley, C. Berlinguette. *Tracking precursor degradation during the photo-induced formation of amorphous metal oxide films*. J. Mater. Chem. A **6**, 4544 (2018).

S. Dierker, M. Aronson. *Reduction of Raman scattering and fluorescence from anvils in high pressure Raman scattering*. Rev. Sci. Instrum. **89**, 053902 (2018).

J. Folk. *Super spins*. Nat. Phys. **14**, 877 (2018).

M. Franz, D. Pikulin. *Topological Superconductivity Quantized, finally.* Nat. Phys. **14**, 334 (2018).

M. Franz, M. Rozali. *Mimicking black hole event horizons in atomic and solid-state systems*. Nat. Rev. Mater. **3**, 491 (2018).

K. Fuersich, V. Zabolotnyy, E. Schierle, L. Dudy, O. Kirilmaz, M. Sing, R. Claessen, R. Green, M. Haverkort, V. Hinkov. *Theory-restricted resonant x-ray reflectometry of quantum materials*. Phys. Rev. B **97**, 165126 (2018).

W. Gannon, L. Wu, I. Zaliznyak, W. Xu, A. Tsvelik, Y. Qiu, J. Rodriguez-Rivera, M. Aronson. *Local quantum phase transition in YFe2Al10*. Proc. Natl. Acad. Sci. U. S. A. **115**, 6995 (2018).

W. Gannon, K. Chen, M. Sundermann, F. Strigari, Y. Utsumi, K. Tsuei, J. Rueff, P. Bencok, A. Tanaka, A. Severing, M. Aronson. *Intermediate valence in single crystalline Yb2Si2Al*. Phys. Rev. B **98**, 075101 (2018).

M. Hammood, A. Mistry, M. Ma, L. Chrostowski, N. Jaeger. *Compact contra-directional-coupler-based filters for CWDM applications*. 2018 IEEE 15th International Conference on Group IV Photonics (GFP) 129 (2018).

N. Hartman, C. Olsen, S. Luscher, M. Samani, S. Fallahi, G. Gardner, M. Manfra, J. Folk. *Direct entropy measurement in a mesoscopic quantum system*. Nat. Phys. **14**, 1083 (2018).

H. He, C. Yee, D. McNally, J. Simonson, S. Zellman, M. Klemm, P. Kamenov, G. Geschwind, A. Zebro, S. Ghose, J. Bai, E. Dooryhee, G. Kotliar, M. Aronson. *Combined computational and experimental investigation of the La2CuO4-xSx (0 <= x <= 4) quaternary system*. Proc. Natl. Acad. Sci. U. S. A. **115**, 7890 (2018).

J. He, A. Huang, N. Johnson, K. Dettelbach, D. Weekes, Y. Cao, C. Berlinguette. *Stabilizing Copper for CO2 Reduction in Low-Grade Electrolyte*. Inorg. Chem. **57**, 14624 (2018).

J. He, N. Johnson, A. Huang, C. Berlinguette. *Electrocatalytic Alloys for CO2 Reduction*. ChemSusChem **11**, 48 (2018).

M. Hepting, R. Green, Z. Zhong, M. Bluschke, Y. Suyolcu, S. Macke, A. Frano, S. Catalano, M. Gibert, R. Sutarto, F. He, G. Cristiani, G. Logvenov, Y. Wang, P. van Aken, P. Hansmann, M. Le Tacon, J. Triscone, G. Sawatzky, B. Keimer, E. Benckiser. *Complex magnetic order in nickelate slabs*. Nat. Phys. **14**, 1097 (2018).

M. Hiraishi, K. Kojima, I. Yamauchi, H. Okabe, S. Takeshita, A. Koda, R. Kadono, X. Zhang, S. Matsuishi, H. Hosono, K. Hirata, S. Otani, N. Ohashi. *Electronic correlation in the quasi-two-dimensional electride Y2C*. Phys. Rev. B **98**, 041104 (2018).

T. Hiratani, O. Kose, W. Hamad, M. MacLachlan. *Stable and sensitive stimuli-responsive anisotropic hydrogels for sensing ionic strength and pressure*. Mater. Horizons **5**, 1076 (2018).

K. Huang, C. Tan, J. Zhang, Z. Ding, D. MacLaughlin, O. Bernal, P. Ho, C. Baines, L. Wu, M. Aronson, L. Shu. *Anomalous quantum critical spin dynamics in YFe2Al10*. Phys. Rev. B **97**, 155110 (2018).

S. Ito, Y. Ueta, K. Koshino, K. Kojima, I. McKenzie, K. Mikami. *Observation of a Metastable P-Heterocyclic Radical by Muonium Addition to a 1,3-Diphosphacyclobutane-2,4-diyl*. Angew. Chem.-Int. Edit. **57**, 8608 (2018).

S. Jahani, S. Kim, J. Atkinson, J. Wirth, F. Kalhor, A. Al Noman, W. Newman, P. Shekhar, K. Han, V. Van, R. DeCorby, L. Chrostowski, M. Qi, Z. Jacob. *Controlling evanescent waves using silicon photonic all-dielectric metamaterials for dense integration*. Nat. Commun. **9**, 1893 (2018).

H. Jayatilleka, H. Shoman, R. Boeck, N. Jaeger, L. Chrostowski, S. Shekhar. *Automatic Configuration and Wavelength Locking of Coupled Silicon Ring Resonators*. J. Lightwave Technol. **36**, 210 (2018).

T. Junginger, S. Abidi, R. Maffett, T. Buck, M. Dehn, S. Gheidi, R. Kiefl, P. Kolb, D. Storey, E. Thoeng, W. Wasserman, R. Laxdal. *Field of first magnetic flux entry and pinning strength of superconductors for rf application measured with muon spin rotation*. Phys. Rev. Accel. Beams **21**, 032002 (2018).

J. Kacmarcik, I. Vinograd, B. Michon, A. Rydh, A. Demuer, R. Zhou, H. Mayaffre, R. Liang, W. Hardy, D. Bonn, N. Doiron-Leyraud, L. Taillefer, M. Julien, C. Marcenat, T. Klein. *Unusual Interplay between Superconductivity and Field-Induced Charge Order in YBa2Cu3Oy*. Phys. Rev. Lett. **121**, 167002 (2018).

S. Kaushal, R. Cheng, M. Ma, A. Mistry, M. Burla, L. Chrostowski, J. Azana. *Optical signal processing based on silicon photonics waveguide Bragg gratings: review*. Front. Optoelectron. **11**, 163 (2018).

C. Kellett, W. Swords, M. Turlington, G. Meyer, C. Berlinguette. *Resolving orbital pathways for intermolecular electron transfer*. Nat. Commun. **9**, 4916 (2018).

A. Khazraie, K. Foyevtsova, I. Elfimov, G. Sawatzky. *Oxygen holes and hybridization in the bismuthates*. Phys. Rev. B **97**, 075103 (2018).

A. Khazraie, K. Foyevtsova, I. Elfimov, G. Sawatzky. *Bond versus charge disproportionation in the bismuth perovskites*. Phys. Rev. B **98**, 205104 (2018).

C. Krull, M. Castelli, P. Hapala, D. Kumar, A. Tadich, M. Capsoni, M. Edmonds, J. Hellerstedt, S. Burke, P. Jelinek, A. Schiffrin. *Iron-based trinuclear metal-organic nanostructures on a surface with local charge accumulation*. Nat. Commun. **9**, 3211 (2018).

C. Kuzyk, M. Chang, K. Jessen, A. Nojeh, C. Aiello, R. F. W. Pease. Opto-thermionic cathodes for SEM. 2018 62nd International Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication (EIPBN)(2018).

E. Lantagne-Hurtubise, C. Li, M. Franz. *Family of Sachdev-Ye-Kitaev models motivated by experimental considerations*. Phys. Rev. B **97**, 235124 (2018).

L. Laplatine, E. Luan, K. Cheung, D. Ratner, Y. Dattner, L. Chrostowski. *System-level integration of active silicon photonic biosensors using Fan-Out Wafer-Level-Packaging for low cost and multiplexed point-of-care diagnostic testing*. Sens. Actuator B-Chem. **273**, 1610 (2018).

C. Li, M. Franz. *Majorana-Hubbard model on the honeycomb lattice*. Phys. Rev. B **98**, 115123 (2018).

F. Li, G. Sawatzky. *Electron Phonon Coupling versus Photoelectron Energy Loss at the Origin of Replica Bands in Photoemission of FeSe on SrTiO3*. Phys. Rev. Lett. **120**, 237001 (2018).

Q. Liang, S. Cui, S. Xu, C. Yao, M. MacLachlan, Z. Li. *A porous triptycene-based covalent polymer stabilized binary metal sulfide for enhanced hydrogen evolution under visible light*. Chem. Commun. **54**, 3391 (2018).

Z. Liao, N. Gauquelin, R. Green, K. Muller-Caspary, I. Lobato, L. Li, S. Van Aert, J. Verbeeck, M. Huijben, M. Grisolia, V. Rouco, R. El Hage, J. Villegas, A. Mercy, M. Bibes, P. Ghosez, G. Sawatzky, G. Rijnders, G. Koster. *Metal-insulator-transition engineering by modulation tilt-control in perovskite nickelates for room temperature optical switching*. Proc. Natl. Acad. Sci. U. S. A. **115**, 9515 (2018).

E. Luan, H. Shoman, D. Ratner, K. Cheung, L. Chrostowski. *Silicon Photonic Biosensors Using Label-Free Detection*. Sensors **18**, 3519 (2018).

E. Luan, H. Yun, L. Laplatine, J. Flueckiger, Y. Dattner, D. Ratner, K. Cheung, L. Chrostowski. *Sub-wavelength multi-box waveguide-based label-free sensors*. Integrated optics: devices, materials, and technologies xxii **10535**, 105350H (2018).

E. Luan, L. Laplatine, J. Flueckiger, O. Al'Mrayat, D. Ratner, K. Cheung, L. Chrostowski. *System-level integrated active silicon photonic biosensor for detecting small molecule interactions*. 2018 IEEE 15th international conference on group IV photonics (GFP), **83** (2018).

M. Ma, Y. Wang, A. Park, H. Yun, N. Jaeger, L. Chrostowski. *Broadband Polarization Splitter-Rotator using Sub-wavelength Grating Assisted Adiabatic Waveguides*. 2018 IEEE 15th international conference on group IV photonics (GFP), **87** (2018).

M. Ma, Z. Chen, H. Yun, Y. Wang, X. Wang, N. Jaeger, L. Chrostowski. *Apodized Spiral Bragg Grating Waveguides in Silicon-on-Insulator*. IEEE Photonics Technol. Lett. **30**, 111 (2018).

M. MacLachlan. *Bringing Nanotubes into Line*. Angew. Chem.-Int. Edit. **57**, 4838 (2018).

I. McKenzie, Y. Chai, D. Cortie, J. Forrest, D. Fujimoto, V. Karner, R. Kiefl, C. Levy, W. MacFarlane, R. McFadden, G. Morris, M. Pearson, S. Zhu. *Direct measurements of the temperature, depth and processing dependence of phenyl ring dynamics in polystyrene thin films by beta-detected NMR*. Soft Matter **14**, 7324 (2018).

T-D Nguyen, W. Hamad, M. MacLachlan. *Aerogel templating on functionalized fibers of nanocellulose networks*. Mat. Chem. Front. **2**, 1655 (2018).

T-D Nguyen, C. D. Nguyen, Nguyen Van Hieu, M. MacLachlan. *Mesoporous Cobalt Tungsten Oxide Heterostructured Nanotoroids for Gas Sensing*. Adv. Mater. Interfaces **5**, 1800269 (2018).

T-D Nguyen, D. Tang, F. D'Acierno, C. Michal, M. MacLachlan. *Biotemplated Lightweight gamma-alumina aerogels.* Chem. Mat. **30**, 1602 (2018).

A. Mistry, M. Hammood, H. Shoman, L. Chrostowski, N. Jaeger. *Bandwidth-tunable, FSR-free, microring-based, SOI filter with integrated contra-directional couplers*. Opt. Lett. **43**, 6041 (2018).

A. Mistry, M. Hammood, L. Chrostowski, N. Jaeger. *FSR-free microring coupling-based modulator*. 2018 IEEE photonics conference (IPC), (2018).

A. Mistry, M. Hammood, H. Shoman, L. Chrostowski, N. Jaeger. *FSR-free microring-based modulator*. 2018 IEEE 15th international conference on group IV photonics (GFP), **73** (2018).

E. Nica, M. Franz. *Landau levels from neutral Bogoliubov particles in two-dimensional nodal superconductors under strain and doping gradients*. Phys. Rev. B **97**, 024520 (2018).

A. Nicolas, J. Rottler. *Orientation of plastic rearrangements in two-dimensional model glasses under shear*. Phys. Rev. E **97**, 063002 (2018).

A. Oechsle, L. Lewis, W. Hamad, S. Hatzikiriakos, M. MacLachlan. *CO2-Switchable Cellulose Nanocrystal Hydrogels*. Chem. Mat. **30**, 376 (2018).

C. Okay, E. Tyhurst, R. Raussendorf. *The cohomological and the resource-theoretic perspective on quantum contextuality: common ground through the contextual fraction*. Quantum Inform. Comput. **18**, 1272 (2018).

A. Parker, J. Rottler. *Entropic Network Model for Star Block Copolymer Thermoplastic Elastomers*. Macromolecules **51**, 10021 (2018).

B. Pena, G. Owen, K. Dettelbach, C. Berlinguette. *Spin-coated epoxy resin embedding technique enables facile SEM/FIB thickness determination of porous metal oxide ultra-thin films*. J. Microsc. **270**, 302 (2018).

E. Piechota, L. Troian-Gautier, R. Sampaio, M. Brennaman, K. Hu, C. Berlinguette, G. Meyer. *Optical Intramolecular Electron Transfer in Opposite Directions through the Same Bridge That Follows Different Pathways*. J. Am. Chem. Soc. **140**, 7176 (2018).

H. Qiu, J. Jiang, P. Yu, D. Mu, J. Yang, X. Jiang, H. Yu, R. Cheng, L. Chrostowski. *Narrow-Band Add-Drop Filter Based on Phase-Modulated Grating-Assisted Contra-Directional Couplers*. J. Lightwave Technol. **36**, 3760 (2018).

E. Razzoli, B. Zwartsenberg, M. Michiardi, F. Boschini, R. Day, I. Elfimov, J. Denlinger, V. Suess, C. Felser, A. Damascelli. *Stable Weyl points, trivial surface states, and particle-hole compensation in WP2*. Phys. Rev. B **97**, 201103 (2018).

L. Reid, T. Li, Y. Cao, C. Berlinguette. *Organic chemistry at anodes and photoanodes*. Sustain. Energ. Fuels **2**, 1905 (2018).

P. Rogge, R. Chandrasena, A. Cammarata, R. Green, P. Shafer, B. Lefler, A. Huon, A. Arab, E. Arenholz, H. Lee, T. Lee, S. Nemsak, J. Rondinelli, A. Gray, S. May. *Electronic structure of negative charge transfer CaFeO3 across the metal-insulator transition*. Phys. Rev. Mater. **2**, 015002 (2018).

P. Rogge, R. Green, P. Shafer, G. Fabbris, A. Barbour, B. Lefler, E. Arenholz, M. Dean, S. May. *Inverted orbital polarization in strained correlated oxide films*. Phys. Rev. B **98**, 201115 (2018).

A. Ronchi, P. Franceschini, L. Fanfarillo, P. Homm, M. Menghini, S. Peli, G. Ferrini, F. Banfi, F. Cilento, A. Damascelli, F. Parmigiani, J. Locquet, M. Fabrizio, M. Capone, C. Giannetti. *Ultrafast orbital manipulation and Mott physics in multi-band correlated materials*. Ultrafast phenomena and nanophotonics xxii **10530**, 105300V (2018).

R. Rosa, S. Bhattacharya, J. Pabla, H. He, J. Misuraca, Y. Nakajima, A. Bender, A. Antonacci, W. Adrip, D. McNally, A. Zebro, P. Kamenov, G. Geschwind, S. Ghose, E. Dooryhee, A. Ibrahim, T. Tritt, M. Aronson, J. Simonson. *Pseudo-icosahedral Cr55Al232-delta as a high-temperature protective material*. Phys. Rev. Mater. **2**, 032401 (2018).

J. Rottler. *Molecular mobility in driven monomeric and polymeric glasses*. Phys. Rev. E **98**, 010501 (2018).

E. Sajadi, T. Palomaki, Z. Fei, W. Zhao, P. Bement, C. Olsen, S. Luescher, X. Xu, J. Folk, D. Cobden. *Gate-induced superconductivity in a monolayer topological insulator*. Science **362**, 922 (2018).

D. Salvatore, D. Weekes, J. He, K. Dettelbach, Y. Li, T. Mallouk, C. Berlinguette. *Electrolysis of Gaseous CO2 to CO in a Flow Cell with a Bipolar Membrane*. ACS Energy Lett. **3**, 149 (2018).

R. Sampaio, E. Piechota, L. Troian-Gautier, A. Maurer, K. Hu, P. Schauer, A. Blair, C. Berlinguette, G. Meyer. *Kinetics teach that electronic coupling lowers the free-energy change that accompanies electron transfer*. Proc. Natl. Acad. Sci. U. S. A. **115**, 7248 (2018).

A. Schiffrin, M. Capsoni, G. Farahi, C. Wang, C. Krull, M. Castelli, T. Roussy, K. Cochrane, Y. Yin, N. Medhekar, M. Fuhrer, A. Shaw, W. Ji, S. Burke. *Designing Optoelectronic Properties by On-Surface Synthesis: Formation and Electronic Structure of an Iron-Terpyridine Macromolecular Complex*. ACS Nano **12**, 6545 (2018).

R. Sherbo, R. Delima, V. Chiykowski, B. MacLeod, C. Berlinguette. *Complete electron economy by pairing electrolysis with hydrogenation*. Nat. Catal. **1**, 501 (2018).

R. Sherbo, M. Moreno-Gonzalez, N. Johnson, D. Dvorak, D. Fork, C. Berlinguette. *Accurate Coulometric Quantification of Hydrogen Absorption in Palladium Nanoparticles and Thin Films*. Chem. Mat. **30**, 3963 (2018).

H. Shishido, Y. Miki, H. Yamaguchi, Y. Iizawa, Vu The Dang, K. Kojima, T. Koyama, K. Oikawa, M. Harada, S. Miyajima, M. Hidaka, T. Oku, K. Soyama, S. Suzuki, T. Ishida. *High-Speed Neutron Imaging Using a Current-Biased Delay-Line Detector of Kinetic Inductance*. Phys. Rev. Appl. **10**, 044044 (2018).

H. Shoman, H. Jayatilleka, A. Park, N. Jaeger, S. Shekhar, L. Chrostowski. *Compact Silicon Microring Modulator with Tunable Extinction Ratio and Wide FSR*. 2018 optical fiber communications conference and exposition (OFC), (2018).

A. Sirusi, A. Page, L. Steinke, M. Aronson, C. Uher, J. Ross Jr. *Unconventional large linear magnetoresistance in Cu2-xTe*. AIP Adv. **8**, 055135 (2018).

J. Sous, M. Chakraborty, R. Krems, M. Berciu. *Light Bipolarons Stabilized by Peierls Electron-Phonon Coupling*. Phys. Rev. Lett. **121**, 247001 (2018).

M. Spengler, R. Dong, C. Michal, W. Hamad, M. MacLachlan, M. Giese. *Hydrogen-Bonded Liquid Crystals in Confined SpacesToward Photonic Hybrid Materials*. Adv. Funct. Mater. **28**, 1800207 (2018).

D. Szunyogh, R. McFadden, V. Karner, A. Chatzichristos, T. Goodacre, M. Dehn, L. Formenti, D. Fujimoto, A. Gottberg, E. Kallenberg, I. Kalomista, R. Kiefl, F. Larsen, J. Lassen, C. Levy, R. Li, W. MacFarlane, I. McKenzie, G. Morris, S. Pallada, M. Pearson, S. Sauer, P. Schaffer, P. Thulstrup, L. Hemmingsen, M. Stachura. *Direct observation of Mg2+ complexes in ionic liquid solutions by Mg-31 beta-NMR spectroscopy*. Dalton Trans. **47**, 14431 (2018).

A. Tait, H. Jayatilleka, T. de Lima, P. Ma, M. Nahmias, B. Shastri, S. Shekhar, L. Chrostowski, P. Prucnal. *Feedback control for microring weight banks*. Opt. Express **26**, 26422 (2018).

A. Terpstra, L. Arnett, A. Manning, C. Michal, W. Hamad, M. MacLachlan. *Iridescent Chiral Nematic Mesoporous Organosilicas with Alkylene Spacers*. Adv. Opt. Mater. **6**, 1800163 (2018).

A. Tran, W. Hamad, M. MacLachlan. *Tactoid Annealing Improves Order in Self-Assembled Cellulose Nanocrystal Films with Chiral Nematic Structures*. Langmuir **34**, 646 (2018).

A. Tran, W. Hamad, M. MacLachlan. *Fabrication of Cellulose Nanocrystal Films through Differential Evaporation for Patterned Coatings*. ACS Appl. Nano Mater. **1**, 3098 (2018).

V. Triandafilidi, S. Hatzikiriakos, J. Rottler. *Molecular simulations of the piezoionic effect*. Soft Matter **14**, 6222 (2018).

R. Vargas-Hernandez, J. Sous, M. Berciu, R. Krems. *Extrapolating Quantum Observables with Machine Learning: Inferring Multiple Phase Transitions from Properties of a Single Phase*. Phys. Rev. Lett. **121**, 255702 (2018).

C. Varma, W. Gannon, M. Aronson, J. Rodriguez-Rivera, Y. Qiu. *Quantum critical singularities in two-dimensional metallic XY ferromagnets*. Phys. Rev. B **97**, 085134 (2018).

K. Voon, O. Foyevtsov, H. Fan, K. Dridi, M. Chang, M. Chowdhury, P. Dosanjh, G. Sawatzky, A. Nojeh. *Effect of thermal pre-treatment on thermionic emission current stability from carbon nanotube forests*. 2018 31ST international vacuum nanoelectronics conference (IVNC) (2018).

K. Wamer, I. Affleck. *Renormalization group analysis of phase transitions in the two-dimensional Majorana-Hubbard model*. Phys. Rev. B **98**, 245120 (2018).

D. Wang, I. Affleck, R. Raussendorf. *Topological Qubits from Valence Bond Solids*. Phys. Rev. Lett. **120**, 200503 (2018).

P. Wang, M. MacLachlan. *Liquid crystalline tactoids: ordered structure, defective coalescence and evolution in confined geometries*. Philos. Trans. R. Soc. A-Math. Phys. Eng. Sci. **376**, 20170042 (2018).

P. Wang, W. Hamad, M. MacLachlan. *Size-Selective Exclusion Effects of Liquid Crystalline Tactoids on Nanoparticles: A Separation Method*. Angew. Chem.-Int. Edit. **57**, 3360 (2018).

Y. Wang, L. Xu, H. Yun, M. Ma, A. Kumar, E. El-Fiky, R. Li, N. Abadiacalvo, L. Chrostowski, N. Jaeger, D. Plant. *Polarization-Independent Mode-Evolution-Based Coupler for the Silicon-on-Insulator Platform*. IEEE Photonics J. **10**, 4900410 (2018).

D. Weekes, D. Salvatore, A. Reyes, A. Huang, C. Berlinguette. *Electrolytic CO2 Reduction in a Flow Cell*. Accounts Chem. Res. **51**, 910 (2018).

J. Wu, X. Yan, R. Watt, M. Nantel, L. Chrostowski, J. Young. *Widely Tunable, High-Q Two-Dimensional Photonic Crystal Cavities for cQED Applications*. 2018 IEEE photonics society summer topical meeting series. Summer, **85** (2018).

Y. Xu, Y. Dai, Thanh-Dinh Nguyen, W. Hamad, M. MacLachlan. *Aerogel materials with periodic structures imprinted with cellulose nanocrystals*. Nanoscale **10**, 38052 (2018).

I. Yamauchi, M. Hiraishi, H. Okabe, S. Takeshita, A. Koda, K. Kojima, R. Kadono, H. Tanaka. *Local spin structure of the alpha-RuCl3 honeycomb-lattice magnet observed via muon spin rotation/relaxation*. Phys. Rev. B **97**, 134410 (2018).

A. Yaresko, A. Schnyder, H. Benia, C. Yim, G. Levy, A. Damascelli, C. Ast, D. Peets, P. Wahl. *Correct Brillouin zone and electronic structure of BiPd*. Phys. Rev. B **97**, 075108 (2018).

Z. Ye, L. Waldecker, E. Ma, D. Rhodes, A. Antony, B. Kim, X. Zhang, M. Deng, Y. Jiang, Z. Lu, D. Smirnov, K. Watanabe, T. Taniguchi, J. Hone, T. Heinz. *Efficient generation of neutral and charged biexcitons in encapsulated WSe2 mono-layers*. Nat. Commun. **9**, 3718 (2018).

C. Yim, C. Trainer, R. Aluru, S. Chi, W. Hardy, R. Liang, D. Bonn, P. Wahl. *Discovery of a strain-stabilised smectic electronic order in LiFeAs*. Nat. Commun. **9**, 2602 (2018).

H. Yun, L. Chrostowski, N. Jaeger. *Ultra-broadband 2 x 2 adiabatic 3 dB coupler using subwavelength- grating-assisted silicon-on-insulator strip waveguides*. Opt. Lett. **43**, 1935 (2018).

P. Yu, H. Qiu, R. Cheng, L. Chrostowski, J. Yang. *High-Q antisymmetric multimode nanobeam photonic crystal cavities in silicon waveguides*. Opt. Express **26**, 26196 (2018).

S. Yu, E. Fajeau, L. Liu, D. Jones, K. Madison. *The performance and limitations of FPGA-based digital servos for atomic, molecular, and optical physics experiments*. Rev. Sci. Instrum. **89**, 025107 (2018).

V. Zabolotnyy, K. Fuersich, R. Green, P. Lutz, K. Treiber, C. Min, A. Dukhnenko, N. Shitsevalova, V. Filipov, B. Kang, B. Cho, R. Sutarto, F. He, F. Reinert, D. Inosov, V. Hinkov. *Chemical and valence reconstruction at the surface of SmB6 revealed by means of resonant soft x-ray reflectometry*. Phys. Rev. B **97**, 205416 (2018).

X. Zhou, D. Peets, B. Morgan, W. Huttema, N. Murphy, E. Thewalt, C. Truncik, P. Turner, A. Koenig, J. Waldram, A. Hosseini, R. Liang, D. Bonn, W. Hardy, D. Broun. *Logarithmic Upturn in Low-Temperature Electronic Transport as a Signature of d-Wave Order in Cuprate Superconductors*. Phys. Rev. Lett. **121**, 267004 (2018).

P. Zimmermann, R. Green, M. Haverkort, F. de Groot. *Quanty4RIXS: a program for crystal field multiplet calculations of RIXS and RIXS-MCD spectra using Quanty*. J. Synchrot. Radiat. **25**, 899 (2018).

Operations

SBQMI Operations Team

Science takes a community, and at SBQMI, that community involves people with a wide range of backgrounds and diverse professional expertise. What unites these individuals is their commitment to a particular goal. More specifically, the goal of SBQMI's Operations Team is to "contribute their diverse expertise and knowledge to advance global quantum materials research."

On a practical, day-to-day level, these people are the administrators, technicians, management staff, and officers whose activities enable collaborative research to take place. Besides the individuals shown in this photo feature, we have vital team members who contribute in a number of areas:

Aven Bendickson
Human Resources Manager

Natalia Bussard
Manager, Programs and Careers

David Dvorak
Research Technician Thin Film Growth

Ilya Elfimov
DFTU Manager

Harish Gautam
Machine Shop Supervisor

Susana Mendez Alcala
Large Grants and Awards Officer

Kostis Michelakis
Director, Nanofabrication Facility

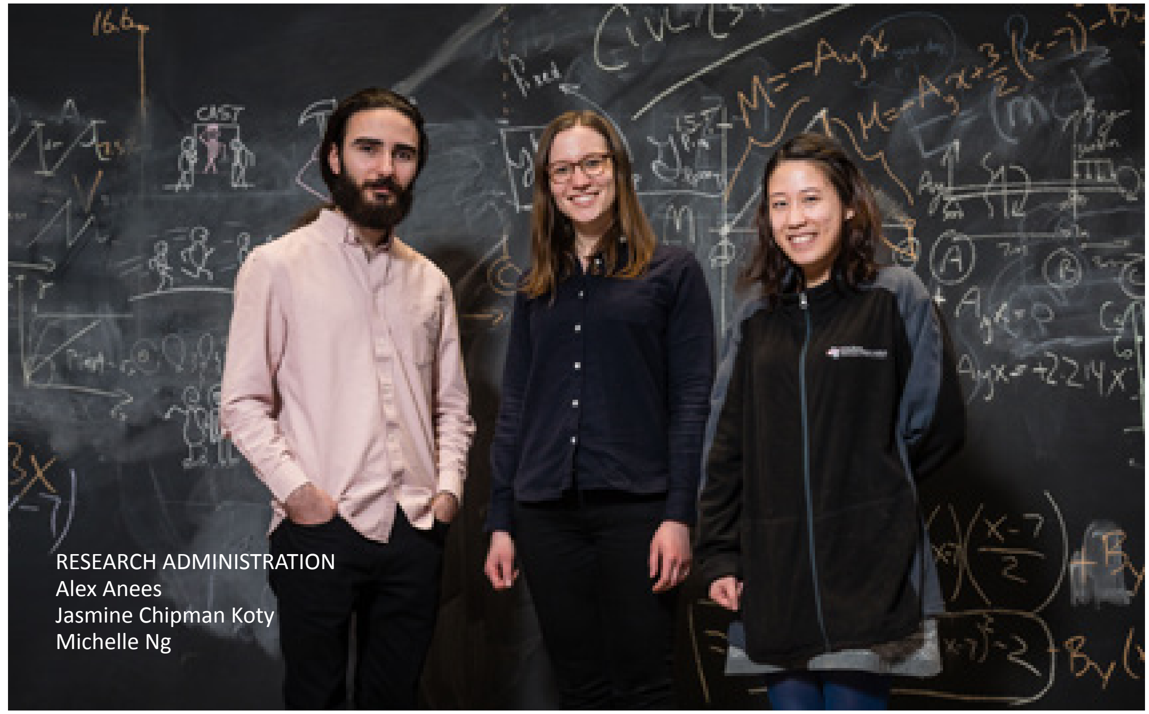
Evgeny Ostroumov
Research Engineer, Laser & Optics

Michael Schneider
Research Engineer

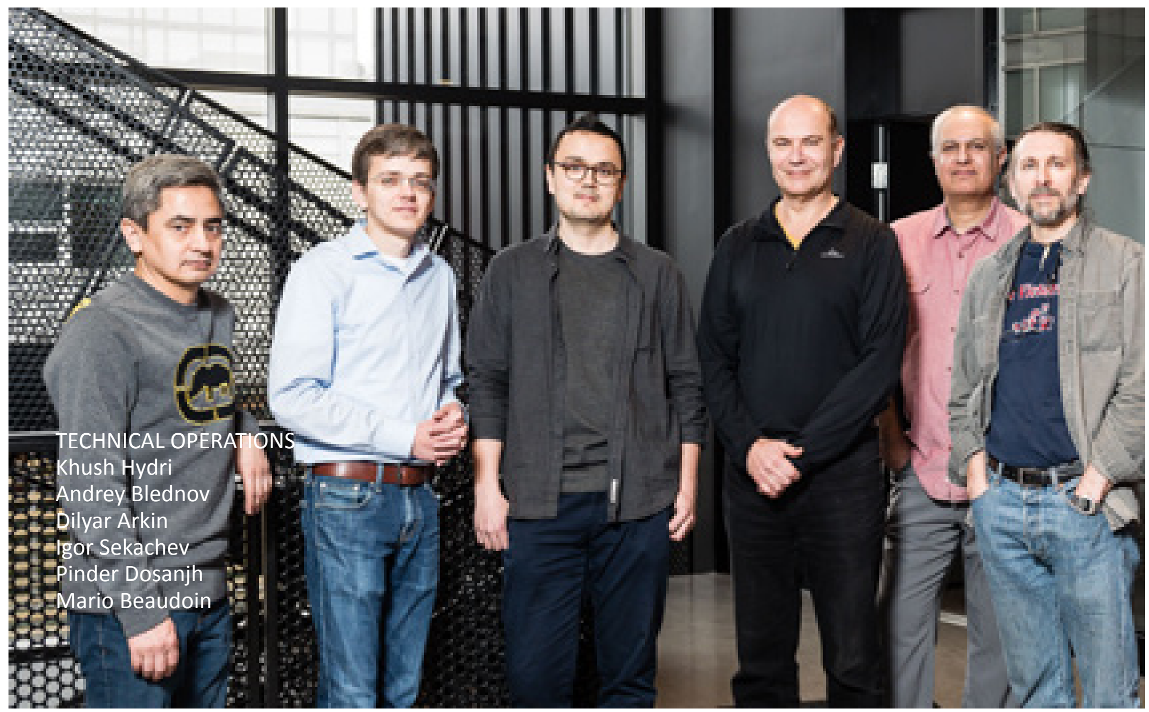
Ovidiu Toader
HPC Systems Analyst/Network Administrator

David Weekes
Business Innovation Manager

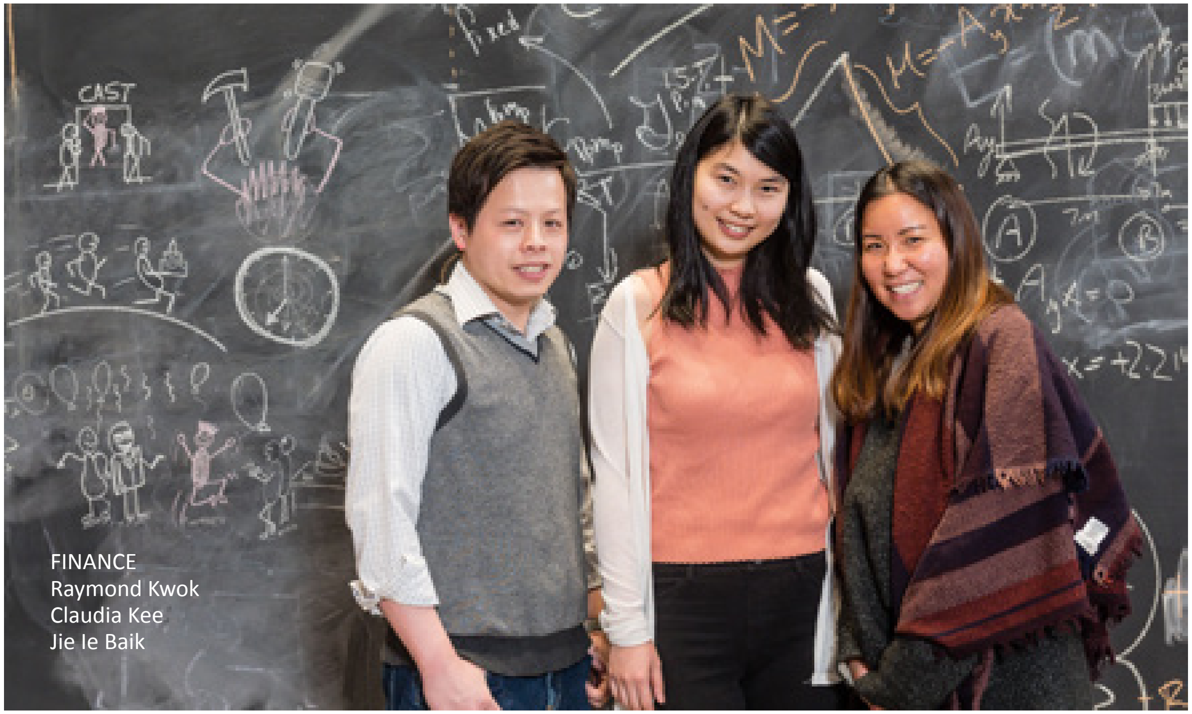
Doug Wong
Engineering Technician



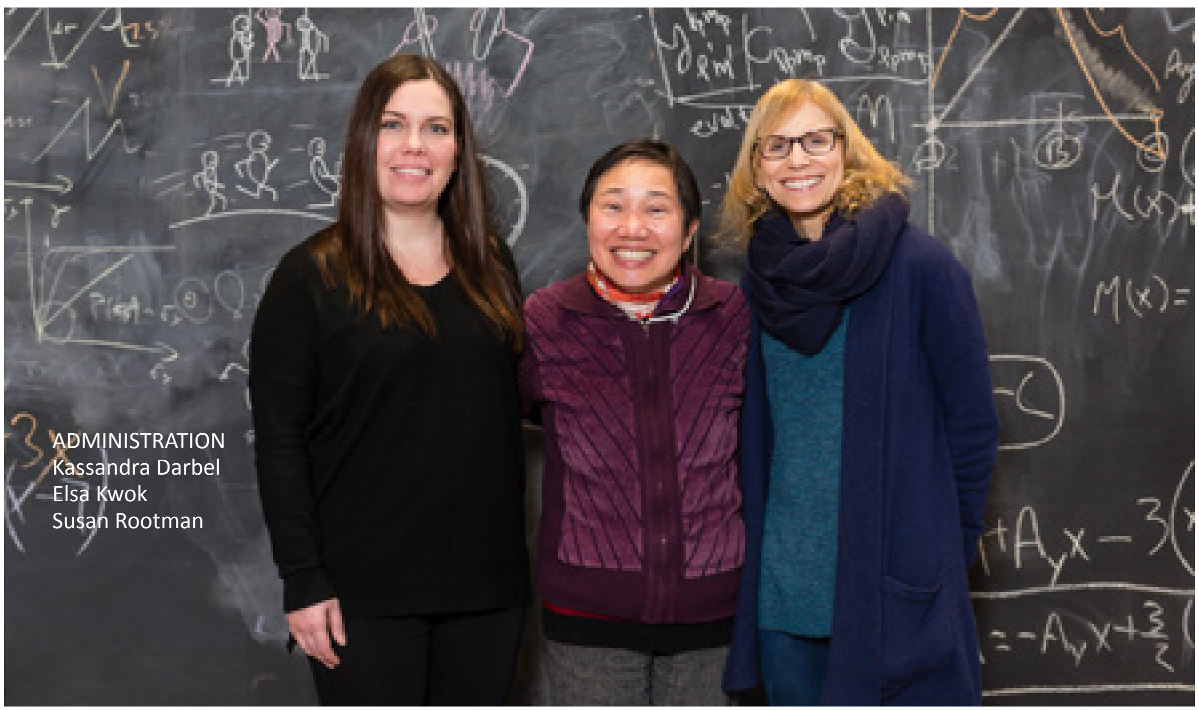
RESEARCH ADMINISTRATION
Alex Anees
Jasmine Chipman Koty
Michelle Ng



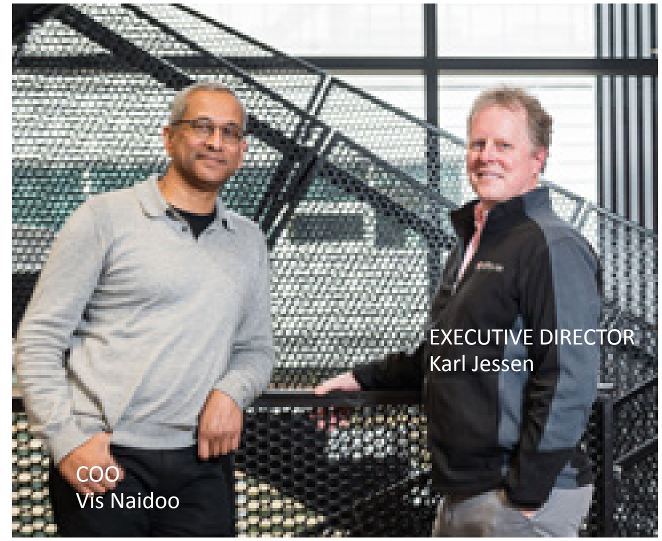
TECHNICAL OPERATIONS
Khush Hydri
Andrey Blednov
Dilyar Arkin
Igor Sekachev
Pinder Dosanjh
Mario Beaudoin



FINANCE
Raymond Kwok
Claudia Kee
Jie Ie Baik

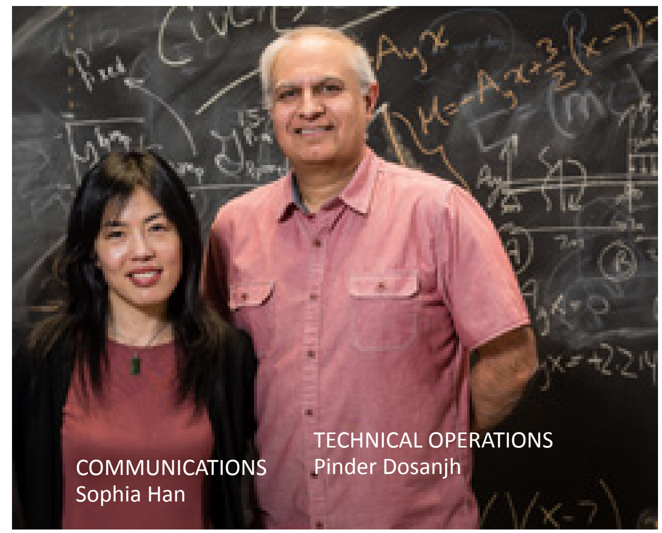


ADMINISTRATION
Kassandra Darbel
Elsa Kwok
Susan Rootman



EXECUTIVE DIRECTOR
Karl Jessen

COO
Vis Naidoo



COMMUNICATIONS
Sophia Han

TECHNICAL OPERATIONS
Pinder Dosanjh

STEWART BLUSSON QUANTUM MATTER INSTITUTE
2355 East Mall
Vancouver, BC, V6T 1Z4, Canada
Contact: communications@qmi.ubc.ca
Website: qmi.ubc.ca

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Contentl/design: Sophia Han, Susana Mendez Alcala, Claire Roan
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Stewart Blusson
Quantum Matter Institute
THE UNIVERSITY OF BRITISH COLUMBIA