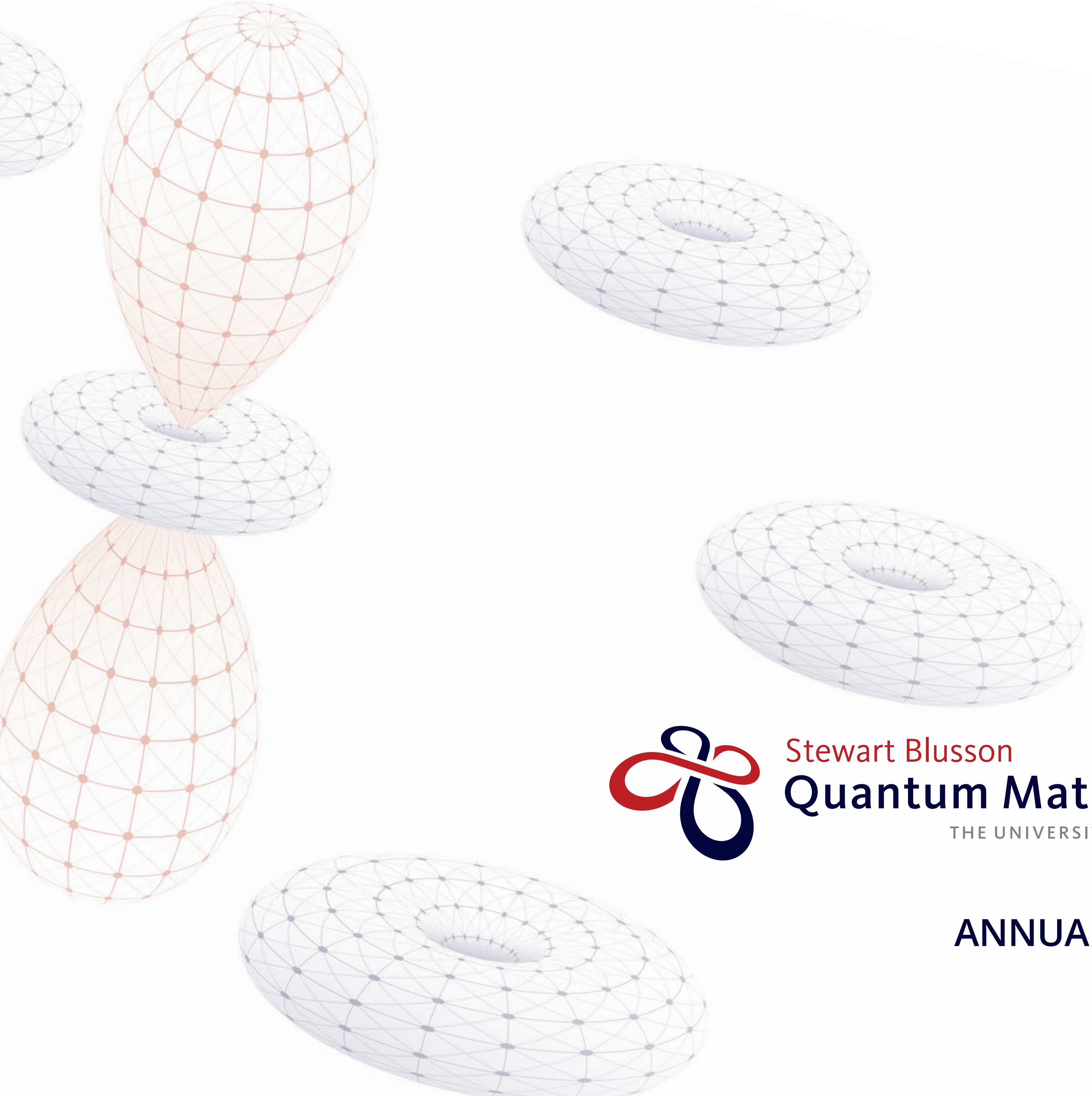


Stewart Blusson Quantum Matter Institute

THE UNIVERSITY OF BRITISH COLUMBIA

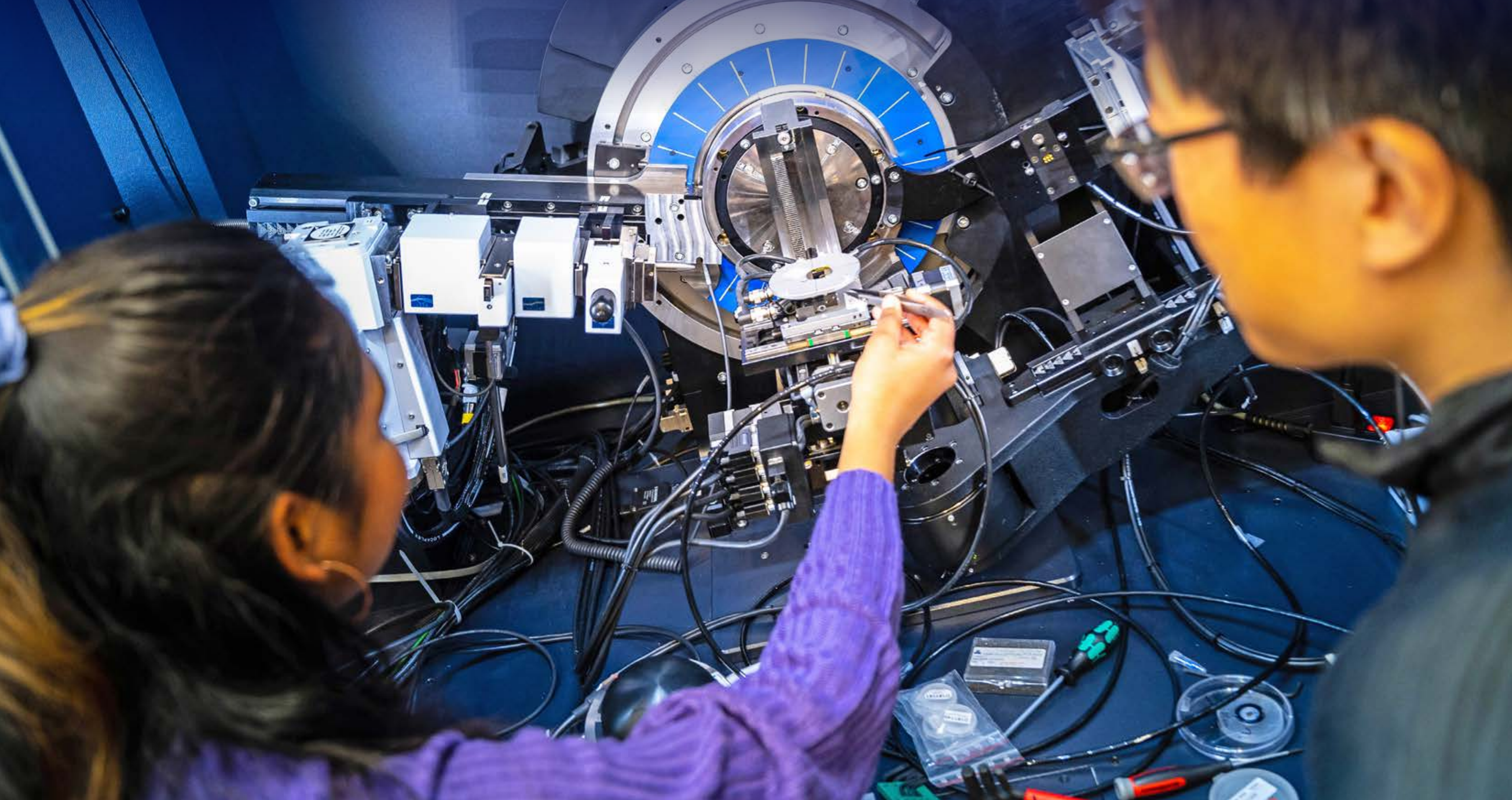
ANNUAL REPORT 2022

MISSION

The Stewart Blusson Quantum Matter Institute (Blusson QMI) 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

Blusson QMI 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.



OUR FUNDERS

Blusson QMI 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
The University of British Columbia (UBC)
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
Pacific Economic Development Canada (PacifiCan)
The European Research Council
The National Research Council
Mitacs

We wish to express our sincere gratitude and appreciation for their support as their contributions have enabled Blusson QMI to accelerate research productivity and technology translation.

LAND ACKNOWLEDGMENT

We acknowledge that the land on which we work, study and gather is the traditional, ancestral, and unceded territory of the **xwməθkwəy̓əm** (Musqueam) people.

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MESSAGE FROM THE SCIENTIFIC DIRECTOR

Image: Andrea Damascelli, Scientific Director, Blusson QMI as captured standing in the inertia block pit in 61A

Twelve years ago, a group of 12 UBC physicists led by George Sawatzky established what is today the Stewart Blusson Quantum Matter Institute (Blusson QMI). The group came together to enable multidisciplinary research into the emerging research field of quantum materials with the belief that such work could one day transform the world. Today, we're honored to witness that this vision has been realized into a world-leading research institute with 26 faculty members from across physics, chemistry, and engineering, including 8 new members from UBC and 6 new faculty hires.

In 2022, Blusson QMI completed a seven-year funding term for the $66.5 million grant we received in 2015 through the federal government's Canada First Research Excellence Fund (CFREF). To date, the grant represents the largest investment the government has made in any single UBC program. As this major funding term came to an end, I'm pleased to see the Institute emerge with a solid foundation, robust training and research programs, established industry collaborations, strong local and international partnerships, and a portfolio of breakthrough discoveries in quantum materials.

In particular, I commend the work of our early career researchers—Alannah Hallas, Andrew Potter, Ziliang Ye, and Ke Zou—who joined Blusson QMI thanks to the CFREF investment. In 2022, we celebrated the success of these individuals who are now recognized as international superstars of quantum material research for novel contributions to the field, and have received prestigious awards and numerous research grants through the year (please see page 6 to 13 for more on our early career researchers).

From entropy engineering of disordered materials to eliciting quantum phenomena in low-dimensional systems and devices, all the way to devising approaches for robust quantum computation, Blusson QMI Grand Challenges continue to inspire innovative theoretical frameworks and experimental outputs by convening researchers from across the Institute to create fundamental solutions for the world's most complex problems (see page 14 for more on our Grand Challenges).

This past year we were honored to engage with the federal government to lay the foundation for Canada's National Quantum Strategy (NQS). We look forward to continuing collaborations with our academic, industry, and government partners to solidify and advance Canada's position as a global leader in the quantum arena. As part of this Canada-wide community engagement effort, I was delighted to serve as the Chair of the 2022 Quantum Days conference. The event, which attracted more than 1000 participants, aimed to bring together the Canadian quantum community as a whole to nurture new connections and opportunities across the country.

As for the international quantum community engagement, we had the privilege of hosting our colleagues from around the world for the Materials and Mechanisms of Superconductivity (M2S) conference in Vancouver. Chaired by Blusson QMI Principal Investigators Mona Berciu and Douglas Bonn, the event attracted more than 350 attendees who participated in a week-long program of scientific talks, discussions, presentations, and networking activities. As the first major post-pandemic in-person gathering, the M2S was a challenging proposition to realize and yet marked a significant milestone and success in revitalizing the international community.

2022 also marked the official extension of the Max Planck-UBC-UTokyo Centre for Quantum Materials to a third 5-year term, which is the first instance of partnership renewal beyond 10 years for any international Max Planck Centre. In September, we celebrated the success of our partnership by hosting the Centre's annual meeting in Vancouver. A highlight of the program was a public concert by the UBC Symphony Orchestra in collaboration with the University of Stuttgart Academic Orchestra—a fantastic celebration of our flagship MP-UBC-UStuttgart International Joint PhD program in Quantum Materials.

In addition, our engagements with the arts community and the public have flourished in 2022. Ars Scientia—a research partnership between Blusson QMI, the Belkin Gallery, and UBC's Department of Physics & Astronomy—recruited three new artists growing the total number of the program's residencies to seven (please see pages 24 to 26 for more on our research clusters). Our students, post-doctoral fellows, and staff were involved in several outreach programs aimed at attracting girls, indigenous youth, and other underrepresented groups in STEM to the world of quantum (please see pages 39 to 45 for more on our outreach and EDI efforts).

Finally, as part of the CFREF funding coming to an end, some of our members have moved on to new roles outside of Blusson QMI. I would like to express my deepest gratitude to those individuals, many of whom have contributed to establishing the Institute since 2015, and making Blusson QMI an enriching, vibrant, and inclusive community. I would also like to welcome our new Communications Manager, Shahrzad Abbasi, who joined our operations team in 2022 from UNSW Sydney, Australia.

I invite you to read on and learn more about the many initiatives and programs that our Institute has built and continues to design and implement for a more inclusive, sustainable, and prosperous Canada. I hope you enjoy our stories!

Andrea Damascelli
Scientific Director
Blusson QMI

BY THE NUMBERS

Our goal is to ensure that Blusson QMI is comprised of the professional personnel necessary to build a world-class institute while prioritizing the development of programs that support equity, diversity, and inclusion.

135
Graduate Students

27
QuEST Students

67
Postdoctoral Fellows

3
Affiliate Members

26
Faculty

3
Canada Research Chairs

21
Administrative Staff

37
Scientific & Technical Staff

5
CIFAR Scholars

RESEARCH

Image: An upper vacuum chamber for a new angle-resolved photoemission spectroscopy (ARPES) system that directly attaches to our molecular-beam epitaxy (MBE) system and will be used to study the electronic properties of novel single crystal thin films.

SPOTLIGHT | BLUSSON QMI EARLY CAREER RESEARCHERS

Enabled by funding from the federal government through the CFREF program, the Blusson QMI early career researchers—Alannah Hallas, Andrew Potter, Ziliang Ye and Ke Zou—continue to deliver impactful results for Canada through designing focused research programs, developing highly specialized research facilities, and training the quantum workforce of the future in their expanding research groups.

ALANNAH HALLAS

Alannah Hallas is an Assistant Professor at UBC's Department of Physics & Astronomy and an Investigator at Blusson QMI since 2019. As the head of the Quantum Materials Design Lab, Hallas is establishing state-of-the-art high-pressure synthesis capabilities at UBC, including a high-pressure image furnace apparatus, which will be the first of its kind in Canada.

Hallas has been recognized with numerous major international awards, including a Vanier Graduate Scholarship (2014); Smalley-Curl Postdoctoral Fellowship in Quantum Materials (2017); Neutron Scattering Society of America Prize (2018), and the prestigious Bryan R. Coles Early Career Prize awarded at this year Strongly Correlated Electron System's Conference (2022). In 2020, she was named CIFAR Azrieli Global Scholar in Quantum Materials, a competitive international program recognizing tomorrow's outstanding research leaders.

Entropy engineering for future technologies

Material scientists from the Hallas Group at Blusson QMI have discovered a disordered material with strong potential for applications in high-tech industries. Their breakthrough study on "entropy engineering" was published in the *Journal of the American Chemical Society*.

The research tackles one of Blusson QMI's Grand Challenges—Atomistic Approaches to Emergent Properties of Disordered Materials—focused on discovering new materials for emerging technologies.

Led by Hallas, the team has showcased that by deliberately selecting the chemical composition of a high entropy material, they can precisely control the material's magnetic properties.

"High entropy materials are composed of a random distribution of different chemical elements that are disordered at the atomic level. 'Disorder' in materials is commonly perceived as a disadvantage—but in this study, we've leveraged disorder to reveal useful properties," said Hallas.

"By being very deliberate in choosing the chemical composition of materials, we can continuously vary the level of disorder, which we quantify by its entropy, from an ordered regime to a highly disordered regime, which we term entropy engineering."

The research has relied on the expertise of several students and early career researchers, including co-lead authors Graham Johnstone and Mario González Rivas. It provides pathways to improving the magnetic materials used in high-tech industries.

Magnetic materials have vast technological applications, including manufacturing advanced wind turbines and designing powerful mass-storage devices. However, the industry relies heavily on the mining of rare earth elements.

Found in the earth's crust, rare earth elements are formed in small quantities, and their extraction involves complex mining processes that are harmful to the environment.

"The raw materials that we're working with are abundant, and because there are effectively an infinite number of possible chemical compositions, we can work towards finding compositions that minimize environmental impact by eliminating the most harmful elements," Hallas said.

"Materials discovery usually requires a trial-and-error process where we have to build upon prior results before we reach a material that has the desired characteristics. The grand idea here is that in the future, we could specify what characteristics are required of a material and have powerful computers that could provide the recipe we need to grow those materials without exploiting our environment."

The Hallas Group, at the Blusson QMI, is focused on the design and discovery of new quantum materials using a broad range of crystal growth techniques. A particular interest of the group is establishing structure-function relationships in quantum materials via characterization of their structural, magnetic, and electronic behaviors in order to facilitate the targeted design of materials with novel or useful properties.

Highlight publications from the Hallas Group in 2022:

G.H.J. Johnstone, M.U. Gonź alez-Rivas, K.M. Taddei, R. Sutarto, G.A. Sawatzky, R.J. Green, M. Oudah, A.M. Hallas. *Entropy engineering and tunable magnetic order in the spinel high-entropy oxide.* J. Am. Chem. Soc. **144**, 45, 20590-20600 (2022)

S. Mugiraneza, A.M. Hallas. *Tutorial: a beginner's guide to interpreting magnetic susceptibility data with the Curie-Weiss law.* Commun Phys **5**, 95 (2022).

H. Wu, A.M. Hallas, X. Cai, J. Huang, J.S. Oh, V. Loganathan, A. Weiland, G.T. McCandless, J.Y. Chan, S.-K. Mo, D. Lu, M. Hashimoto, J. Denlinger, R.J. Birgeneau, A.H. Nevidomskyy, G. Li, E. Morosan, M. Yi. *Nonsymmorphic symmetry-protected band crossings in a square-net metal PtPb4.* npj Quantum Mater. **7**, 31 (2022).

> The grand idea here is that in the future, we could specify what characteristics are required of a material and have powerful computers that could provide the recipe we need to grow those materials.
>
> — Alannah Hallas

Image: Alannah Hallas (front), Janna Machts (left), Gargi Kodgirwar, Dongjoon Song, Mario Ulises González Rivas, Mohamed Oudah, Joern Bannies, and Samikshya Sahu.

ANDREW POTTER

Andrew Potter joined the Department of Physics & Astronomy at UBC as an Assistant Professor and Blusson QMI as an Investigator in August 2021. Potter has established and leads a research group focused on areas such as topological phases of matter, condensed matter theory, quantum information science and quantum computing. His research has implications across a range of projects, including Blusson QMI Grand Challenges.

New state of matter could make quantum computers less error-prone

UBC researchers led by Andrew Potter from Blusson QMI, in collaboration with Quantinuum, and the Flatiron Institute, have demonstrated a new phase of matter that could be protective against a range of errors in quantum computation.

Their research, which was published in *Nature,* revealed a new topological phase uncovered using Quantinuum's trapped ion quantum simulator. This phase arises outside of equilibrium, the default for most systems—and in fact, cannot exist in equilibrium—offering a way to prevent qubits (the quantum equivalent of bits) from entangling.

"One problem in quantum computing is that if you have qubits that are coupled to each other, but you didn't mean them to be, they can accidentally entangle themselves," said Potter.

"That entanglement can cause errors, or crosstalk, between the qubits. These errors represent a significant barrier to achieving a functional quantum computing platform."

"Even if you keep all the atoms under tight control, they can lose their quantumness by talking to their environment, heating up or interacting with things in ways you didn't plan," said first author Philipp Dumitrescu, a Flatiron Research Fellow at the Institute's Center for Computational Quantum Physics.

"In practice, experimental devices have many sources of error that can degrade coherence after just a few laser pulses."

Quantum entanglement is a phenomenon in which two systems become strongly correlated and "talk over" each other so that the particles in each system cannot be perceived as acting independently. In previous work, Potter and colleagues proposed a theory in which a new phase of matter could manipulate quantum entanglement and self-correct those errors.

Qubits are the quantum version of a bit, which in classical (binary) computing are units of information. Binary computing relies on a single physical state in which bits take one form or another represented by the numbers one and zero. Quantum computing uses undefined quantum states, and while a qubit is analogous to a bit in some ways, they function very differently.

Trapped ion quantum computing uses chains of ions that function as qubits. Out of equilibrium, the ions are isolated from their surrounding environment and protected against outside interference, allowing quantum states to emerge. Most systems tend to relax into thermal equilibrium with their surroundings, similar to how a hot pan will gradually cool to room temperature. Trapped ion systems offer enough control that researchers can build in time- and space-dependent interactions to create the new phase the team hoped to realize.

"To achieve this state, the team drives the system out of equilibrium by repeatedly applying pulses of light," said Potter, who began the theoretical work behind this new paper as a postdoctoral fellow at the University of California, Berkeley. "The result is that we're able to drive the ions into a new non-equilibrium phase of matter that is insensitive to control errors."

This work has relevance to the Blusson QMI Grand Challenge in quantum computing, as it relates to the interplay of topological phases with computing computational power and error correction.

Highlight publications from Andrew Potter's team in 2022:

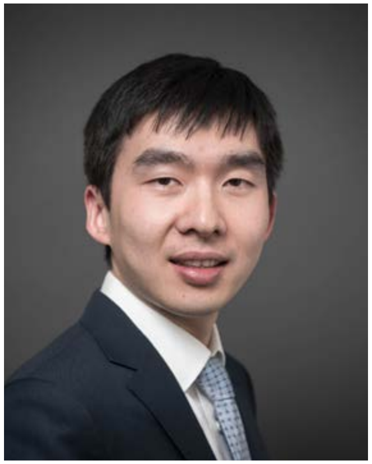
P.T. Dumitrescu, J. Bohnet, J. Gaebler, A. Hankin, D. Hayes, A. Kumar, B. Neyenhuis, R. Vasseur, A.C. Potter. *Dynamical topological phase realized in a trapped-ion quantum simulator*. Nature **607**, 463 (2022).

F. Barratt, U. Agrawal, A.C. Potter, S. Gopalakrishnan, R. Vasseur. *Transitions in the Learnability of Global Charges from Local Measurements*. Phys Rev Lett **129**, 200602 (2022).

R Wen, AC Potter. "Bulk-boundary correspondence for intrinsically-gapless SPTs from group cohomology." arXiv preprint arXiv:2208.09001 (2022)

Image (left to right): Rui Wen, Joseph Sullivan, Andrew Potter, Alice Xiong, Gaurav Tenkila.

> The result here is that we're able to drive the ions into a new non-equilibrium phase of matter that is insensitive to control errors. To achieve this state, the team drives the system out of equilibrium by repeatedly applying pulses of light.
>
> — Andrew Potter



ZILIANG YE

> "This is the first observation of an intrinsic photovoltaic effect in a van-der-Waals (vdW) material, which has layered structures, designed with an intentional stacking order.
>
> — Ziliang Ye

Ziliang Ye joined UBC's Department of Physics & Astronomy as an Assistant Professor and Blusson QMI as an Investigator in 2017. With a goal of developing novel quantum devices, Ye leads Blusson QMI's 2D Grand Challenge, and a research group focused on exploring how topology, correlation effects, and other emergent degrees of freedom interact with each other in two-dimensional (2D) van der Waals materials such as graphene, phosphorene, transition metal dichalcogenide, hexagonal boron nitride, and their heterostructures.

New material shows promise as programmable semiconductor

Research from Ziliang Ye's laboratory at Blusson QMI, published in the journal *Nature Photonics*, demonstrates a spontaneous polarization-induced photovoltaic effect in a potentially programmable semiconductor material.

These findings are based on a specific lab-grown crystal phase called rhombohedral molybdenum disulfide, and they demonstrate promising optoelectronic properties that do not exist in the material's usual thermodynamically stable (hexagonal) phase.

This work is among the first experiments in the world to achieve ferroelectric spontaneous polarization via a designed stacking order between atomic layers, which could one day be used to build high-speed photodetectors, flexible biosensors, or more efficient optical energy harvesters.

"This is the first observation of an intrinsic photovoltaic effect in a van-der-Waals (vdW) material, which has layered structures, designed with an intentional stacking order," said Ye.

Photovoltaic materials convert light into energy. Research elsewhere has demonstrated ferroelectric behaviors in artificially stacked crystal layers, but this is the first time that researchers have been able to demonstrate the effect in a single lab-grown crystal.

"The effect is new, and by developing a naturally stacked material in the lab rather than manually stacking layers one by one, we were able to achieve a scalable structure with perfect alignment and a very large domain with high efficacy."

"The idea arose from broken inversion symmetry, similar to artificially stacked crystal layers," said Dongyang Yang, a graduate student in Ye's lab and co-first author. "The difference is that now we are using a single molybdenum disulfide ($MoS2$) crystal with homogeneous spontaneous polarization throughout."

The team, including Yang and co-first author, Postdoctoral Fellow Jingda Wu, have partnered with colleagues at the University of Tokyo, who have grown the 3R-$MoS2$ crystal in their lab, to develop a device that harvests the spontaneous polarization for photovoltaic applications. Using a single crystal not only greatly eases the fabrication process, but also eliminates misalignment problems commonly seen during manual stacking.

Therefore, it has great potential for large-scale semiconducting devices, not limited to photodetectors.

Ferroelectricity has been studied for decades in oxide materials: recently, researchers around the world, including Ye's team at the University of British Columbia, have realized that it can also be found or realized in vdW materials.

"Our discovery is a good supplement to the studies in this field," said Yang. "Compared to ferroelectric oxides, which are normally transparent to visible light, 3R-phase vdW semiconductors can absorb wavelengths ranging from visible to infrared," said Wu. "This greatly expands the use of ferroelectrics in optoelectronic applications."

Ferroelectric memory by itself is a very important topic in industry, and the team's findings could potentially lead to photodetectors with memory capability. Ye and colleagues are working with a theory team, led by Marcel Franz to reveal more secrets about this material.

While Ye's team has observed efficient photocurrent generation in their research, further studies are needed to make it practical for actual photodetection applications.

"Our ongoing study shows some evidence that this kind of device has a very fast response speed," said Wu. "It has the potential to be used in next-generation high-speed communication applications."

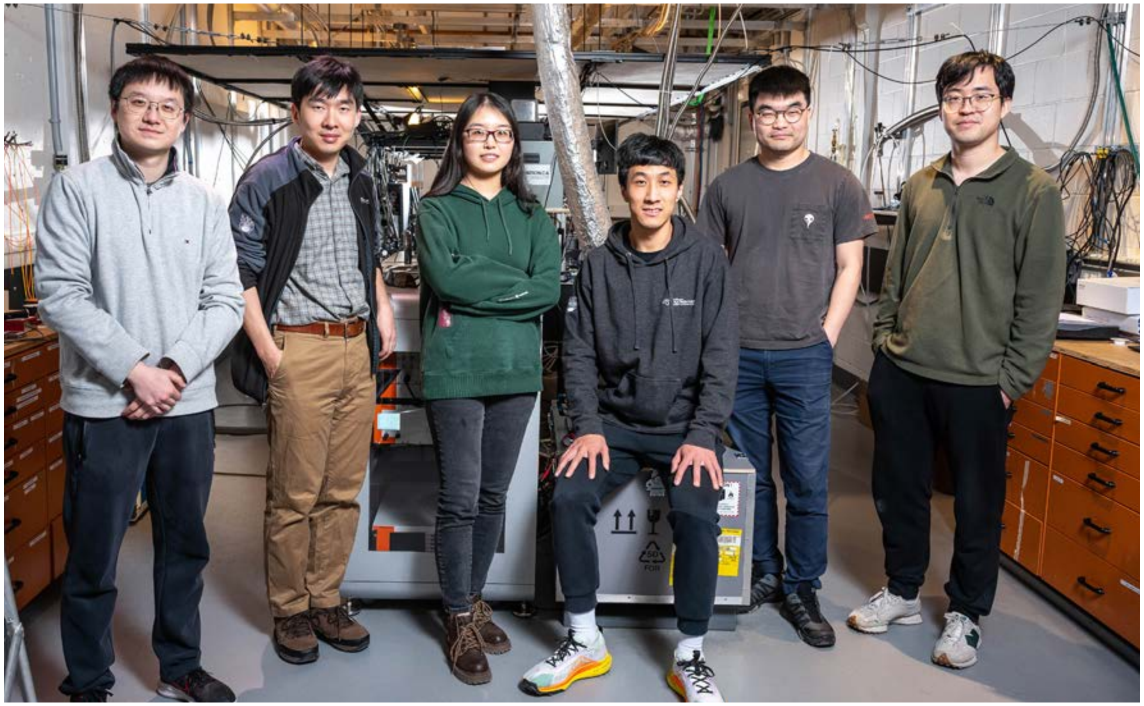


Image: Yunhuan Xiao, Ziliang Ye, Jing Liang, Yuan Xie, Jingda Wu, Dongyang Yang.

Highlight publications from Zilliang Ye's Lab:

J. Wu, D. Yang, J. Liang, M. Werner, E. Ostroumov, Y. Xiao, K. Watanabe, T. Taniguchi, J.I. Dadap, D.J. Jones, Z. Ye. *Ultrafast response of spontaneous photovoltaic effect in 3R-MoS2-based heterostructures*. Sci. Adv. **8**, eade375 (2022).

J. Liang, D. Yang, J. Wu, J.I. Dadap, K. Watanabe, T. Taniguchi, Z. Ye. *Optically probing the asymmetric interlayer coupling in rhombohedral-stacked MoS2 bilayer*. Phys. Rev. X **12**, 041005 (2022).

D. Yang, J. Wu, B. T. Zhou, J. Liang, T. Ideue, T. Siu, K.M. Awan, K. Watanabe, T. Taniguchi, Y. Iwasa, M. Franz, Z. Ye. *Spontaneous polarization induced photovoltaic effect in rhombohedrally stacked MoS2*. Nat. Photon. **16**, 469 (2022).

KE ZOU

Ke Zou has been with UBC as an Assistant Professor and an Investigator at Blusson QMI since 2018. He leads a group interested in the growth of complex oxide and chalcogenide films by molecular beam epitaxy and the studies of their properties and functions. The group aims to achieve scientific and technological breakthroughs in new materials and new functional devices.

Quantum synapses could solve the memory wall problem in computers' random-access memory

Researchers in Ke Zou's lab at Blusson QMI have designed quantum materials with intentionally created "impurities" to mimic brain activity for artificial intelligence applications.

A paper from Zou and colleagues, published in the journal *Advanced Electronic Materials*, highlights the influence of proton (hydrogen ion H^+) incorporation —via low-cost topochemical techniques in a transition metal oxide lattice—and provides insight into their effects on resistive switching mechanisms.

This efficient, cost-effective approach to fabricating quantum devices may bring the idea of a "brain on a chip" closer to reality.

Transition metal oxide materials have unique electrical and magnetic properties that make them a potentially useful platform for computer memory storage devices. Currently, many such devices are fabricated using silicon, but silicon memory devices have inherent processing limitations when scaled to smaller dimensions.

"Resistive random-access memory (RRAM) or memristor devices show promise as tools to achieve lower-cost, higher endurance processing that consumes less power," said Srinivas Vanka, who co-authored the paper as a postdoctoral fellow in Zou's lab, and who has since gone on to a role with a Vancouver-based nanotechnology company. "We believe that complementary metal-oxide-semiconductor compatible neuromorphic hardware can also address the 'memory wall' problem in computing."

The "memory wall problem" is a major challenge facing modern computing, wherein advances in CPU processing speed have outpaced advances in memory speed: conventional microchips have more or less reached the limit of their ability to process information. To solve this, the team is working to develop novel memory devices using easily accessible materials that will facilitate automated data storage using analog memory devices.

"We're using materials and techniques developed by Prof. Zou and others at Blusson QMI to create a new avenue for an entirely different memory architecture not seen in conventional silicon devices," said Vanka. "This could be a game-changer."

The researchers used a commercially available substrate (base material) and applied a thin film of metal. They then treated the surface of the material with a low-cost topochemical application to remove defects in the material and change the electrical properties of the underlying metal oxide in order to generate new properties.

"We believe a device like this could represent a turning point in our goal to simulate brain activity on a chip," said Vanka.

These new properties turn the material from a standard metal into a tool that can function like a synapse between artificial neurons. It is these properties the team is set to explore next, in collaboration with Max Planck–UBC–UTokyo Centre for Quantum Materials (CQM) researchers. In addition to its connection with the CQM, this work is an important contribution to Blusson QMI's Grand Challenge in 2D materials.

Highlight publications from Ke Zou's Group:

Y. Zou, H. Shin, H. Wei, Y. Fan, B.A. Davidson, E.J. Guo, Q. Chen, K. Zou, Z.G. Cheng. *Transport behaviors of topological band conduction in* $KTaO_3$*'s two-dimensional electron gases*. npj Quantum Mater. **7**, 122 (2022).

H. Shin, C. Liu, S. Godin, F. Li, R. Sutarto, B.A. Davidson, K. Zou. *Highly Tunable Ferromagnetic 2D Electron Gases at Oxide Interfaces*. Adv. Mater. Interfaces **9**, 2201475 (2022).

S. Vanka, H. Shin, B.A. Davidson, C. Liu, K. Zou. *Hydrogen Atom Doping—A Versatile Method for Modulated Interface Resistive Switching*. Adv. Electron. Mater. **8**, 2200353 (2022).

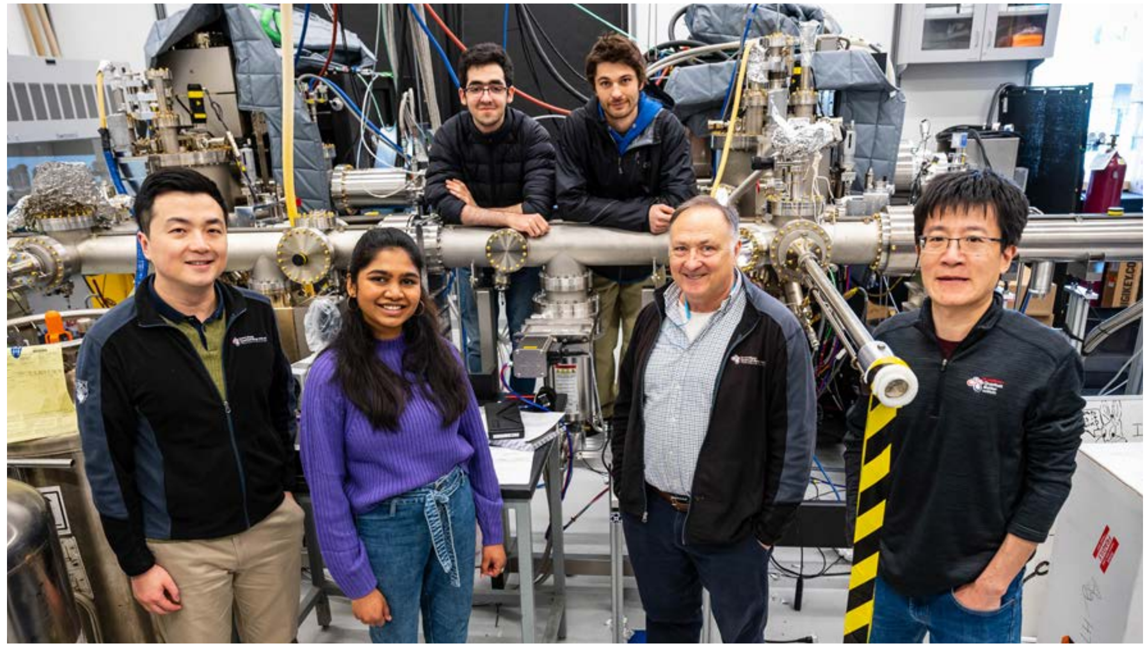


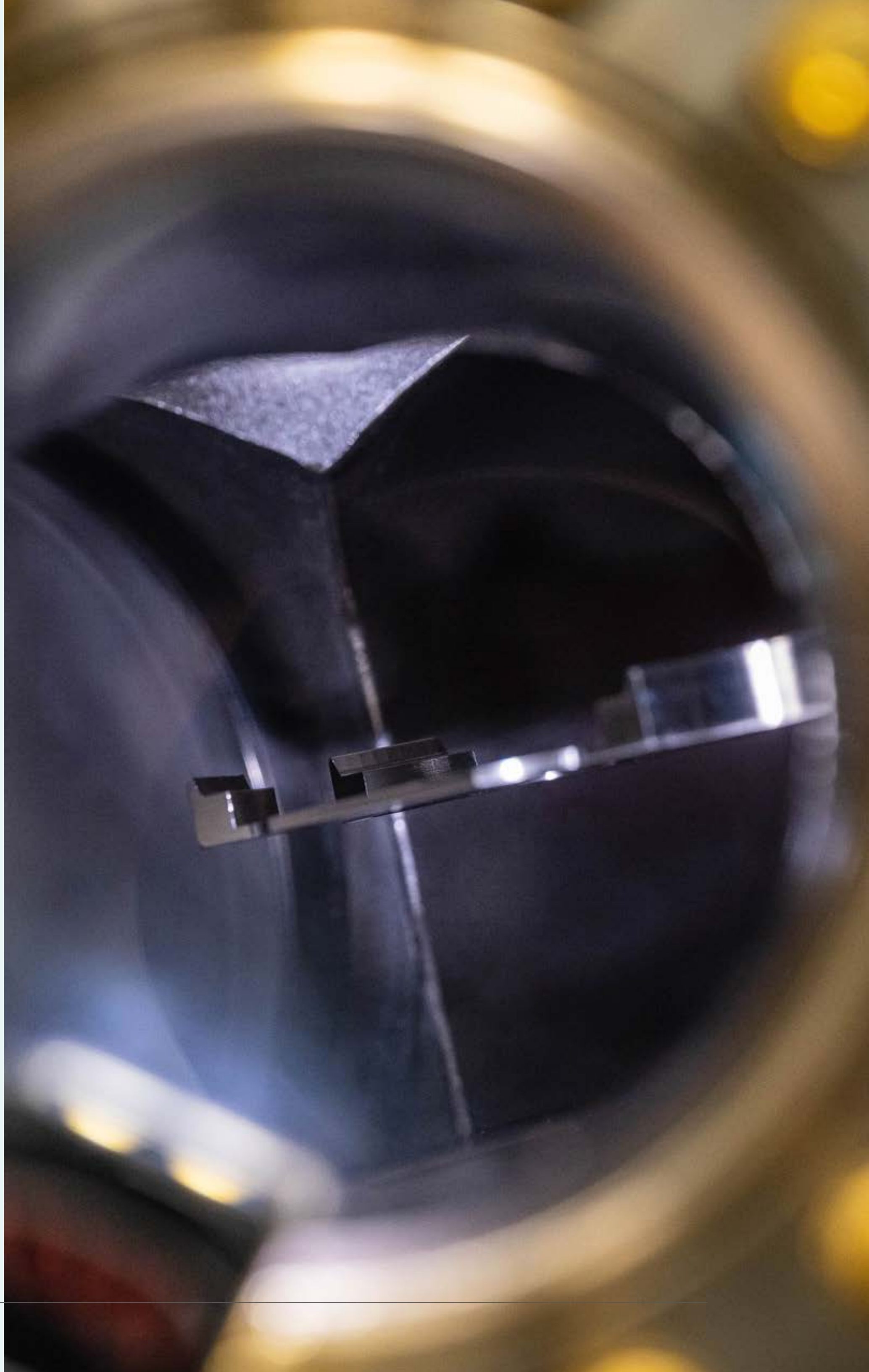
Image (left to right): Ke Zou, Gargi Kodgirwar, Gor Nahapetyan, Ryan Roemer, Bruce Davidson, Fengmiao Li.

> Neuromorphic computing holds immense potential to revolutionize computing capabilities by providing efficient and brain-inspired solutions for various applications. Its importance lies in its ability to improve in many aspects, such as cognitive computing, scalability, energy efficiency, and the development of brain-inspired algorithms. By exploring the new group of materials, our work contributes to advancing neuromorphic computing by identifying materials that can enhance its performance and capabilities.
>
> — Ke Zou

BLUSSON QMI GRAND CHALLENGES

Blusson QMI Grand Challenges are aimed at finding solutions to current and future problems faced by Canadians through developing materials, tools and technologies with applications in a range of areas, including the environment, medical technologies, and computing.

We leverage our unique capabilities and expertise in pursuit of a trio of Grand Challenges; these three bold, ambitious ideas are interdisciplinary in nature, connecting researchers with expertise in theory, experiment, and materials design. Our Grand Challenges guide our research priorities and engage all of our research groups and investigators in collaboration over the next decade.



NEW APPROACH CREATES MAJORANA PARTICLES AT HIGH TEMPERATURES

In 2021, Marcel Franz and colleagues proposed a high-temperature topological superconductor made from two monolayer-thin sheets of copper-based materials with a twist. In 2022, a follow-up paper published in the journal *Physical Review Letters* tweaks the recipe, adding a crucial ingredient so that the material can function as a different type of a topological superconductor, capable of hosting exotic particles called Majorana fermions, at temperatures that are more easily achieved in laboratory and industry applications.

"The material we had looked at previously was interesting, and potentially useful, but the most exciting class of topological superconductors—the ones we think will be useful for fault-tolerant quantum computing—are those that support Majorana zero modes," said Franz, Professor in UBC's Department of Physics & Astronomy.

Franz and colleagues initially set out to create a topological superconductor out of copper-based materials (also known as cuprates), and they were successful in proposing this; the sample materials for the experimental study are being developed under the direction of Ziliang Ye, Assistant Professor in UBC's Department of Physics & Astronomy.

This new work builds on earlier theoretical papers in which the researchers studied the material, BSCCO ($Bi_2Sr_2CaCu_2O_{8+\delta}$), in isolation. Now, the team has considered placing the twisted cuprate bilayer on the surface of a topological insulator, such as bismuth selenide (Bi_2Se_3), to generate Majorana zero modes.

Majorana zero modes are electronic states that are theoretically favourable to potential computing applications because they resist perturbation and could produce fewer errors in processing quantum information. The missing ingredient in Franz's earlier work, however, is spin-orbit coupling, which occurs when the spin of the electron and its orbital angular momentum interact, a phenomenon that was absent in BSCCO but that emerges when the material is supported by Bi_2Se_3.

"The formula we came up with is actually not that complicated: we twisted bilayer BSCCO and put it in contact with Bi_2Se_3; the combination, under ideal conditions, may lead to topological superconductivity of a new kind," said Franz. "The surface of Bi_2Se_3 exhibits the strongest spin-orbit coupling that you can possibly have; it provides what BSSCO is missing in abundance."

Other topological superconductors capable of supporting Majoranas would require temperatures within 1°C of the absolute zero, a temperature not easily achieved in conventional laboratory environments. However, Franz's recipe for BSCCO applied to Bi_2Se_3 could see topological superconductivity at nearly 100°C warmer, which would require less complex cooling systems and more readily available—and less expensive—detection methods.

A. Mercado, S. Sahoo, M. Franz. *High-Temperature Majorana Zero Modes*. Phys Rev Lett **128**, 137002 (2022).

Image (left to right): Ziliang Ye, Marcel Franz and Oguzhan Can.

A NEW LIGHT ON SPINTRONICS

Matteo Michiardi

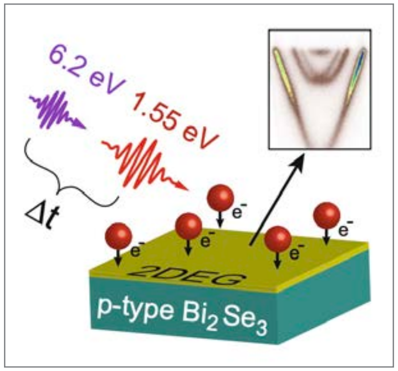


Image: TR-ARPES experiment on p-type Bi2Se3; the cleaved sample is gated in situ by alkali atom deposition. A near-infrared (1.55 eV) "pump" pulse perturbs the system, and a UV (6.2 eV) pulse is used to probe the electronic structure by ARPES. The time delay (Δt) between pump and probe pulses is varied to resolve the electron dynamics.

M. Michiardi, F. Boschini, H.H. Kung, M.X. Na, S.K.Y. Dufresne, A. Currie, G. Levy, S. Zhdanovich, A.K. Mills, D.J. Jones, J.L. Mi, B.B. Iversen, P. Hofmann, A. Damascelli. *Optical manipulation of Rashba-split 2-dimensional electron gas*. Nat. Commun. **13**, 3096 (2022).

Most electronic devices exploit the electric charge of the electrons in a material to store and manipulate information. However, electrons possess another fundamental property, their spin, which researchers have long tried to exploit for its potential as a less volatile source of energy. New research from Andrea Damascelli and colleagues at Blusson QMI has uncovered a way to use light to control the spin of electrons in semiconductor materials.

The advancement of spin-electronics, or spintronics, has the potential to yield more efficient and faster computing compared to conventional electronics. Published in the journal *Nature Communications*, this discovery is an important milestone on the road to faster and more energy-efficient quantum devices.

"Using angle-resolved photoemission spectroscopy (ARPES) and time-resolved ARPES performed at Blusson QMI's UBC-Moore Center for Ultrafast Quantum Matter, we found a new way to control the spin of the electrons moving through the material using lasers to create optical excitation," said Matteo Michiardi, a Senior Scientist at Blusson QMI who works closely with Damascelli. "Interestingly, this effect is universal within all semiconductors."

To control the spin, researchers have typically relied on magnetic or electric fields in materials where the spin is entangled in the direction of the electrical current; this phenomenon is known as spin-orbit coupling. However, optical fields offer an unprecedented platform to control the spin of the electrons, bridging the gap between spintronics and optoelectronics.

"We discovered that by exploiting a physical effect similar to the one that powers photovoltaic (solar) cells, we can change this entanglement, allowing us to control the spin of the electrons flowing in the material," said Michiardi.

The researchers applied a thin layer of alkali atoms to a bismuth selenide crystal (Bi2Se3) to generate a puddle of free electrons at the surface of the material where the spin-orbit coupling is strong. Using an ultrafast laser pulse, lasting only 200 femtoseconds (quadrillionths of a second), they were able to change the strength of the coupling and the spin direction of the flowing electrons.

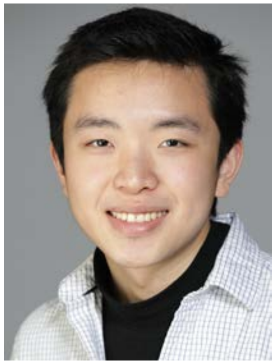
"This is particularly exciting because the ability to control spin-orbit coupling with light gives us the opportunity to explore new avenues both in terms of research and device development," said Michiardi, who designed the experiment and the mathematical models to demonstrate the functionality and clarify the team's findings.

"The idea is that if you can find a way to use spin rather than charge in an efficient way, you can potentially create hardware for a range of applications that require far less energy to function," said Damascelli.

While computing is a potential application for spintronics devices, this research has even greater implications. Spin-orbit coupling is a general effect employed in a number of quantum technology fields, and these findings offer a potentially new way to control quantum properties, a benefit that may be impactful across a range of applications.

Michiardi and colleagues in Damascelli's Quantum Materials Lab are currently completing the development of a beamline for spin-resolved ARPES at the Quantum Materials Spectroscopy Centre at the Canadian Light Source. The beamline will enable the team to continue this line of research and to develop and test new and interesting systems for novel spintronic functionalities.

SUPERCONDUCTIVITY IN TWISTED DOUBLE BILAYER GRAPHENE



Ruiheng Su

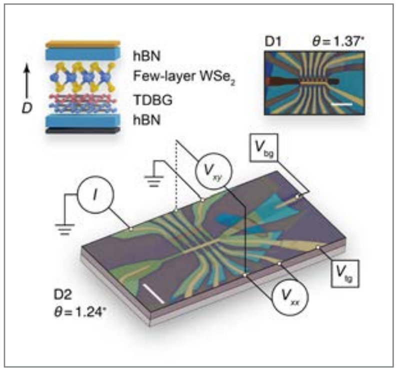


Image: Optical images of twisted double bilayer graphene devices. The devices were assembled by placing a WSe_2 flake on top of two bilayer graphene sheets rotationally misaligned by 1.3 degrees. Encapsulating the stack with hexagonal boron nitride (hBN) layers allows independent control of the carrier density (n) and displacement field (D) in the sample via top and bottom electrostatic gates (V_tg and V_bg). The white scale bar indicates 10 micrometers.

Beginning with the discovery of superconductivity in twisted bilayer graphene (two monolayers of graphene with a twist between them) in 2018, superconductivity has now been discovered in several van der Waals heterostructures based on two or more layers of graphene, with or without twists.

Adding tungsten diselenide (WSe2), which is another van der Waals material, next to graphene structures has been shown, in several cases, to strengthen superconductivity: to increase the critical temperature, increase the range of angles over which superconductivity is observed, and more. One surprising holdout from the family of graphene superconductors has been twisted double-bilayer graphene (TDBG, two bilayers with a twist): although many correlated electron phenomena observed in TDBG are analogous to those in other graphene structures, superconductivity has not been seen.

Ruiheng Su, an undergraduate student in Joshua Folk's Quantum Devices group, led an experiment in the summer of 2022 to investigate whether adding WSe2 next to TDBG would induce superconductivity also in this structure. After a summer of making devices (over 30 of them), he found two that were good enough to measure at a low temperature, and remarkably, he discovered superconductivity in both samples. Perhaps most interestingly, the superconductivity was confined to very small regions of the gate voltage-tuned phase diagram, but the superconducting regions were quite different for the two devices (for example, one was in the conduction band and the other in the valence band).

Critical temperatures are very low (< 100 mK for both samples), but moderate violations of the Pauli limit suggest something non-trivial about the Cooper pairing. The research follows previous work from the Quantum Devices group, showing that magnetism could also be induced in this material. The fact that TDBG can be tuned from magnetic to superconducting states just by changing gate voltages illustrates the enormous influence that electronic correlations have on the phenomenology of this system.

For both studies, the researchers have taken advantage of Blusson QMI's 2D material stacking facility, which enables exfoliating and stacking of 2D materials, offering capabilities for high-yield and large-flake exfoliation of various van der Waals materials, automated searching for microscopic flakes, and making samples with a controlled twist between the layers.

R. Su, M. Kuiri, K. Watanabe, T. Taniguchi, J. Folk. *Superconductivity in Twisted Double Bilayer Graphene Stabilized by WSe2*. arXiv:2211.16449 (2022).

ATOMISTIC APPROACH TO EMERGENT PROPERTIES OF DISORDERED MATERIALS

QUIET COATINGS: TOWARDS HIGH THROUGHPUT TESTING OF MIRROR COATINGS FOR GRAVITATIONAL WAVE DETECTORS

On September 14, 2015, the Laser Interferometer Gravitational-Wave Observatory (LIGO) in the U.S. detected gravitational wave 150914, which marked the first-ever observation of a binary black hole merger, confirming a major prediction of Albert Einstein's 1915 general theory of relativity.

The discovery was made possible by the enhanced capabilities of Advanced LIGO: a major upgrade that increased the sensitivity of the instruments compared to the first generation LIGO detectors, enabling a large increase in the volume of the universe probed.

Backed by the LIGO Scientific Collaboration (LSC), which is powered by over 1200 scientists from over 100 institutions in 18 different countries, LIGO continues to lead the way in gravitational wave detection and the development of state-of-the-art detection instruments.

As part of UBC's LIGO effort led by Jess McIver, a team of Blusson QMI researchers is working towards improving the performance of mirror coatings in use in LIGO instruments. At present, LIGO's gravitational wave detectors are limited in sensitivity by thermal noise in mirror coatings. As such, new high refractive index, low mechanical loss materials are needed for mirror coatings, but more generally in optomechanical and quantum information components.

The team, which includes Joerg Rottler, Jeff Young, and Ke Zou, as well as Postdoctoral Fellows Kirsty Gardner and Matthew Mitchell, have combined their expertise in modeling and thin-film deposition and characterization, to enable a cycle of simulation, fabrication, and measurement of candidate thin-film materials that could improve the coatings.

In 2022, the researchers completed the experimental setup needed to measure the loss of mechanical microresonators (and, therefore, also the loss of the coating materials on the resonators) and conducted their first "ringdown" measurements (measurements of how the vibration of the disks dies away over time) of an uncoated microdisk.

"This was a major milestone as it showed that our vacuum chamber was performing as required, our measurement system worked, and we were able to quantify the "ringdown time" of our microdisks and show that the disks are of high enough quality to use for the measurements of thin films," said Gardner.

Also in 2022, the team had great success with depositing an amorphous oxide—the type of material that current coatings are made of, and which they plan to test in future—onto their microdisks.

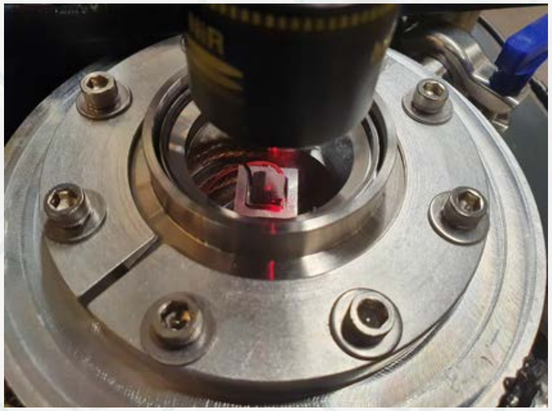
Blusson QMI Investigator Ke Zou and Fengmiao Li (Research Assistant in Ke Zou's group), along with their co-op student Henry Mullock, tested different parameters such as heat and film thickness during thin film deposition onto the microdisks to ensure the disks don't bend, buckle, or break.

"This means that we have a solid understanding of how to deposit thin films without adversely affecting our microdisks, and we're in a position to put this process into action and produce coated samples for measurement," Gardner said.

Progress was made on the atomistic modeling front by Joerg Rottler, along with (now graduated) Master's student Daniel Wong and current postdoc Daniel Bruns, who made significant advances with their models of how thin-film materials behave at an atomistic level. They identified which two-level systems (particular configurations of atoms which are responsible for mechanical loss and, therefore, noise in thin-film coatings) contribute the most to mechanical noise, and made predictions of mechanical loss in amorphous silicon.

For more information on this project, please see here: https://lsc.ubc.ca

Background image: Optical microscope images of fabricated microdisks, r ~ 70 μm.
Below: Photograph of a chip in our vacuum chamber.



CAPSTONE TEAM TASKED WITH APPLYING ENGINEERING PHYSICS TO A BLUSSON QMI GRAND CHALLENGE

For researchers like Kirsty Gardner, who works with Blusson QMI Investigator Jeff Young, Capstone project teams offer unique expertise in Engineering Physics that is helpful as she works to devise novel materials to improve gravitational wave detectors as part of the LIGO project and Blusson QMI's Atomistic Approach to Emergent Properties of Disordered Materials Grand Challenge.

The students including Alexi Garbuz, Bridget Meyboom, Dora Yang, and Ray Su worked with Gardener on the *High Throughput Testing of Coating Mechanical Loss for Advanced LIGO* project.

"One of the big things is that they were able to conduct research and do some of the setups for a different way of measuring the mechanical vibration of specific thin-film materials to understand their properties," said Gardner. "What we do is apply the thin-film over a microdisc and then cause the disc to vibrate. If we can measure how the vibration evolves, we can learn about the properties of that material."

The team was able to develop several deliverables relevant to the LIGO project, contributing useful tools that will remain after they have moved on.

"One of the things that one of the students did was devise an elegant way to analyze the data we collected," said Gardner, who co-supervised the project with Matthew Mitchell (Postdoctoral Fellow) and Jeff Young.

Top: Kirsty Gardener, Postdoctoral Fellow, Blusson QMI.
Bottom: Pictured (left to right): Alexi Garbuz, Bridget Meyboom, Ray Su, and Dora Yang, the undergraduate research team who worked on the LIGO project, demonstrate their work at the UBC Engineering Physics 2022 Final Project Showcase.
Image credit: Lou Dahl.

"The vibrating signal that we're looking for is quite small, and it can be somewhat tricky to filter out this signal from the background. The students ran simulations to determine what the signal will look like and then set up a system that mimics the expected signal. They took that signal and analyzed it to see if they could recover the information that we wanted to get from that signal."

The signal occurs at a specific frequency, and over time, it weakens and can become lost in the noise of the measurement equipment.

"A big part of what they were working on was figuring out where the signal drops and we can't measure it anymore," said Gardner. "By separating the signal from the noise, the students were able to measure it for as long as possible, which ultimately means we'll be able to give more accurate information to the LIGO team."

A SIMPLE CLEAN ENERGY DEVICE WITH COMPLEX PHYSICS GETS NEW HOPE FOR VIABILITY

Ehsanur Rahman, former UBC PhD student now Assistant Professor at Bangladesh University of Engineering and Technology.

Alireza Nojeh, Principal Investigator, Blusson QMI.

Much of the heat generated on Earth is wasted. If we could generate electricity from the high temperatures produced as a byproduct of industrial processes or existing electricity generation plants, it would expedite our transition from fossil fuels into a new era of cleaner energy. But while an elegant solution has been known conceptually since the early 20th century, there is complex physics underlying every aspect of thermionic energy transfer, and scientists have yet to resolve some of the major challenges standing in the way of a breakthrough.

In 2022, Ehsanur Rahman received the Shoulders-Gray-Spindt (SGS) award for the paper *A Multiphysics Approach to Modeling Thermionic Energy Converters,* which he co-authored with Blusson QMI Investigator Alireza Nojeh and presented at the 35th International Vacuum Nanoelectronics Conference (IVNC 2022). At the time, Rahman presented the paper as a culmination of his four years of PhD research, bringing previous publications together with new work to offer a comprehensive computer model of a functional thermionic energy conversion device. The paper illuminates new avenues for academic and industry researchers to pursue.

Thermionic energy conversion was first proposed in 1915 as a way to harness electricity from heat. Innovation peaked in the mid-20th century as the National Aeronautics and Space Administration (NASA) experimented with the technology to power spacecraft, satellites, and some terrestrial applications, but it was never commercialized to a useful scale.

"It's a very simple device concept and structure," said Rahman, who received a 2019 Vanier Canada Graduate Scholarship for his project *Thermionic Emission from Carbon Nanotube Forests: A Novel Approach to Generation of Solar Electricity*. "However, the physics are very challenging and competing mechanisms have kept the technology from progressing."

"Because an oversimplified view of this technology has existed for so long, to drive major progress we need a theoretical approach to inform the engineering," said Nojeh. "To understand the device physics, we need powerful simulation tools."

Rahman's model elucidates the physical challenges that have prevented progress and describes a pathway to a viable future for thermionic energy conversion.

"A thermionic energy converter has to be able to use both the heat and optical energy exchanged within the device," said Rahman. "What's interesting is that we can see now that the results we can anticipate when we account for the physics are counterintuitive. With better understanding, we are now able to consider different models for these devices."

"With concerted effort, there could be a commercially viable future for this technology," said Nojeh.

Rahman is now an Assistant Professor at the Bangladesh University of Engineering and Technology in Dhaka, Bangladesh.

The SGS award recognizes the best paper given at IVNC and is named after the founders of the field of vacuum microelectronics and nanoelectronics. IVNC is the premier annual conference in the field, and only one SGS award is given every year.

E. Rahman. *A theoretical study of static heat-to-electricity conversion based on thermionic emission and complementary mechanisms.* UBC (2022).

BLUSSON QMI GRAND CHALLENGES | PUSHING THE BOUNDARIES OF NOISY INTERMEDIATE SCALE QUANTUM (NISQ) COMPUTING BY FOCUSING ON QUANTUM MATERIALS

NEW EVIDENCE FOR QUANTUM ADVANTAGE IN QUANTUM MACHINE LEARNING

Jonas Jäger, PhD student, Blusson QMI.

Roman Krems, Principal Investigator, Blusson QMI.

J. Jäger, R.V. Krems. *Universal expressiveness of variational quantum classifiers and quantum kernels for support vector machines.* Nat Commun **14**, 576 (2023).

A new study by UBC researchers shows that quantum machine learning models can achieve 'quantum advantage' by solving a complex class of mathematical problems that is impossible to crack with a classical computer. The study was published in *Nature Communications*.

Quantum advantage refers to the instances where quantum computers outperform their classical counterparts when scaling to enormous datasets containing countless variables.

"The models have universal expressiveness in that they solve not just one problem, but they capture the complexity of an entire class of problems that are too complicated to solve with classical machine learning. This means any future discoveries of problems that fall under this complexity class could benefit from these models as well," said PhD student and first author of the paper Jonas Jäger.

"While quantum machine learning is often considered to be one of the most promising use cases of quantum computing, there are only a few rigorous results about its real computational advantages," Jäger said. "Our results offer theoretical guarantees that such advantages indeed exist."

Led by Blusson QMI Investigator and Professor at UBC's Department of Chemistry Roman Krems, the study proves a quantum advantage exists for two of the most popular quantum machine learning classification models: Variational Quantum Classifiers (also known as quantum neural networks) and Quantum Kernel Support Vector Machines.

"With this knowledge, we can now confidently explore important real-world applications and develop effective approaches for building informative data encoding quantum circuits that could unlock the full potential of quantum machine learning," said Jäger.

The research points out that the advantages reported in the study are somewhat subject to the quality of the datasets presented to the system. As quantum computing is still very much in the experimental stage, a challenge faced by researchers is encoding the classical data for processing by a quantum device.

"The mathematical problem that we've solved using these models is quite abstract and doesn't have many practical applications. But, because it presents such special properties under the complexity theory, it can be used by others as a benchmark to test how different quantum machine learning models perform," Jäger said.

Jäger joined UBC in Sept 2022 to commence his PhD studies under the supervision of Roman Krems. Krems and his team work at the intersection of quantum physics, machine learning and chemistry on problems of relevance to quantum materials and quantum technologies, including quantum computing, quantum sensing and quantum algorithms.

Among the group's research interests are developing algorithms to explore physics by machine learning and to build physics into machine learning for applications from quantum condensed matter to molecular dynamics, exploring the interplay of quantum computing and machine learning, and exploring new regimes of quantum scattering: the universality of diffractive scattering, molecular collisions in fields and probabilistic predictions of scattering observables.

HORIZON EU FUNDING BOOSTS QUANTUM ALGORITHMS RESEARCH

A new project linking 11 Canadian and European universities was awarded more than CAD $3 million by Horizon Digital Europe. The project, Foundations of Quantum Computational Advantage (FoQaCiA), focuses global expertise on expanding the theoretical basis for the design of quantum algorithms. In Europe, Laboratorio Ibérico Internacional de Nanotecnología (INL) in Portugal is the lead institution; in Canada, the lead institution is UBC spearheaded by Robert Raussendorf, Professor in UBC's Department of Physics & Astronomy, as Principal Investigator.

Horizon Europe is a new funding program intended to boost research and innovation within the European Union; it replaces Horizon 2020, and will fund projects through 2027. Raussendorf and colleagues were awarded support under the digital and emerging technologies cluster.

The FoQaCiA project seeks to identify novel foundational ideas for how to harness quantum phenomena for computation. It will emphasize four areas of quantum phenomenology:

- Quantum contextuality, non-classicality, and quantum advantage.
- The complexity of classical simulation of quantum computation.
- Arithmetic of quantum circuits.
- The efficiency of fault-tolerant quantum computation.

Raussendorf has long been influential in the field of measurement-driven quantum computing, and his expertise is highly valued, especially at UBC where he has guided the development of Blusson QMI's *Pushing the Boundaries of Noisy Intermediate Scale Quantum (NISQ) Computing by Focusing on Quantum Materials* grand challenge. FoQaCiA will contribute to this grand challenge, as progress in quantum algorithms is critical for the development and applicability of quantum computation.

The Horizon Europe program has increased its funding by 30 percent over the previous allocations, making it the most ambitious research and innovation program in the world. NSERC supports the Canadian arm of the project through its NSERC-European Commission on quantum technologies.

Honours projects offer graduate-style research to undergraduate students

Julian Ding, whose background is in Computer Science and Physics, used his Honours project as an opportunity to learn more about quantum computing. Ding, who received supervision from Robert Raussendorf, used his coding experience to work on a numerical simulation of a quantum error-correcting code on a quantum architecture proposed by Raussendorf, Young, and a graduate student, Xiruo Yan.

"We used the simulation to test the performance of the Kitaev surface code on this proposed quantum computer before it was built," said Ding.

The result is a Python-based scheme that makes quantum processing more robust by encoding qubits to find a probable pattern of errors and correct them in real time.

Ding has recently graduated from UBC and secured a role in the software development industry at a company called Demonware. Rio Weil also used his Honours project to learn more about quantum computing in another project with direct ties to Blusson QMI Grand Challenges. His project sits at the intersection of theoretical and experimental quantum computation.

Weil's project aimed to address measurement-based quantum computing anchored on the groundbreaking theory by Raussendorf and Hans J. Briegel (2003) that proposed measurement-based quantum computing with cluster states. Weil's work focused on how to use quantum computing to determine areas of quantum advantage.

Using IBM's quantum devices, Weil looked at algorithms to efficiently generate resource states to measure their computational power experimentally.

"One thing that intrigues me about the field as a whole is that it's very new: we've seen big investments in quantum computing in recent years, but it's still a very new area of research, with a lot of fascinating fundamental questions to explore," said Weil. "We still don't really understand what makes quantum computing so potentially powerful, so this is an exciting time to be studying in the field."

QUANTUM SCIENCE AND TECHNOLOGY LABORATORY

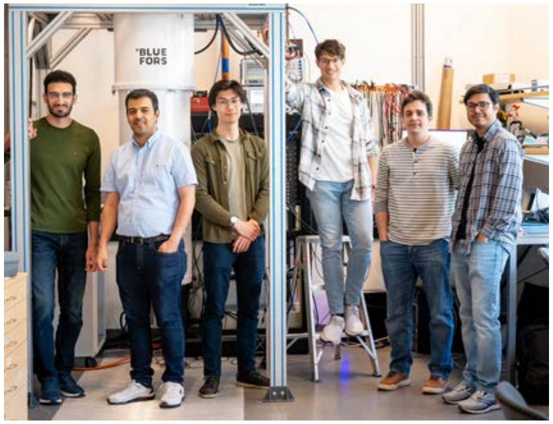


Image (left to right): Mohammad Khalifa (PhD candidate), Ebrahim Sajadi (Postdoctoral Fellow), Philip Kirwin (MSc candidate, primary supervisor Lukas Chrostowski), Nusair Islam (Undergraduate researcher), Joe Salfi, Mukhlasur Tanvir (PhD candidate), Quantum Science and Technology Laboratory, UBC (as captured by Paul Joseph, UBC).

Led by Joseph Salfi, the team at the Quantum Science and Technology Laboratory develop and employ advances in controllable solid-state quantum systems that can be used to answer fundamental questions about how nature behaves and, which have the potential to revolutionize what can be computed using a paradigm called quantum computation.

Universal Quantum Computers

Quantum computers, which harness the power of quantum superposition and entanglement, have the potential to perform calculations well beyond what is possible with foreseeable classical computers. However, building a quantum computer is challenging, because such a computer demands two seemingly incompatible properties: collections of quantum mechanical two level systems that can readily be manipulated, and which also have long coherence times.

Quantum Simulators

Quantum simulators are special purpose quantum information systems that can be used to mimic other less controllable quantum systems, and are anticipated to be among the first real technological applications in quantum information, to help design materials or chemical processes. They are also anticipated to enable real laboratory tests of exotic aspects of many-body quantum theory, exploiting their high controllability to go beyond what which can be tested in traditional experiments.

In 2022, Salfi's team published the world's first demonstration of a quantum-limited amplifier operating in Tesla-level magnetic fields, 1000x higher magnetic fields than before. They have also demonstrated the ability to control Si-integrated Ge hole quantum dot charge states down to the last hole in a simplified device, and the world's first integration of superconducting resonators onto Si-integrated Ge substrates.

In 2022, the team also completed a computational study on the design of realistic hole spin qubit devices. The study predicts that highly counterintuitive optimal operation points that were previously predicted in toy potentials, survive in realistic potentials and gives guidelines on how to design such devices. It further anticipates that qubit manipulation rates are much higher than previously thought, owing to the anharmonicity of realistic potentials in devices.

A quantum limited amplifier is a quantum amplifier device, limited by the Heisenberg uncertainty principal, that is invariably needed to perform fast accurate qubit measurement. In the past, such technologies were limited to fields of only a few mT, around 1000 times smaller. This is important because Tesla-level magnetic fields are required for many quantum information technologies, e.g., spin-based qubits, hybrid spin/superconductor quantum systems such as Majorana Fermions, and magneto-opto-mechanical systems.

Salfi's team is affiliated with the Department of Electrical and Computer Engineering, Blusson QMI, and the Advanced Materials Process Engineering Laboratory (AMPEL) at UBC.

M. Khalifa, J. Salfi, *Nonlinearity and parametric amplification of superconducting nanowire resonators in magnetic field.*Phys. Rev. A. **19**, 034024 (2023).

RESEARCH EXCELLENCE CLUSTERS

UBC research clusters are formed by interdisciplinary networks of researchers addressing key societal and cultural problems, and working together to solve challenges that transcend traditional boundaries associated with departments, institutions, and funding agencies.

The Vice-President, Research & Innovation and the Provost & Vice-President (Academic) at UBC Vancouver have established the Grants for Catalyzing Research Clusters (GCRC) competition that provides seed funding in support of developing visionary research clusters. Blusson QMI is honored to host two such clusters: *Ars Scientia* and the *Quantum Computing Research Cluster.*

ARS SCIENTIA

Since its inception in 2019, Ars Scientia has been a catalyst for new opportunities, collaborations and partnerships, successfully convening a multidisciplinary team of artists and scientists to invigorate art, science, and pedagogy in search of profound exchange and collaborative research outcomes.

In 2022, three new resident artists—Scott Billings, Jeff Mair, and Timothy Taylor—joined Ars Scientia, growing the total number of the program's residencies to seven.

Highlights from the 2022 residencies

As part of the 2022 residencies, Blusson QMI Investigator Alannah Hallas collaborated with visual/media artist jeff mair to create a new paint that incorporates crystalline material grown in her lab. Mair used the paint to produce a series of visual art pieces (see image next page).

Timothy Taylor, Associate Professor at the School of Creative Writing, developed a syllabus for a new science writing course dubbed *Storytelling, Persuasion, and Physics* to be launched in 2023. Across 2022, Taylor and mair have collaborated on writing a book about their experience as Ars Scientia resident artists, which is expected to be published in 2023.

Scott Billings 3D printed microscopic statues with the Additive Manufacturing Group (Engineering) using the NanoFab facility at Blusson QMI. The facility is part of the Quantum Colaboratory, a world-leading initiative founded by the 3 quantum-based CFREF programs—Blusson QMI at UBC, Institut Quantique at Université de Sherbrooke (UdeS), and Transformative Quantum Technologies (TQT) at the University of Waterloo (UW)—that enables user access to highly specialized capabilities and infrastructure in Canada for quantum science and technology development (see page 36 for more on Quantum Colaboratory).

Quantum Materials Paintings #2-7, High Entropy Oxide lab-formed crystals mixed with clear acrylic medium on panels 2022. JG Mair and Alannah Hallas.

In the summer of 2022, Blusson QMI Research Associate and Ars Scientia Program Coordinator James Day organized a workshop titled *Art + Science + Collaboration* for undergraduate students. The program included a talk from QMI's graduate student Daniel Korchinski (physicist), a panel discussion with the four graduate students who have been involved in Ars Scientia residencies (2021), and an interactive "collaboration activity" during which the students could put into practice the knowledge shared in the first part of the workshop.

As part of Ars Scientia events, another workshop called *Shifted Thinking* led by Day in collaboration with the UBC Quantum Club provided an overview of the value of thinking in pictures and in shifting frames. By bringing together artistic practice and scientific research, the event invited participants to uncover dynamic and unexpected outcomes by forcing a shift in perspective.

In a four-part interview series of online conversations, Marcus Prasad (Ars Scientia Project Assistant) chatted with residency participants about some of the key questions, surprising intersections and lingering effects of the interdisciplinarity sustained throughout the Ars Scientia artist/scientist residencies.

Seemingly at odds, with Marcus Prasad

Marcus Prasad thinks of his time with Ars Scientia as a kind of mini-residency with colleague James Day as the two worked together to launch and grow the research cluster and its programs. Prasad, who worked as Assistant Project Coordinator with the research cluster, has a background in interdisciplinary endeavours but found navigating the cultural differences between artists and scientists fascinating, and a valuable exercise in understanding human nature.

"I was really fascinated that all of the interactions between these two groups with very different perspectives kind of boiled down to basic questions or who we are as humans and why we interact with each other in certain ways, and how knowledge production takes place," said Prasad.

"I also really liked collaborating with James, and learning about the similarities and differences between our academic cultures, from language differences to varying approaches to program administration; we worked really well together and I hope we learned a lot from each other."

A point that struck the artists and scientists differently was the concept of "deliverables" and its connotations.

"With the artists, there was this sense of relief that there was no clear expected 'deliverable;' the scientists had the opposite reaction," said Prasad. "I think it comes down to culture: the scientists wanted to know what the expectations were around what to present, and what kind of content they needed to come up with. I thought that was really interesting, just two very different approaches to communicating the results of these partnerships."

One of the highlights of the program was that there weren't any anticipated outcomes: the residency program guidelines were deliberately open-ended, with the idea that the experience was more about learning to work together across disciplines than it was about specific outcomes.

THE QUANTUM COMPUTING RESEARCH CLUSTER

Led by Blusson QMI Investigator and Professor at UBC's Department of Electrical and Computer Engineering, Lukas Chrostowski, the Quantum Computing Research Cluster conducts multidisciplinary collaborative research across a range of areas in quantum computing, including fundamental theory, hardware, engineering and algorithms. Since its inception in 2019, the cluster has aimed to discover and develop world-unique approaches that will build a useful, scalable quantum computer, capable of outperforming classical computers.

The cluster has launched several initiatives, including the NSERC CREATE Quantum Computing program, a joint graduate training program between UBC, Simon Fraser University (SFU), and the University of Victoria (UVic), that trains the next generation of Canadian researchers in quantum computing hardware and software with the support of quantum industry leaders (D-Wave Systems, IBM, Microsoft and Google). So far, the program has recruited 36 students, the first cohort of whom graduated in 2022.

Stimulated by the CREATE program to build a strong regional quantum community, the cluster has also led the creation of Quantum BC, a joint UBC, SFU, UVic initiative that aims to strengthen and showcase collaborative efforts across research, training and innovation in quantum computing.

During 2022, Quantum BC has held several workshops with Canadian universities (Université de Sherbrooke, University of Calgary), quantum institutes (Institut Quantique, Institute for Quantum Computing and Blusson QMI), and CMC Microsystems. Highlights include a workshop on Quantum Machine Learning which provided students with unique hands-on access to the first IBM quantum computing system in Canada, and a one-of-a-kind workshop on how to design, fabricate and test superconducting devices and the annual Quantum Computing Roadmapping workshop, which featured talks from faculty, industry, and students on the current state and future outlook of quantum computing technology development in BC.

The cluster has aimed to improve diversity in the quantum computing field by partnering with UBC's Geering Up Engineering Outreach and industry partners (D-Wave Systems and Microsoft), through the Digital Supercluster-funded project, Diversifying Talent in Quantum Computing (see page 47 for more on this collaboration).

INFRASTRUCTURE

Image: Andrea Damascelli inspecting the inertia block that will house Blusson QMI's new transmission electron microscopy facility.

CLEANROOM SENSORS DETECT ERUPTION 10,000 KILOMETERS AWAY

A volcano erupted in Tonga in January and the atmospheric disturbance was detected by pressure sensors in the cleanroom at Blusson QMI nearly 10,000 kilometers away.

The cleanroom is a space within the Advanced Nanofabrication Facility (ANF) on the fourth floor of the AMPEL building at Blusson QMI. It is used by researchers at UBC, other universities, and our partners in industry to develop nanotechnology devices for applications that range from DNA sequencing to quantum electronics. In order to support this highly sensitive research, the facility needs to be carefully monitored by environmental sensors that measure temperature, humidity, and pressure.

“Changes in humidity and temperature inside the cleanroom affect nanofabrication processes,” said Kostis Michelakis, Director of the ANF. “For example, some of our processes involve chemical reactions, and we have calibrated them to work under certain such conditions with a certain rate or outcome. If temperature and/or humidity change, those processes will not perform predictably.”

In order to ensure that lab conditions are optimal inside the cleanroom, the ANF team relies on custom-built sensors and monitoring programs developed by Ovidiu Toader, Systems Analyst at Blusson QMI. Using inexpensive single board computers such as Raspberry Pi and widely available sensors, Toader has developed agile systems that provide valuable real-time information about the conditions inside the cleanroom so that Michelakis and colleagues can adjust the environmental controls in the space.

“Commercial sensors may not always give you what you want, and so we’re very much into the flexible, small devices that we can tailor to our specific needs,” said Toader. “Keeping the humidity under control throughout the year—it’s more humid in the building in the summer, for example—it’s a big job, and we need to be very aware as conditions change.”

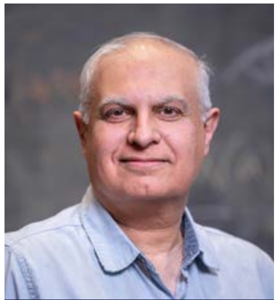
While temperature and humidity are important factors, a third sensor monitors the pressure inside the room.

“Clean, dust-free air is supplied inside the cleanroom. In order to prevent outside air from entering, which can add dust and interfere with temperature and humidity, we just keep the air-pressure a bit higher inside the cleanroom, compared to what it is outside,” said Michelakis. “With the pressure sensor, we check that this condition is indeed met.”

The pressure sensor is quite sensitive, to the point where it can detect atmospheric pressure changes within the building, including the slightly different altitudes between floors.

“The fact that we caught the Tonga event means that it sent a pressure wave of that magnitude around the globe,” said Michelakis. “It may not be something new for volcano experts, but it is certainly exciting to be able to see it in our setting.”


Kostis Michelakis


Pinder Dosanjh


Mario Beaudoin


Andrey Blednov


Khush Hydri


Matthias Kroug

ANF'S RESEARCH SCIENTISTS: DELIVERING WORLD-CLASS RESEARCH SERVICES AND TRAINING

ANF research scientists, as part of the Quantum Colab*, provide expert research support services and training on state-of-the-art equipment to facility users to support them in reaching their research goals.

- Kostis Michelakis, Director
- Pinder Dosanjh, Operations Manager
- Mario Beaudoin, Research Associate
- Andrey Blednov, Cleanroom Technician
- Khush Hydri, Engineering Technician/Cleanroom technician
- Matthias Kroug, Electron-Beam Lithography Engineer

* The Quantum Colab is a partnership between the Stewart Blusson Quantum Matter Institute (Blusson QMI) at the University of British Columbia (UBC), Institut Quantique at Université de Sherbrooke (UdeS), and Transformative Quantum Technologies (TQT) at the University of Waterloo (UW) aimed at accelerating quantum research and technology development by providing access to world-leading research expertise and facilities that exist within the universities.

TechOps TEAM LEADS HELIUM CONSERVATION AND SUSTAINABILITY

The technical operations (TechOps) team at Blusson QMI are leaders in helium conservation and recycling, making the Institute a model for how to effectively manage supply issues during challenging times.

Helium is a byproduct of natural gas refinement, and while it is abundant in the universe, it is not a renewable resource here on Earth: due to a series of disasters affecting helium production around the world, the gas has been in short supply. In addition, despite there being an oil and gas industry in Canada, Canada does not produce helium. For these reasons, helium is very expensive.

It is also an essential element in cooling research equipment, such as the scanning tunneling microscopes used in the Laboratory for Atomic Imaging Research. To study the behaviour of individual atoms in quantum materials, the materials need to be very, very cold: helium liquefiers at Blusson QMI cool helium to 4 degrees Kelvin, or -270 degrees Celsius.

To ensure that our faculty, scientific staff, and students have the resources they need to conduct low-temperature research, TechOps staff, led by Pinder Dosanjh, have developed the infrastructure for recovering and reliquefying the helium boil-off.

"Some systems use a liter of helium per hour, which over a few days can add up to hundreds of thousands of dollars worth of supply," said Dosanjh. "If we can recycle helium, we can cut those costs down substantially for the users."

The Brimacombe and AMPEL buildings are currently outfitted with a recovery system and liquefiers thanks in large part to funding from the Canada Foundation for Innovation (CFI), the B.C. Knowledge Development Fund (BCKDF) and the Natural Sciences and Engineering Research Council of Canada (NSERC). Dosanjh and colleagues operate the infrastructure's operation (which requires considerable supervision and support for users). As a result, Blusson QMI researchers can sustain their work despite the increasing cost and scarcity of helium.

Over the last two years, the TechOps team has worked to further improve the infrastructure, which was recently entirely rebuilt and upgraded to copper and stainless steel lines to almost every lab in the building. The result is a more reliable and efficient system, with a conservation rate of more than 75 percent.

For those labs that do not rely on helium specifically, and can sustain alternate cooling approaches, Dosanjh and colleagues have been transitioning away from wet systems (liquid helium) to 'dry systems'. The latter use electricity and work well for equipment such as angle-resolved photoemission spectroscopy (ARPES) that is not as susceptible to external perturbation.

"With a compressor, and a piece of simple equipment you can plug into a wall, you can forgo liquid helium altogether, but you can still get the extremely cold temperatures," said Dosanjh. "There are now lots of these in the building."

The TechOps team at Blusson QMI continues to focus on improving the sustainability of our research, and are in many ways leading the development of these systems. With the exception of the compressor unit, most of the components added onto Blusson QMI instrumentation is designed and developed in-house.

"Our team has spent much of the last year working to make our cooling systems more efficient and reliable," said Dosanjh. "It's a lot of work, but it means we can keep our science going with a lot less strain on our research budgets."

In 2022, Dosanjh was awarded the President's Service Award for Excellence (PSAE), the highest honour given to staff at UBC (see page 56 to read more).

COMPUTATIONAL INFRASTRUCTURE FOR ACCELERATING QUANTUM TECHNOLOGY

Andrew Potter received funding—via the Canada Foundation for Innovation (CFI) and the B.C. Knowledge Development Fund (BCKDF)—to build a custom-designed supercomputing system that will enable research to enhance the power of quantum computers to simulate large, complex materials and molecules, aid the design of more effective quantum processors, and act as sophisticated control systems to operate and test experimental quantum processor prototypes being developed at UBC.

The new system will provide unique computing capabilities that reinforce and extend QMI's excellence in quantum computing research, and facilitate partnerships between researchers and industry quantum computing efforts to accelerate technology transfer.

ADVANCED LASER ABLATION SPECTROSCOPY: A GREEN PATH TO CANADA'S CRITICAL MINERALS

Blusson QMI Investigator David Jones was awarded funding to develop new sensors for mining applications. The unique John R. Evans Leaders Fund (JELF) infrastructure project will support the development of two types of advanced laser ablation spectroscopy (LAS) capabilities: (1) laser-induced breakdown spectroscopy (LIBS), and (2) laser-ablation dual frequency comb spectroscopy (LA-DCS).

The mining industry is urgently seeking new ways to improve current practices, as well as environmental, societal, and economic outcomes. Sensing technologies integrated into mined materials handling represent an immediate opportunity to achieve these goals.

These new sensors, with advanced performance specifications, will intrinsically change how mining companies operate providing tangible benefits to mining sustainability, resource utilization, mine productivity, and environmental management; and will drive the production of critical minerals and metals to support the transition to a green economy.

This new effort also links to an emerging collaboration with the University of Saskatchewan and the University of Waterloo. The three institutions have joined forces with a mission to tackle the environmental legacy of mines while planning for future resource development, as well as the discovery and development of novel functional properties in advanced materials with a focus on sensors and devices.

Image: Dongjoon Song, Alnnah Hallas, Blusson QMI.

FLOATING ZONE IMAGE FURNACES INSTALLED

In 2022, the Hallas Group completed the installation of two floating zone image furnaces, which they are using to grow single crystals of quantum materials. Crystals grown by the floating zone method can be very large and pristine, enabling their study with advanced characterization methods. The floating zone method uses a highly focused heat source, such that a camera can be mounted nearby, allowing the researchers to watch and adjust the crystal growth in real time. The two floating zone furnaces use two different heating sources—the first uses halogen lamps focused by mirrors and the second uses laser diodes and is the first of its kind in Canada. The Hallas Group is currently applying this method to the growth of high entropy oxides, cuprate superconductors, and geometrically frustrated magnets under the expertise of Research Associate Dongjoon Song.

QMI PIS RECEIVE NSERC RTIS

This year, new funding for research projects at Blusson QMI was announced by the Government of Canada and the Natural Sciences and Engineering Research Council of Canada (NSERC).

“At NSERC, we dedicate significant resources to our Discovery research programs precisely because we cannot predict where successes will occur,” said Alejandro Adem, President of NSERC. “We foster excellence by providing thousands of exceptional researchers at various stages in their careers with the stable foundation needed to lead thriving research programs and create unparalleled training opportunities for the next generation of scientists and engineers.”

Research Tools and Instruments (RTI) grants foster and enhance the discovery, innovation and training capability of university researchers in the natural sciences and engineering by supporting the purchase of research equipment. Blusson QMI investigators were awarded more than $790,000 in RTI grants in the past competition.

Sarah Burke
Spatially resolved spectroscopy of Quantum Materials: Scanning probe Microscopy control system for high resolution tunnelling spectroscopy

Andrea Damascelli
Cost-effective continuous operation of the CLS-QMSC Beamline at cryogenic temperatures at CLS.

Alannah Hallas & Meigan Aronson
Unveiling the structure and formation of quantum materials via x-ray diffraction with nonambient temperature stages

Mark MacLachlan
Urgent Replacement of UV-vis/near-IR Spectrometer

George Sawatzky
An electron beam evaporator for real-time and precise flux control for molecular beam epitaxy

Ke Zou
An integrated materials nanofabrication workstation for the Quantum Materials and Device Foundry

PARTNERSHIPS

Image (right to left): Ke Zou, Bruce Davidson, and students at Blusson QMI's Molecular Beam Epitaxy (MBE) Lab.

MAX PLANCK-UBC-UTOKYO CENTRE FOR QUANTUM MATERIALS

The Max Planck-UBC-UTokyo Centre for Quantum Materials is a world-leading collaborative venture between the Max Planck Society (Germany), The University of British Columbia (Canada), and the University of Tokyo (Japan) featuring internationally recognized leading scientists and extensive infrastructure for research in quantum materials. This unique partnership supports more than 90 collaborative projects, scholarly exchanges, and annual workshops.

In 2022, all three organizations signed the extension of the partnership into 2027. A testament to the strength of the partnership and the collaborations that have emerged from it, this is the first time an international Max Planck Centre has been extended beyond a ten-year period.

Centre for Quantum Materials collaboration leads to discovery in rarely studied semimetal drumhead state

A study observing the topologically non-trivial drumhead state emerging from nodal-line semimetals offers new insights into how these newly discovered states behave in real materials. The work, led by Blusson QMI's Sarah Burke and colleagues, was highlighted as an Editor's Choice paper published in the journal *Physical Review B* in 2022.

In the hunt for real materials exhibiting this new physics, the so-called "square-net" materials have emerged as important candidates due to their symmetry-enforced topology and Dirac band-crossings. In 2016, at a Max Planck-UBC-UTokyo Centre for Quantum Materials workshop, Sarah Burke from Blusson QMI and Leslie Schoop, an Assistant Professor in the Department of Chemistry at Princeton University (who at the time was a postdoctoral researcher with the Max Planck Institute for Solid State Research in Stuttgart), met at the right time to work together on an ideal candidate to see the drumhead state: ZrSiTe, or zirconium silicon telluride.

As Schoop presented a talk laying out a compelling case for studying ZrSiTe, Burke wondered if it is possible to probe the drumhead state by looking at how electrons scatter in it by using a technique known as quasiparticle interference (QPI).

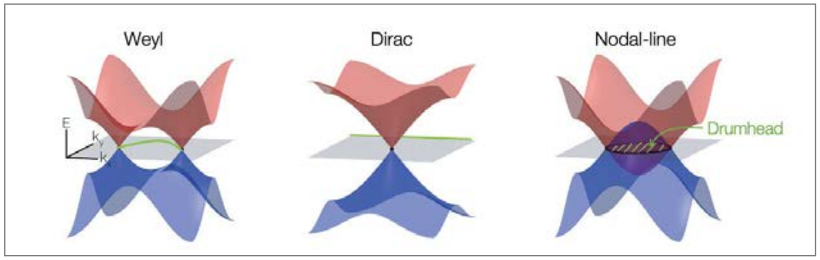


Image: an illustration of the drumhead state in nodal-line semi-metals as compared to related topological semi-metal counterparts. Image credit: Brandon Stuart.

"The first thing I asked her was, 'Does it cleave?'" said Burke, who excitedly approached Schoop during a coffee break to learn more. "And, can I have some?"

"Cleaving" means breaking the material into pieces; many materials do not cleave cleanly, leaving erratic surfaces that are hard to study using surface-sensitive techniques such as Scanning Tunneling Microscopy (STM), a method Burke uses to observe surfaces at the atomic level.

"This material cleaves beautifully, and so it's very amenable to investigation via ARPES and STM," said Burke.

ARPES, or angle-resolved spectroscopy, is a technique used to detect the movement and energy of electrons in a material. ARPES can only detect up to the Fermi energy level, which is where electrons sit at the lower limit of the thermodynamic temperature scale (zero degrees kelvin); STM can look above the Fermi energy and at the atomic scale.

"It was also looked at with ARPES before we looked at it with STM, so while another group first resolved this topologically nontrivial state, we were able to map the complete ocupied and unoccupied states while demonstrating that QPI could be used to probe drumhead states," said Burke.

"One challenge with drumhead states is that theoretical models miss a lot of the complexity that real materials have," said Burke. "One of the things that the material that we looked at has that the toy models don't is spin-orbit coupling, so the question was whether these drumhead states would survive the presence of spin-orbit coupling."

"What's interesting is that we were able to show that the drumhead states survived across the whole range of energies that it was predicted to exist for," said Burke. "The reason is that the energy scale of this topological state is much larger than the spin-orbit coupling, and so, at least under these conditions, the state survives the perturbation."

Confirming that the drumhead state survives the presence of at least the modest spin-orbit coupling present in ZrSiTe shows the robustness of the topology and opens up a wider range of materials in which physicists can try to study the drumhead state.

Burke credits Lukas Muechler (Assistant Professor, Pennsylvania State University) and Raquel Quieroz (Assistant Professor, Columbia University) for their contributions to the underlying theory describing both the material and scattering observed by STM.

B.A. Stuart, S. Choi, J. Kim, L. Muechler, R. Queiroz, M. Oudah, L.M. Schoop, D.A. Bonn, S.A. Burke. *Quasiparticle interference observation of the topologically nontrivial drumhead surface state in ZrSiTe.* Phys. Rev. B **105**, L121111 (2022).

Directional ballistic transport in the two-dimensional metal PdCoO2

In a study supported by the Max Planck Society and the European Research Council (ERC) under the European Union's Horizon 2020 Research and Innovation Programme, a team of researchers, including Blusson QMI's Doug Bonn, show for the first time in a two-dimensional metal, that a strongly faceted Fermi surface can lead to strongly orientation-dependent conduction in otherwise identical ballistic devices cut from the same single crystal.

The reported observations are of fundamental and practical importance to the question of the minimal attainable resistance in nanoscopic conductors, which ultimately limits the potential miniaturization of electric conductors in technological applications.

Notably, the phenomena reported in the study are far from being restricted to delafossites. Materials with facetted Fermi surfaces are not rare. Gated bilayer graphene is one of the most promising platforms for extensions of this research.

M.D. Bachmann, A.L. Sharpe, G. Baker, A.W. Barnard, C. Putzke, T. Scaffidi, N. Nandi, P.H. Mcguinness, E. Zhakina, M. Moravec, S. Khim, M. König, D. Goldhaber-Gordon, D.A. Bonn, A.P. Mackenzie, P.J.W. Moll. *Directional ballistic transport in the two-dimensional metal $PdCoO_2$*. Nat. Phys. **18**, 819 (2022).

Unveiling the underlying interactions in novel material systems from photoinduced lifetime change

The essence of strongly correlated electron physics is understanding how novel ground states, such as hightemperature superconductivity, charge orders, and excitonic insulator (EI), emerge from competing degrees of freedom. The EI is a quantum many-body state involving electron-hole pairing, which can appear in semimetals or narrow gap semiconductors.

Several material systems have recently been proposed as EI candidates. These materials have been the subject of extensive experimental exploration and theoretical modeling, in an effort to provide definitive confirmation on the existence of the excitonic ground state and to elucidate the plethora of unique electronic and optical properties.

Theoretical studies on this topic have revealed the importance of the electron-lattice coupling, although the interplay between electron-electron and electron-phonon contributions to the excitonic insulator state is currently debated.

Motivated by this debate, researchers from the Max Planck-UBC-UTokyo Centre for Quantum Materials and colleagues performed a comparative analysis of a photo-doped semimetal (Ta2NiSe5 (TNS)) using techniques that treat electronic and lattice degrees of freedom on equal footing.

Their analysis showed that electron-electron interactions play a vital role (albeit not the sole one) in stabilizing the insulating state and established the comparison between lifetime and gap evolution as an important probe of correlated insulators. More broadly, this work demonstrated a generic way to determine the origin of the gap in correlated insulators by analyzing the lifetime effects of photo-doped states.

Georges, A. Damascelli, A.J. Millis. *Unveiling the underlying interactions in Ta_2NiSe_5 from photoinduced lifetime change.* Phys. Rev. B **106**, L121106 (2022).

Professor Liu Hao Tjeng, Director and Scientifc member at the Max Planck Institute for Chemical Physics of Solids, Dresden at Blusson QMI

MP-UBC-UTokyo Summer Course

Spectroscopic Methods for Strongly Correlated Quantum Materials

The spectacular physical properties of quantum materials challenge our comprehension of solid-state physics. These properties include unconventional superconductivity, unusually large magneto-resistance, metal-insulator transitions, heavy-fermion behavior, multiferroicity, "bad metal" behavior, amongst others.

From May 16 – June 25, 2022, the centre hosted a lecture series on Spectroscopic Methods for Strongly Correlated Quantum Materials by Professor Liu Hao Tjeng, Professor Bernhard Keimer, Professor Andrea Damascelli, Dr. Ryan Day, and Professor Doug Bonn.

The Series presented a selection of spectroscopic and computational methods that are very powerful for the determination of the electronic degrees of freedom of strongly correlated systems with the objective of arriving at theoretical understanding and conceptual frameworks that capture the essential mechanisms underlying the quantum properties of interest.

JOINT RICE RCQM AND UBC BLUSSON QMI WORKSHOP

In December, Blusson QMI and Rice University's Center for Quantum Materials jointly hosted the fourth event in the *New Frontiers in Quantum Materials Series*. The workshop brought together researchers and trainees from each institution to explore opportunities for new and synergistic research collaborations with a focus on: Strange Metals & Topology, Strange Metals Near Localization, Flat Bands & Heterostructures and Topology & 2D Systems.

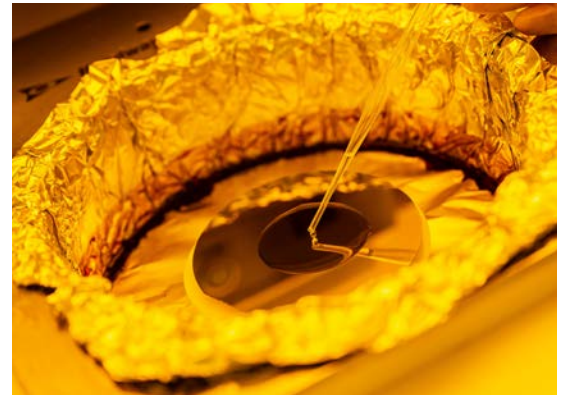


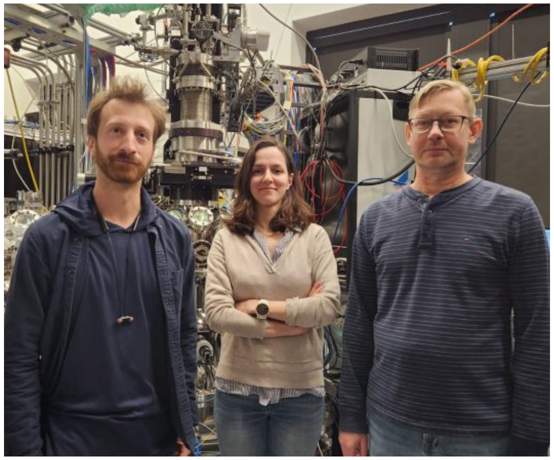
Image: Photoresist being applied to a silicon single crystal wafer.

NANOFAB ACCELERATOR PROGRAM

The Advanced Nanofabrication Facility (ANF) at Blusson QMI officially launched the first round of its *Nanofab Accelerator Program* in partnership with the National Research Council of Canada Industrial Research Assistance Program (NRC-IRAP) in 2022.

The program provides eligible small or medium-sized businesses (SMEs) with specialized nanofabrication services, including but not limited to, maskless photolithography, 100kV electron-beam lithography, photonic wire-bonding and a range of processes for thin film deposition and etching.

Companies have access to recently upgraded cleanrooms. Services are offered on a per-usage fee basis, including SME staff training for using the various tools and professional assistance from the facility's technical staff. IRAP will provide up to $12,000 of support per SME project. For more information on this program, please contact Pinder Dosanjh at dosanjh@ phas.ubc.ca



Dr. Matteo Michiardi, Blusson QMI; Dr. Saba Sadeghi, University of Waterloo (UW); and Dr. Sergey Zhdanovich, Blusson QMI. Sadeghi visited the Blusson QMI's facilities to obtain direct experience with the Quantum Colab resources at the UBC node. Quantum Colab nodes host several visits each year to enhance the ease of knowledge transfer between nodes and improve the user experience when utilizing shared resources.

QUANTUM COLAB: ACCELERATING QUANTUM RESEARCH THROUGH COLLABORATION

The Quantum Colaboratory (Quantum Colab) is a partnership between Blusson QMI at UBC, Institut Quantique at Université de Sherbrooke (UdeS), and Transformative Quantum Technologies (TQT) at the University of Waterloo (UW) aimed at accelerating quantum research and technology development by providing access to world-leading research expertise and facilities that exist within the universities.

In 2022, the program hosted several workshops, hands-on training sessions on advanced equipment, and visits at each node aimed at activating new collaborative opportunities. A highlight was a workshop that focused on growing superconducting materials. The event featured expert presentations describing the full development path for growing different superconducting materials, followed by a discussion and a Q&A session between the speakers and the audience.

Blusson QMI Operations Manager Pinder Dosanjh said: "The workshop provided a good platform for discussion and knowledge exchange between the speakers and participants. The Quantum Colaboratory aims to provide an environment that enables all interested users, from researchers to nonprofits and industry, to benefit from the highly specialized capabilities and facilities that exist at our institutions and form collaborative projects that could strengthen Canada's leadership in quantum technologies."

The University of Waterloo's Quantum-Nano Fabrication and Characterization Facility Director Nathan Nelson–Fitzpatrick said: "The Canadian government has devoted significant resources to building up specific capabilities at the three CFREF-funded quantum programs in Canada. The Quantum Colaboratory is an exercise in extracting greater value out of these investments by fostering communication and collaboration between experts at the three constituent nodes. In working together, we can share unique technical and human resources that each node has developed. This will accelerate the research of the entire Canadian quantum community."

Université de Sherbrooke Quantum Fablab Director Mathieu Juan said: "Quantum Colab provides a clear path for the continued development of tools and processes necessary to advance quantum sciences and technologies in Canada. Our three-university partnership will foster collaborations through various activities such as this past workshop and leverage the expertise of the different nodes, leading to impactful outcomes that we could otherwise not achieve alone."

Image (right to left): Ziliang Ye and students Jing Liang and Yunhuan Xiao.

OUTREACH AND COMMUNITY ENGAGEMENT

Image: Grade 9 students watch Pinder Dosanjh's demo of superconductivity using a levitation track at Blusson QMI on Kids to Work Day.

Training Canada's future quantum workforce starts with introducing our youth to the very same fascinating phenomena that sparked curiosity in the founders of our field and continue to inspire researchers around the world today.

As a publicly funded institute, we are on a mission to proactively engage with the wider society to galvanize the next generation of quantum scientists through hands-on public outreach and community engagement programs.

BC TEACHERS GET PROFESSIONAL DEVELOPMENT COURSE IN QUANTUM COMPUTING

High school science teachers in British Columbia (BC) were provided a new tool to help them teach quantum computing concepts to their students in 2022. The new course, hosted on EDx, was developed by UBC's Geering Up Engineering Outreach program and Quantum BC's Diversifying Talent in Quantum Computing initiative. It builds on existing science curricula and offers the tools and exercises for teachers to apply quantum computing lessons that align with BC's prescribed learning outcomes. The self-directed course, which takes 6 to 10 hours to complete, launched on August 12.

"The course puts a quantum lens on BC's science curriculum," said Ella Meyer, Quantum Computing Outreach Coordinator at Blusson QMI. "We were committed to maximize the efficiency of the implementation: this program synergistically adds a quantum context to BC's physics and chemistry curriculum."

"We thought a lot about how to make this work for a variety of schools, including those in rural areas that might not have access to expensive equipment and software," said Meyer. "The experiences include things like double-slit experiments that help students understand the physics of light: these types of experiments can be done using simple tools that can be ordered inexpensively online, or even found at local dollar stores."

The goal of the training program is to make quantum science accessible and fun. The course was co-developed by CREATE Program in Quantum Computing student Ana Ciocoiu, whose expertise informed the content of the course. Reid Patterson, Senior Outreach Facilitator with UBC Geering Up, contributed his expertise in teacher education in adapting the content to the EDx platform.

Programs such as this EDx course aim to close the "understanding gap" between academic and industry professionals and the broader public, who may not have access to the tools to learn about quantum science and technology.

LAUNCHPAD PROGRAM PROPELS STUDENTS TOWARD SUCCESS IN GRAD SCHOOL

A new program developed by UBC's Department of Physics & Astronomy developed in 2022 has aimed to connect undergraduate students and recent graduates with the experience and information they need to thrive in graduate physics programs at UBC.

The Launchpad Program, developed by faculty members, research scientists, graduate students, postdoctoral fellows, and staff members from UBC Physics & Astronomy, Blusson QMI, and TRIUMF, was designed with a goal to foster diversity of graduate students and, longer term, to address inequities in physics programs.

It has been designed for students who are women or non-binary, Black, Indigenous, and People of Color (BIPOC), 2SLGBTQ+, living with disabilities, and/or are in the first generation in their family to attend university.

The program is best suited to undergraduate students or recent graduates who are eligible for admission to physics, astronomy, medical physics or engineering physics graduate programs at UBC in 2023 or 2024.

The program consists of a four-day workshop, as well as mentorship to support students through the process of applying to graduate programs. In addition to providing planning support and workshop content, Blusson QMI will open its doors to tours for program participants.

"We are proud to support this initiative to reach out early to underserved groups to help them consider their options for graduate studies and illuminate the process," said Sarah Burke, who serves on the Launchpad Executive Committee and has been involved throughout the planning process. "We hope this program will ease the transition from undergraduate to graduate studies for those that may be lacking other sources of support."

"Launchpad compliments Blusson QMI's undergraduate research program, Quantum Pathways, and our commitment to building a more inclusive field," said Burke.

"In this program, talented students in equity-deserving groups learn about physics and astronomy research, student life at UBC and how to prepare their graduate program application through workshops and a mentorship program," said Adele Ruosi, Science Education Specialist in Physics and Astronomy.

"Learning the 'hidden curriculum'—implicit academic, social, and cultural assumptions and expectations that are not formally established and conveyed but that invisibly governs academic achievement—is pivotal for these students' future."

"It is so inspiring to see the number of applications growing, and to receive applications from students studying not just in Canada, but from Nigeria and Tanzania, and all around the world," said Ruosi.

In order to ensure the program is accessible, there are no fees to apply, and travel costs will be covered for participants from outside of Vancouver (Canada, US, Mexico); the program runs remotely for those who wish to participate from elsewhere in the world.

Funding from the program comes from UBC's Equity & Inclusion Office through its Enhancement Equity Fund, with financial contributions from program partners, including Blusson QMI.

KIDS TO WORK DAY

Kids to Work Day is an annual event that takes place in early November each year and is an opportunity for UBC staff to bring their Grade 9 children to visit their parents' workplace.

As part of this year's Kids to Work Day event, Pinder Dosanjh was joined by a group of Grade 9 students to demonstrate a superconductor cooled by liquid nitrogen levitating over a magnetic track. The program also included visits to several other labs and facilities at Blusson QMI.

Image: Grade 9 students replicate the superconductivity demo while supervised by Pinder Dosanjh.

Images courtesy of Geering Up

KIDS LEARN QUANTUM COMPUTING AT SUMMER CAMP

The summer of 2022 saw kids learn quantum computing principles and solve problems using a real quantum computer at summer camps in Metro Vancouver and Kelowna. The camps, which were hosted by UBC's Geering Up Engineering Outreach program, offered an introduction to concepts in science, technology, engineering, and math (STEM), teaching the basics of computing and quantum computing to kids from grades 6 to 12. Geering Up also offers online quantum computing camps for kids in grades 5 through 12.

The camps were an opportunity to introduce kids to the possibilities in quantum science and technology fields.

"Quantum computing is a relatively new field in tech, and because of that, we're at an exciting moment where we get to decide what the field will look like," said Ella Meyer, Quantum Computing Outreach Program Coordinator at Blusson QMI and Geering Up. "If we can connect with kids at a young age, we can create a really inclusive, vibrant field over the next few generations."

Meyer has been working with the Geering Up team and consultants in both industry and education to develop a quantum computing curriculum that speaks to kids, but that can be easily integrated into existing programs.

Topics range from how computing works, to what quantum computers are and how they work and are different from classical computers, with lessons on drag and drop coding, how algorithms work, and what key terms like "superposition" and "entanglement" mean.

"Geering Up is a forerunner in the field of emerging technology, and this is a great way for kids to develop those foundational skills that they can build on through subsequent camps and their own education as they pass through the K-12 system," said Meyer.

A particular highlight of the program has been its relationship with D-Wave Systems, a Vancouver-based quantum computing company and a leader in the industry. D-Wave and Geering Up are connected through Quantum BC's Diversifying Talent in Quantum Computing Quantum Hub, an initiative supported by the Canadian Digital Technology Supercluster. As students learn the basics of quantum computing this summer, they'll be able to put that learning to work using D-Wave's 2000Q quantum processor.

"This is a cool time in history to be part of," said Meyer. "Quantum computing as a field is still in its formative years, and so kids in BC are really growing up alongside it. We're still in a place where anyone can be part of this, and that's very exciting."

ABOUT UBC GEERING UP

UBC Geering Up Engineering Outreach is a non-profit organization with the mandate of promoting science, engineering, and technology to youth across British Columbia. Affiliated with the University of British Columbia, Geering Up is designed, organized, and operated by UBC students.

OUTREACH PROGRAM CHALLENGES SCIENTIST STEREOTYPES

A new outreach program for science students in grade 8 was launched in 2022 to challenge scientist stereotypes and invite kids to interact with physicists and learn about who they are in and outside the lab.

As part of the program, graduate students, postdoctoral fellows and staff from Blusson QMI engaged with students in Jonathan Hultquist's science classes at Sir Charles Tupper Secondary School (Tupper) from February to April 2022.

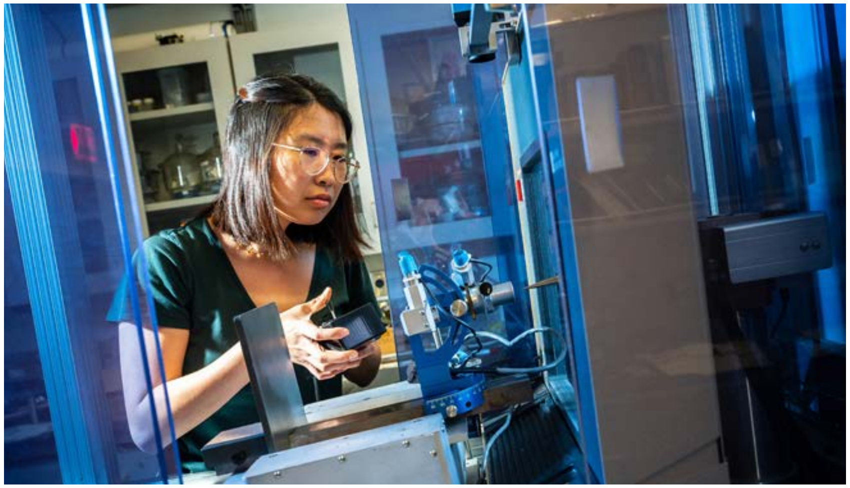
"These presentations offer students a glimpse at what a career in science might look like, and give students a chance to see scientists as accessible, well-rounded individuals," said Hultquist.

PhD student MengXing Na, Postdoctoral Fellows Sayak Dasgupta and Marta Zonno, and staff member Ella Meyer delivered two talks: the first, "Who I Am as a Scientist," gives students the opportunity to learn about how the presenters came to be researchers.

"The presenters talk about their sports, their hobbies, their education," said Natalia Bussard, Manager, Programs & Careers at Blusson QMI. "It's a way to show the students that a career in science is achievable, and that researchers look like them and have interests that are similar to theirs."

For more than 50 years, Draw-A-Scientist studies have challenged children to draw what a scientist looked like to them. A 2018 meta-analysis found that "based on 78 studies (N = 20,860; grades K-12), children's drawings of scientists ... have become more gender diverse over time, but children still associate science with men as they grow older. These results may reflect that children observe more male than female scientists in their environments, even though women's representation in science has increased over time (Miller et al, 2018)."

Therefore, it is important to connect students with working scientists in order to challenge stereotypes about who can be a scientist before they self-select out of programs they might have an aptitude for and enjoy.



MengXing (Ketty) Na, Postdoctoral Fellow

"The feedback we received was very positive," said Bussard. "I expected that about 50 per cent of students would express an interest in science, and was surprised to discover that as many as 75 per cent of students were interested in exploring opportunities in science."

The second talk from each presenter in the series was about their work, presented in plain language, which gave the audience a chance to see a range of potential career tracks in physics. In addition, each speaker presented an experiment.

Na presented an experiment demonstrating how light-matter interaction can teach us about the world we live in. In her demo, she shone a green laser at three different balloons (red, black and green) to show that when the colour of light and the balloon match, the light (and its energy) is reflected; when the colours do not match, the light (and energy) is absorbed, melting the plastic and making the balloons pop.

"Popping balloons is fun and flashy, but it really makes you think," said Na. "Science isn't limited to fancy labs and expensive detectors. Light-matter interactions are all around us and our eyes are nature's wonderful detectors, constantly giving us information about the world we live in."

Zonno described experimental research as a bit like cooking: "I never follow a recipe and I'm never certain how it will turn out; in the lab I play with lasers and the intensity of the light and electrons, and I enjoy seeing the different results and exploring new ideas based on those discoveries."

> Science isn't limited to fancy labs and expensive detectors. Light-matter interactions are all around us and our eyes are nature's wonderful detectors, constantly giving us information about the world we live in.
>
> —MengXing Na

In addition to talking about their work, the speakers talked about the scientific method and answered questions about things like experiment design and how a researcher moves from a question to a result.

Students in British Columbia begin making choices about the courses that will lead to university as early as grade 10, and so it is critical to reach students before they register for their grade 11 and 12 science courses. By humanizing scientists and making their work accessible, the program aims to reduce perceived barriers to students who want to pursue careers in research and scientific outreach.

The program was originally proposed by Blusson QMI Scientific Director Andrea Damascelli in 2020 with the goal of reaching students with identities and backgrounds that are not currently well-represented in physics.

"It is very positive to see that this has been so well-received," said Bussard, who looks forward to running similar outreach in lower mainland schools. "Reaching students in their formative years and creating lasting relationships with schools is important to Blusson QMI as part of our goal to improve the diversity and inclusivity of our field."

The relationship with Tupper doesn't end with the presentations: Na, Dasgupta, Zonno, and Meyer continue to provide support and mentorship for students as they develop science fair and other research projects in spring.

Reference: D.I. Miller, K.M. Nolla, A.H. Eagly, and D.H. Uttal. *The Development of Children's Gender-Science Stereotypes: A Meta-analysis of 5 Decades of U.S. Draw-A-Scientist Studies*. Child Dev, (2018).

UNBOXING QUANTUM SERIES

Launched in 2022, Unboxing Quantum is a public seminar series by Blusson QMI aimed at demystifying quantum science for a general audience and providing an insider's perspective on the research—and the researchers—shaping Canada's quantum future. Presented in plain language, this series makes quantum science accessible and provides meaningful information about quantum science, research and technology.

In May, PhD student, Vanier Scholar, and experimental physicist MengXing Na presented an illuminating talk titled *Seeing the World in a Different Light* that focused on the interaction between light and materials and what it can tell us about the world we live in.

In June, Postdoctoral Fellow Kirsty Gardner presented a talk titled *Tiny Devices and Huge Detectors* shedding light on the LIGO Project (Laser Interferometer Gravitational-Wave Observatory) and her experience as a queer person in STEM.

In October, Outreach Coordinator and UBC alumna, Ella Meyer discussed quantum entanglement and spooky action, the topic that led to the 2022 Nobel Prize in physics.

The series continues in 2023 and is set to expand through partnering with other science outreach programs from across BC.

EQUITY, DIVERSITY, AND INCLUSION

Image: Shahrzad (Zad) Abbasi, Communications Manager; Aditi Adhikari, Administrative Assistant; Pinder Dosanjh, Operations Manager; Alex Anees, Research Operations Facilitator; Claudia Kee,Research Operations Facilitator; Blusson QMI Business Operations Unit.

At Blusson QMI, we strive to cultivate a culture of inclusion and a sense of belonging that enables our community to continuously assess and address barriers to full participation and foster an environment where everyone can reach their full potential. We strongly believe diversity breeds innovation and firmly stand for it and celebrate it in all its forms.

INTERNATIONAL DAY OF WOMEN AND GIRLS IN SCIENCE

February 11 is the International Day of Women and Girls in Science, a United Nations-led initiative to highlight the important role that girls and women play in science and technology research and innovation. In 2022, we used this opportunity to tell the story of four women scholars at Blusson QMI who inspired each other throughout their careers to succeed, despite moments of uncertainty

Equity and inclusion of women and girls in science is a particularly urgent priority for the quantum community: though Canada has been a global leader in quantum science and technology for a long time, the Canadian quantum community is still in many ways finding its footing.

To put things in perspective, in 2010, women made up 44% of first-year STEM students aged 19 and under in undergraduate degree programs in Canada. Representation was lower in physical and chemical sciences at 32%. According to 2019 statistics in the United States, under 19% of doctorates in condensed matter physics were earned by women.

FINDING OURSELVES IN EACH OTHER

When Mona Berciu began her postdoctoral work in condensed matter, it was clear that she was the exception to the rule. Berciu came to Canada in 1994 to study at the University of Toronto, immigrating from Romania where everyone took the same classes. She slowly began to realize that women studying physics was a matter for surprise in Canada.

"It took me a while to figure out that people were very surprised because it was physics and a woman, not physics as such," said Berciu, now Professor in UBC's Department of Physics & Astronomy.

In 2001, going through a tough time and uncertain about her desire to remain in the field, Berciu gave a candidate talk at a Canadian university describing her work investigating how charged particles move through a magnetic semiconductor. In the audience was Sarah Burke, now Associate Professor UBC's Departments of Chemistry and Physics & Astronomy.

"Mona gave a stunning, high level but accessible talk that all the students were blown away by." Had she taken the job, Berciu would have been only the third woman faculty member in Burke's department. "It was really nice to see a woman interviewing and crushing it as a potential faculty member."

Burke knew as an undergraduate student that she wasn't well-represented in her field, but realized this more fully when attending a graduate student society event, where she was only one of two women postdoctoral fellows in physics. "I hadn't felt like it mattered to have role models as a graduate

Left: Mona Berciu, Investigator, Blusson QMI.

Centre: Sarah Burke, Investigator, Blusson QMI.

Right: Graduate student Samikshya Sahu (left) with Blusson QMI Investigator, Alannah Hallas (right), at the Quantum Materials Design Lab.

student, until I experienced it, and saw the impact on others. It just felt so much better, like, oh, these are my people, I'm not alone."

During a particularly difficult period in 2013, with her partner in hospital and unsure of whether she should continue in quantum matter research, Burke gave a talk about her work viewing materials at atomic levels to understand electronic and optoelectronic processes. Alannah Hallas was in the audience, feeling like an outsider after having switched from chemistry to physics for her doctoral degree. Burke, she felt, was speaking her language.

"She was an early career researcher, doing amazing science, and a woman; it was the first time I had encountered someone in this field that I could relate to," said Hallas.

Hallas, an Assistant Professor in UBC's Department of Physics & Astronomy, works in quantum materials discovery, aiming to create materials that don't exist in nature and could have interesting or unique properties.

In other words, she grows crystals in her lab. Her experience in STEM has been largely positive, she says, but day to day microaggressions occur, including a recent incident when a man who searched out her office phone number after a research talk to tell her she's a 'lovely person.' "That just doesn't happen to my colleagues who are men," said Hallas.

When Samikshya Sahu, a PhD student in Hallas' lab, was considering graduate schools in 2019, Hallas was part of the reason she chose UBC.

"It was inspiring to see a woman achieving so much at such a young age." Sahu's undergraduate class had about 11 women out of the 55 students, and only one woman with a faculty appointment. She finds the situation at Blusson QMI is "completely different", with women as leaders and mentors providing an empowering example. "You're more inspired when you see women who are good at what they do. I feel like I can do it too."

Berciu remembers as a young professor skipping meals at conferences out of fear of where to sit. "Things are improving," she said. "These days, if you need it, chances are there is someone who looks like you to sit near. I can't remember the last time I was the only woman in a room of men."

Image: Gideon Uchehara

CREATE STUDENT BUILDING BLACKS IN QUANTUM

Gideon Uchehara might have taken a different path to quantum science, had he known more about it. As a student in Nigeria, there may have been opportunities to explore quantum science and technology, but he wasn't aware of them. Now, he is building Blacks in Quantum, a network to connect other Black leaders in quantum science in order to make the opportunities he wished he had more of available to Black scholars.

"Quantum science, and quantum computing needs Black people," said Uchehara, a PhD student in the NSERC CREATE Program in Quantum Computing. "We will not be able to solve the world's problems while seeing those problems from a limited perspective. Quantum computing needs Black perspectives."

Uchehara is studying quantum machine learning at the University of British Columbia; he completed his Master's in Electrical and Computer Engineering at McGill University, after which he worked at Ballard on fuel cell systems.

"I realized that even though it was interesting work, it wasn't for me," said Uchehara. As luck would have it, he saw a post about the CREATE program from Lukas Chrostowski on LinkedIn: "It hit me: this is exactly what I had been looking for," he said.

Finding a place in BC's quantum community

Since enrolling in the first CREATE cohort in 2020, Uchehara has been active within BC's quantum community. When he attended a Quantum BC planning workshop last summer, Uchehara noticed that even though panelists spoke about the urgent need to diversify the field, there were no other Black people present.

"People were very objective about the field needing to be inclusive," he said. "Black people have to be involved in this era of technology, but many outside of these academic spaces don't have access to the opportunity to study, to learn, to get involved."

Uchehara is now working to build a Blacks in Quantum community, to promote opportunities like the CREATE program, or scholarships, or other outreach initiatives that give Black students access to mentors and support.

"I would like this community to serve as a platform to build the bridge between established, mostly white professors and Black students who want to get into the field," said Uchehara.

Quantum science must be inclusive now

In 2021, venture capital funds invested more than one billion dollars for quantum computing research and tech projects, and the Government of Canada committed $360 million to develop a national quantum strategy. As interest in quantum technology builds, it is imperative to engineer inclusion into academic and industry training programs now.

"Now is the time to engage Black people and generate interest, get them involved, and set them up for success," said Uchehara. "If we can empower people to be innovative, they can develop tech solutions and solve their own problems. There is tremendous untapped talent, but the other side of it is that Black people understand what they need better than people without the same lived experiences."

"Black perspectives and ingenuity will be critical to solving problems like health equity, climate change, and income inequality," said Uchehara, who wonders if he might be farther along in the quantum computing field had he been exposed to it as a possibility earlier in his education.

"I want every support that I can get to make sure that this community works," he said. "My goal is to build a community for people like me who want to learn about quantum technology, but don't know where to begin."

DIVERSIFYING TALENT IN QUANTUM COMPUTING

The Diversifying Talent in Quantum Computing (DTQC) program was launched in 2019 to introduce young, diverse K-12 students to quantum computing (QC) and give educators the tools to teach QC in classrooms. The program focuses on attracting girls, Indigenous youth, and other underrepresented groups in STEM to the world of quantum computing.

In 2022, DTQC has continued to create impact through activities targeting diverse youth with a focus on Indigenous outreach. The program reached more than 180 Indigenous students across 12 communities. The curriculum focused on an introduction into how quantum computers read information compared to classical computers. Students were presented with "typical" quantum problems to solve, and they participated in an activity that incorporated binary code and beadwork.

Since its launch, DTQC has reached over 2,500 youth (43% girls).

2500+ YOUTH

1080 GIRLS
(43% OF REACH)

180+ INDIGENOUS YOUTH

300+ EDUCATORS
ACROSS NORTH AMERICA

1st accredited high school quantum computing course in Canada

18 InSTEM programs

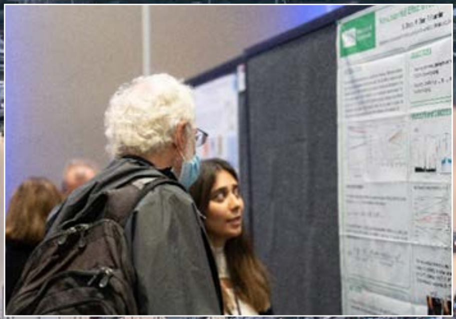
31 in-school workshops

60 summer camps running QC programs

5+ collaboration partners

2 EdX courses (open learning platform)

SIGNATURE EVENTS



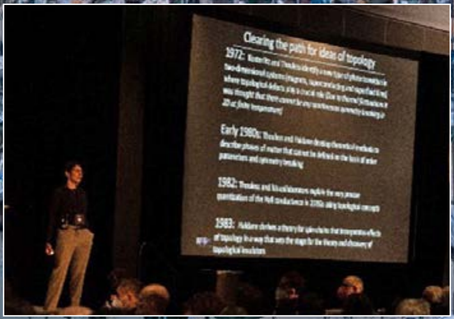


Image: Vancouver Downtown False Creek area from an Aerial Perspective (source: Shutterstock).

M2S CONFERENCE 2022

The 13th International Conference on Materials and Mechanisms of Superconductivity & High-Temperature Superconductors (M2S Conference 2022), which took place from July 17 to 22 at the Vancouver Convention Center, was Blusson QMI's premiere event this year.

Chaired by Blusson QMI Investigators Prof. Douglas Bonn and Prof. Mona Berciu, and with Blusson QMI Scientific Director Prof. Andrea Damascelli as Scientific Program Chair, the event attracted more than 350 attendees, including field leaders, researchers, students and industry delegates who participated in a week-long program of scientific talks, discussions, presentations and networking activities.

Since 1988, the Materials and Mechanisms of Superconductivity (M2S) conference has, every three years, brought together researchers in condensed matter physics and quantum mechanics from around the world to share the latest research in the field of superconductivity. The first conference was held in Interlaken, Switzerland, shortly after the discovery of high temperature superconductivity by the Nobel Prize winners Johannes Georg Bednorz and Karl Alexander Muller. Subsequent meetings have been held in Palo Alto, Kanazawa, Grenoble, Beijing, Houston, Rio de Janeiro, Dresden, Tokyo, Washington, Geneva, and Beijing.

The 2022 conference brought together researchers from across the full spectrum of studies in superconductivity to enable the exchange of ideas, foster collaborations, and fuel future research. All aspects of research in the field were represented, including materials development, advances in theory and experiment, research for real-world applications, and a range of contemporary topics in the field.

The extensive program provided an opportunity to learn about the developments in well-established lines of research, as well as exciting new discoveries of recent years. Among the topics discussed were major studies on cuprates, iron-based superconductors, and the latest progress in understanding high-temperature superconductivity in these systems. For new areas of research and discovery, the program delved into topics such as topological superconductivity, device structures using twisted layers, the discovery of superconductivity in nickelates and in kagome materials, and new applications in quantum devices and quantum computing.

Awards, including the 2022 Heike Kamerlingh-Onnes Prize, the 2022 Bernd T. Matthias Prize and the 2022 John Bardeen Prize, went to a handful of outstanding academics for their work in driving major breakthroughs in the research of superconductivity.

Prof. Bernhard Keimer (Max Planck Institute for Solid State Research, Stuttgart, Germany), Prof. Giacomo Ghiringhelli (Physics Department, Politecnico di Milano, Italy) and Prof. Pengcheng Dai (Rice University, Houston, USA) shared the 2022 Kamerlingh-Onnes Prize for experiments determining spin and charge correlations in high temperature superconductors using x-ray and neutron scattering.

This year, special efforts were made to make the Conference more accessible to junior researchers and to promote more diverse and inclusive participation. A post-event survey showed endorsement for the success of the Conference, as all respondents rated their experience as "excellent" or "very good".

The M2S 2022 wouldn't have been possible without the guidance of the M2S International Advisory Committee, the M2S Scientific Program Committee, and the generous support of our many sponsors, including ICAM-I2CAM Institute for Complex Adaptive Matter, the Gordon and Betty Moore Foundation, the International Union of Pure and Applied Physics (IUPAP), and more.

Sponsors and exhibitors

MP–UBC–UTOKYO CENTRE FOR QUANTUM MATERIALS ANNUAL MEETING

Hosted by Blusson QMI, the annual meeting for the MP–UBC–UTokyo Centre for Quantum Materials took place between September 19 to 21, 2022 at UBC's Vancouver campus. The workshop was attended by more than 100 participants, including 16 research collaborators from internationally renowned institutes, including the Max Planck Institute for Solid State Research, University of Stuttgart, and University of Tokyo.

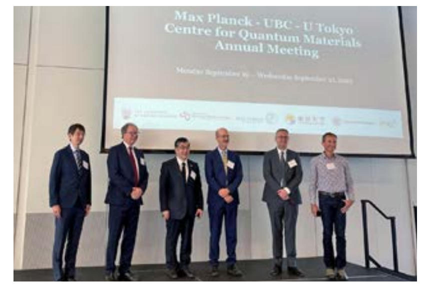
We welcomed a number of prestigious guests, including the co-directors of our partnering institutes—Prof. Bernhard Keimer (MPI Stuttgart and the University of Stuttgart), Prof. Ryo Shimano (University of Tokyo, Japan)—as well as Prof. Makoto Ganokami (President of RIKEN and the former President of the University of Tokyo) and Prof. Dr.-Ing. Wolfram Ressel (the University of Stuttgart's Rector).

The 3-day event featured 27 scientific presentations from highly distinguished scientists, covering an array of results and advancements in quantum materials research, including quantum devices and infrastructure development. Across the talks, many reported on results from the close collaborative among the three partnering institutions under the MP-UBC-UTokyo agreement. The significant results were a testament to the commitment the partners have toward building the research front in Quantum Materials.

Concurrent with the annual meeting, UBC hosted the University of Stuttgart's leadership team (led by Dr.-Ing. Ressel) to celebrate the highly regarded partnership between the two institutions, specifically the joint PhD program.

Prof. Santa Ono, UBC's President at the time, hosted the delegation for a dinner reception at UBC's President's House alongside members from Blusson QMI and the Max Planck partnership team. The gathering marked the significance of the MP-UBC-UTokyo Centre for Quantum Materials partnership as part of the collaboration efforts between the two universities and acknowledged the numerous joint research work, exchange programs and co-publishing efforts our institutions have forged throughout the years.

The highlight of the program was a public concert by the UBC Symphony Orchestra in collaboration with the University of Stuttgart Academic Orchestra (who travelled to Vancouver as part of the University of Stuttgart's delegation) at the Chan Centre for the Performing Arts on September 20. The musical program included Brahms, Bartók and Schumann. A small quartet group from the Stuttgart Orchestra also performed at the opening ceremony of the MP-UBC-UTokyo annual meeting.



QUANTUM DAYS 2022 UNITES CANADIAN QUANTUM SECTOR

Chaired by Blusson QMI Scientific Director Andrea Damascelli, Quantum Days 2022 showcased the strength of the Canadian quantum science community by bringing together diverse expertise from across the country to connect and collaborate between February 8-10. Attended by more than 1000 participants, the event featured 68 speakers, 56 poster presentations, 21 exhibitors, 19 career fair exhibitors and 125 job listings and more.

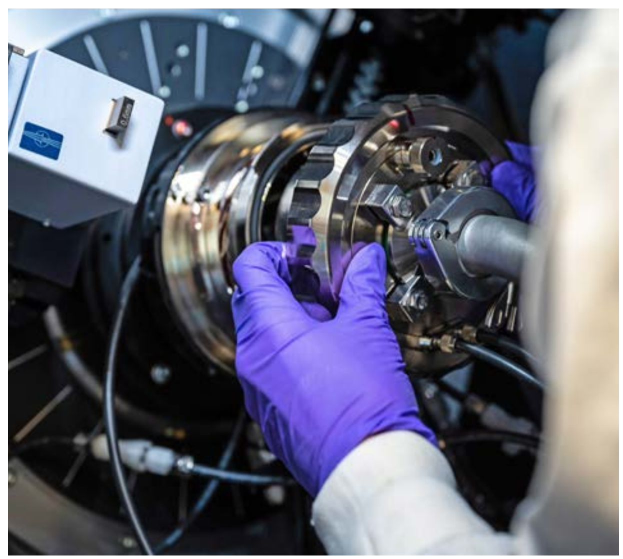
"Quantum science is maturing, and the Canadian quantum ecosystem is thriving," said Andrea Damascelli. "Now is the time to work together to leverage the Government of Canada's commitment to a national quantum strategy and cement Canada as a global leader in quantum science and technology research and innovation."

The event was officiated by opening remarks from Mona Nemer, Chief Science Advisor to Canada's Prime Minister, and was organized by NanoCanada, a Canadian hub for science, innovation, and entrepreneurship, in partnership with CMC Microsystems. The University of British Columbia is among the founding sponsors of the event.

The virtual format of the event meant that organizers were able to draw diverse expertise, with panels on topics as varied as quantum materials, Canada's quantum workforce, and how to fund your start-up venture. Students had the opportunity to take part in networking sessions, including a career fair with representatives from national and international companies in quantum technology, and a poster competition judged by industry leaders (with $5000 in prizes).

"Quantum Days is highly valued as a fully inclusive national meeting that draws together quantum stakeholders from government, industry, and academia," said Barry Sanders, Quantum Days founder and Professor and Director, Institute for Quantum Science and Technology at the University of Calgary. "It is a wonderful counterpart to other quantum activities that are driven by economic and strategic imperatives."

Building on the momentum of a very successful inaugural Quantum Days in 2021, the 2022 event represented a conscious effort from leaders in the community to advocate for Canadian quantum science as a whole, and to nurture new opportunities across the country. With the commitment of the Government of Canada to fund a national quantum strategy, it is important to bring Canadian quantum science researchers, students, business people, and policymakers together and establish priorities and next steps.



BLUSSON QMI ANNUAL RETREAT

This year the Blusson QMI Annual Retreat took place on September 23–25 at Loon Lake Lodge and Retreat Centre in Maple Ridge, British Columbia. The land on which we gathered is located in the traditional, ancestral, and unceded territory of the Katzie and Kwantlen people.

Attended by more than 100 members from across Blusson QMI, the retreat was an opportunity to reconnect as a community, engage in scientific discussions, and celebrate our successes and accomplishments over the past few years.

Blusson QMI Scientific Director Andrea Damascelli and Managing Director Kim Kiloh opened the retreat by acknowledging the land and providing an overview of the program, including scientific talks, discussions and group activities.

Highlights included an overview of Blusson QMI's Grand Challenges by Andrea Damascelli, Ziliang Ye, Josh Folk, Alannah Hallas, Jeff Young, Roman Krems, and Jess McIver well as discussions on the future of neutron scattering in Canada and applications for lasers in mining.

PEOPLE

Image (left to right): Doug Bonn, Jisun Kim, Sarah Burke, James Day, Joen Bannies.

ASHUTOSH BHUDIA

Ashutosh Bhudia is off on his next adventure: he's going on to study at one of Australia's leading quantum computing institutes on a pair of scholarships, leaving Joseph Salfi's lab to study with Salfi's former postdoctoral supervisor, Sven Rogge. Ashutosh recently completed a co-op year at the Stewart Blusson Quantum Matter Institute (Blusson QMI), where he worked on his Physics Honours thesis, *Novel on-chip microwave filters for circuit quantum electrodynamics with spin qubits.*

Ashutosh has started his PhD research at the University of New South Wales in Sydney in September 2022, where he continues to work with superconducting quantum devices.

For Ashutosh, this next stage is exciting, if a little daunting, but he is encouraged by his experience at UBC.

"I'm excited to live and work in a new environment, and meet new people," he said. "With the great experiences at Blusson QMI—in my academics, research and everyone who I met along the way that made it all possible—I am confident that I have the skills and background to excel in my PhD research."

KATHERINE COCHRANE

Katherine Cochrane completed her PhD in Chemistry at UBC under the supervision of Blusson QMI's Sarah Burke in 2017. She used scanning probe microscopy to investigate materials used for novel organic photovoltaics. Today, Katherine is a research scientist at the semiconductor company KLA.

"I knew I was interested in physical chemistry and understanding how materials worked on a fundamental level. I was really drawn to scanning probe microscopy due to its unique ability to visualize materials on the single molecule level," said Katherine.

"At KLA, I am on a team that is building a next generation electron microscope for semiconductor wafer inspection. I use many of the skills that I learned at Blusson QMI on a daily basis. Part of my job still involves lab work, and the technical skills that I learned are invaluable, particularly in the area of vacuum science. In addition, the scientific communication skills I learned from Sarah have been key to my success. In particular, the ability to turn complex data into clear, concise figures or slides has been something that I use daily."

MARIO GONZALEZ RIVAS

Under the right conditions, you can convince 1000 electrons to work together. "It can be challenging, but it's probably easier than to get 1000 people to work together," said Mario Ulises Gonzalez Rivas, who is working on his PhD in Alannah Hallas' lab at Blusson QMI. Mario has a unique background, moving from studies in nanotechnology as an undergraduate student to a Master's degree in materials science at the University of Guadalajara before finding his interest in condensed matter physics.

In Hallas' lab, his research is focused on high-entropy oxides, a priority area of research at Blusson QMI that ties into the *Atomistic approach to emergent properties of disordered materials* grand challenge.

"I'm just fascinated by how making some small chemical changes to a structure that you already have you can completely change its behavior," said Mario. "That's one of my favorite things about this work."

While condensed matter and quantum materials are relatively new areas of study for Mario, he enjoys his proximity and access to field-leading experts, including Hallas and George Sawatzky.

RYAN ROEMER

Ryan Roemer is a PhD student in Ke Zou's group studying 2D materials grown by Molecular Beam Epitaxy (MBE). He joined UBC in 2018.

"My research has focused on characterizing novel 2D materials for both fundamental and practical purposes. I have worked on Fe-based high-temperature superconductors in which the superconducting mechanisms are not well understood, and 2-dimensional magnets that until recently were not thought to be physically realizable. I have investigated how the electronic and magnetic interactions evolve as a function of thickness and some aspects of how the quantum phase transitions are triggered," said Ryan.

"The research program at Blusson QMI is top notch. You're surrounded by experts who make time to sit down to discuss your research and train you on the instruments. I think we do a great job here to make learning more accessible," Ryan said.

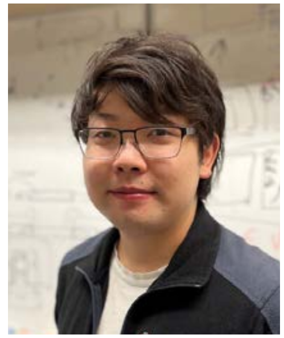
Ryan completed his undergraduate degree at the University of California in Santa Cruz, where he studied physics, chemistry and math. Ryan hopes to join a national laboratory after completing his PhD in 2023.

MIA STANKOVIC

Mia Stankovic is a PhD student in the Berlinguette Group at UBC's Department of Chemistry and Blusson QMI. She was among the three winners of the 2022 Tyler Lewis Green Research Foundation grant for her research on the decarbonization of chemical manufacturing using a membrane reactor.

"My goal for this project is to develop chemical hydrogenation pathways that can be integrated into the real world. I am currently exploring the production of fuels and commodity chemicals from biomass-derived compounds as an alternative to petrochemicals," Mia said.

Mia graduated from Queen's University in 2020 with a bachelor's degree in chemistry and shortly after accepted a master's position in the Berlinguette Group, which quickly turned into a PhD. Mia is currently the lead graduate student on the project. She has been responsible for training several junior students who have joined the team and also serves as the project lead for a large industrial collaboration through the Berlinguette Group.



XIRUO YAN

"I still remember when I was starting out with my PhD and Jeff Young asked me 'what do you want to do?'" said Xiruo Yan. "So I said, 'I've always wanted to go into quantum computing.'" He has now taken on a role with the Canadian quantum computing company Xanadu joining the systems integration team as an experimental physicist to build computing tools.

Xiruo came to UBC in 2014 and began working on his Master's with Jeff Young. At UBC, Young introduced Xiruo to new experimental skills, including how to fabricate single-photon detectors. During his time at at Blusson QMI, Xiruo developed a quantum computing architecture that uses a very specific quantum system, with a methodology and techniques that can be applied to a range of possible systems.

Xiruo hopes that students at Blusson QMI are aware of opportunities to connect with companies like Xanadu to land industry positions after graduation. He encourages Blusson QMI students to look him up and send him a note: "It can be hard to meet the right people and get a foot in the door with the company you would like to work for. Feel free to reach out and connect with me!"

AWARDS AND RECOGNITION

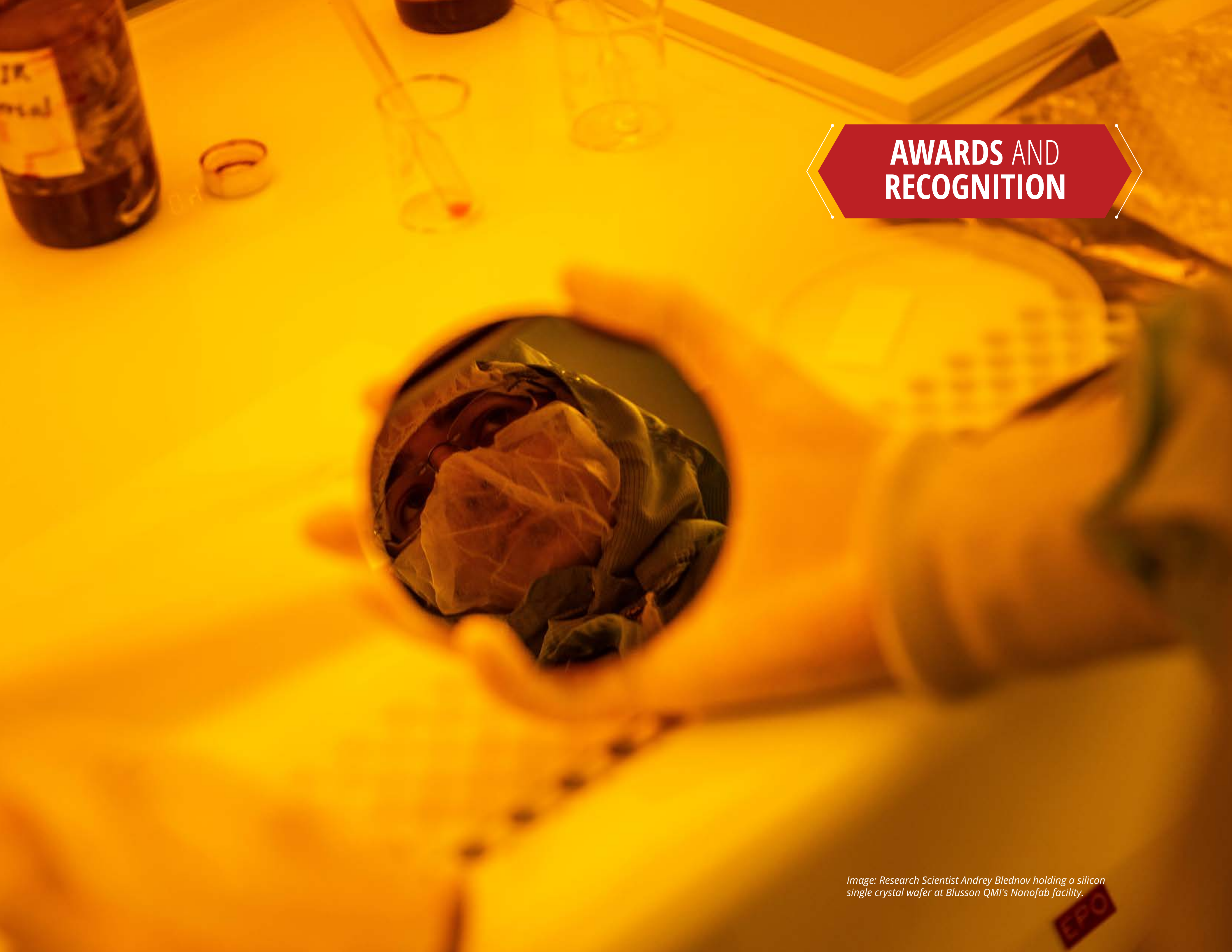


Image: Research Scientist Andrey Blednov holding a silicon single crystal wafer at Blusson QMI's Nanofab facility.

PINDER DOSANJH RECEIVES UBC'S HIGHEST STAFF HONOUR

Pinder Dosanjh has been awarded the President's Service Award for Excellence (PSAE), the highest honour given to staff at the University of British Columbia (UBC). The PSAE celebrates staff members who have sustained exceptional contributions to the University. With more than 30 years on campus, Dosanjh has long been an influential member of the physics community at UBC, and the heart of the of Blusson QMI.

"Pinder is one of those people so deeply woven into all aspects of an institution that is difficult to imagine it without him," said Doug Bonn, who first met Dosanjh, then a student, when he came to UBC as a postdoctoral fellow in 1989. The two worked closely with Walter Hardy throughout the 1990s. "From those early days, Pinder has been right at the heart of the emerging centre of research excellence that would eventually become Blusson QMI."

Dosanjh first took on the role of Research Engineer with the Department of Physics & Astronomy in the superconductivity lab in 1990, and since then he has been a driving force in developing the superconductivity research effort at UBC, from the development of critical infrastructure to training students to conducting his own research.

Now Operations Manager, and leader of Blusson QMI's Technical Operations team, he has demonstrated incredible success when it comes to publication metrics. For someone who has worked at the interface between science and operations, the level and impact of his scientific output—more than 71 publications, 2710 citations, h-index 24—is remarkable (and generally unheard of for someone in a Management & Professional role).

"It is unprecedented that he is able to excel so significantly in his day-to-day work and also produce a steady stream of academic research papers; since 2010, he has produced on average four publications per year with a steadily increasing body of citations," said Andrea Damascelli. "He is unique at UBC, and to be frank, anywhere. His unique combination of skills and expertise has enabled him to be a catalyst for growth at Blusson QMI."

Dosanjh is an influential member of the Canadian scientific community beyond his research output; he has been a leader in the development of a new $16.2 million CFI-funded beamline at the Quantum Materials Spectroscopy Centre (QMSC) at Canada Light Source (CLS). He led the project for over 12 years, from early design through to implementation, an effort that has enormous benefits for quantum materials research: the QMSC is a facility of national significance that is supported by 17 universities. Dosanjh has visited the CLS with his technical operations team several times over the past few months to install final components and bring the QMSC to completion.

His contributions to science at UBC and in Canada are considerable, but he has also quietly influenced generations of students through his hands-on approach to teaching and training. Dosanjh's skills training for students has, over time, become established as a formal program. Now, Blusson QMI's annual Summer Skills Workshops Series benefits students in the Quantum Pathways program as well as students in other undergraduate summer programs. In fact, the workshops are so valuable that they are even attended by many outside undergraduate programs, providing benefits to anyone looking to learn important research skills. He also worked with Machine Shop Supervisor Harish Gautam to develop a student machine shop where students at any level can come to learn to design and fabricate research tools or instrument parts to support the work they do in the labs.

"Pinder holds an almost mythical status among students," said Alexandra Tully, head of the Blusson QMI Student Committee. "When a graduate student first arrives at the institute, their best first move is to talk to Pinder. But although his expertise is varied and renowned throughout the institute, Pinder's generosity is really what sets him apart: Pinder influences every aspect of this place for the better."

During the first months of COVID-19 pandemic, Dosanjh sustained our critical infrastructure and worked closely with AMPEL's Gary Lockhart to bring Blusson QMI and AMPEL back into operation earlier than other buildings on campus, while managing the complexity of working in compliance with emerging safety rules. In addition, he worked closely with UBC teams to ensure the safety and efficiency of COVID-specific research during the period when UBC spaces were closed; he navigated the research exemption process and got research teams back to work safely and efficiently, all while prioritizing important research activities.

Dosanjh provides exceptional leadership, vision, and service to the Blusson QMI community. A calm, capable leader, he is as important to our culture as he is to our research. His warmth and enthusiasm for quantum matter have been a focal point for visitors: for donors, visiting students, or other guests, Dosanjh often demonstrates quantum phenomena using the levitation track he co-developed with Doug Bonn and Walter Hardy as a graduate student. Through this simple but compelling demo, Pinder has made quantum science more accessible, providing an entry into a very complex topic with playfulness and fun. Dosanjh makes Blusson QMI memorable and is himself a memorable part of Blusson QMI for anyone who has the good fortune to interact with him.

"Pinder brings an empathetic and supportive management style to his teams, and that warmth and supportiveness extends to the entire Blusson QMI community," said Damascelli. "He is generous with his time and his insight, and the way he interacts with people and his willingness to help, mentor, and supervise young scientists speaks to his generosity and passion for the work that he does. There is no one quite like Pinder, and I am so proud that he is receiving this most-deserved and important recognition from the University."

JAMES DAY — UBC SCIENCE EXCELLENCE IN SERVICE AWARD

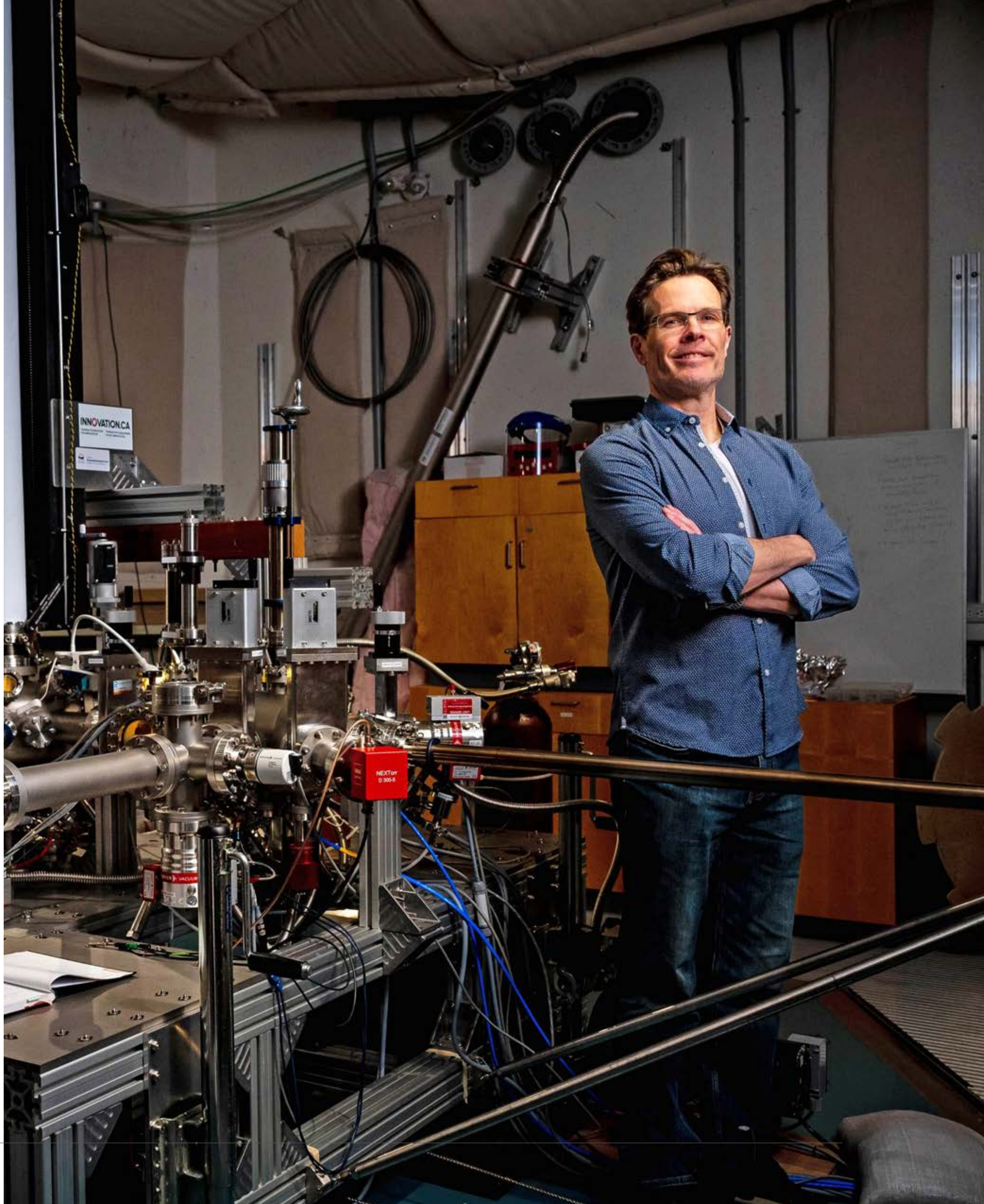
James Day, a Senior Research Associate at Blusson QMI, has been awarded an Excellence in Service Award by UBC's Faculty of Science. The awards were presented by the Dean of the Faculty of Science, Meigan Aronson, in a ceremony held in March 2023.

"James has always been a cohesive force in establishing an enriching, equitable, and inclusive research environment for everyone," said Blusson QMI Scientific Director Andrea Damascelli.

"As an experienced and rigorous scientist, James holds a wealth of institutional knowledge and experimental skills that he shares with colleagues and trainees. Whether it is through his scientific work, mentoring trainees, initiating and leading unique programs, or simply hosting elementary and high school students in the lab, he enriches the culture of Blusson QMI with his generosity and creativity," Damascelli said.

Day said he is deeply grateful for the recognition and appreciation that the award represents.

"Learning that I had been selected to receive this award was quite a meaningful experience.



It served as a powerful affirmation of the time, energy, and passion that I have invested in serving the QMI community. It feels like validation of the work and dedication that I have put into making a positive impact on the people and causes that I care about," said Day.

Day has been an instrumental part of Blusson QMI's community. He supports the High-Temperature Superconductivity (SUPERCON) lab, which uses microwave techniques to probe the electronic properties of unconventional superconductors, and the Laboratory for Atomic Imaging Research (LAIR), which applies scanning probe microscopy tools to develop a deep understanding of new materials.

"James is an anchor of QMI community, especially for students. Students regularly confide in him as they navigate the research environment, often for the first time, and James provides meaningful guidance and mentorship to help them through challenges from technical details to the human side of doing science," said LAIR Lead Associate Sarah Burke.

Day said he finds the most rewarding part of his day-to-day to always be the interactions with the students.

"I feel that my job is to help them get through their programs efficiently; I feel that my duty is to help them enjoy that experience. I hope they can learn as much from me as I do from them," Day said.

Day has worked closely with students from underrepresented groups through Blusson QMI's flagship equity, diversity, and inclusion (EDI) program, *Quantum Pathways*, which provides up to four years of research experience to undergraduate students in the field of quantum materials throughout their curriculum.

As Program Manager for Ars Scientia, a transdisciplinary research partnership by Blusson QMI, the Belkin Art Gallery, and the Department of Physics & Astronomy, Day has led a nascent residency program linking local artists with UBC physicists to foster new modes of knowledge exchange across the arts, sciences and their pedagogies.

"I can't imagine receiving this award without first having been granted opportunities by the QMI to become involved in the first place. I owe big thanks to many for modelling great behaviour and for inviting me to make a difference," Day said.

A full list of the 2022 Faculty of Science Excellence in Service Awards is provided below:

- Michael Gordon, *Associate Professor, Zoology*
- José Rodriguez Nuñez, *Associate Professor Teaching, Chemistry*
- Regina Bestbier, *Research Assistant, Institute for the Oceans and Fisheries*
- James Day, *Research Associate, Quantum Matter Institute*
- Michelle Moksa, *Research Manager, Microbiology and Immunology*
- Laura Selander, *Administrative Support, Computer Science*
- Joseph Tam, *Director IT Operations, Mathematics*
- Ashley Welsh, *Interim Associate Director, Skylight, Deans Office*
- Julie McNutt, *Graduate Student, Chemistry*
- Andrew Sharon, *Graduate Student, Microbiology and Immunology*

FACULTY

Curtis Berlinguette

Canada's Clean50 for 2023
The Clean50 award recognizes leaders from across Canada who have advanced climate action and developed climate solutions. As CEO and Co-Founder of Miru Smart Technologies Corp., Curtis was recognized in the "Research & Development" category. At Miru Curtis leads a team of designers and engineers building next-generation electrochromic windows that are responsive to the world's needs.

Sarah Burke

Killam Award for Excellence in Mentoring
This award recognizes outstanding mentorship of numerous graduate students over many years. Sarah was recognized for her efforts in supporting the development of graduate students and nurturing their intellectual, professional, and personal development.

Andrea Damascelli

Canada Research Chair Tier 1 Renewal
The Canada Research Chairs program invests up to $311M per year to attract and retain the world's most accomplished minds. Andrea was re-appointed as the Canada Research Chair in Electronic Structure of Quantum Materials.

Marcel Franz

Royal Society of Canada Fellow
Fellows of the Royal Society of Canada are distinguished Canadians who have made remarkable contributions in the arts, the humanities and the sciences. Marcel was recognized for his foundational theoretical work in high-temperature superconductivity, and pioneering ideas in graphene and topological quantum matter.

Alannah Hallas

The Bryan R. Coles Prize
Presented at the 2022 International Conference on Strongly Correlated Electron Systems in Amsterdam, The Netherlands, the Bryan R. Coles Prize recognizes an early career researcher who has made significant contributions to the experimental study or discovery of strongly correlated electron materials and phenomena. Alannah received this award in recognition of her contributions to the discovery of new novel quantum materials through high-pressure synthesis.

Mark MacLachlan

Canada Research Chair Tier 1 Renewal
The Canada Research Chairs program invests up to $311M per year to attract and retain the world's most accomplished minds. Mark was re-appointed as the Canada Research Chair in Supramolecular Materials.

Robert Raussendorf

Alexander von Humboldt Professorship
Funded by the Federal Ministry of Education and Research, the Humboldt Professorships are the most prestigious awards in Germany. As an internationally recognized expert in theoretical physics specializing in quantum information theory, Robert will receive $3.5M over five years to conduct research at Leibniz University Hannover.

Jeff Young

UBC Emeritus College Member
Jeff Young was granted Professor Emeritus status, and thus joins the UBC Emeritus College as a Member. The College offers an intellectual pathway to retirement while maintaining a close connection to UBC and academia. Jeff will continue to serve on the Executive Committee and will also serve as an Acting Scientific Director for QMI's Advanced Nanofabrication and Cleanroom facilities.

STUDENTS AND POSTDOCTORAL FELLOWS

Mia Stankovic (Berlinguette Group)

Tyler Lewis Green Energy Research Foundation Award
Wilma Ethel Elias Scholarship in Chemistry
The Tyler Lewis Clean Energy Research Foundation supports "the fundamental research required for the development of a sustainable society using clean and renewable energy sources for generations to come." Mia received this grant in recognition of her research related to membrane reactors that provide an opportunity to electrify and decarbonize. In addition, Mia was awarded UBC's Wilma Ethel Elias Scholarship in Chemistry, which is named after the first woman to receive a PhD at UBC. The scholarship supports the next generation of women in chemistry research.

Cissy Suen (Damascelli Group)

Advanced Light Source Doctoral Fellowship
The Advanced Light Source Doctoral Fellowship (funded by Lawrence Berkely National Lab and the US Department of Energy) allow recipients to work at the frontier of synchrotron radiation research and to help advance state-of-the-art techniques and applications. Fellows also benefit from a series of professional development activities, including an orientation program, seminars, and an opportunity to present results at the end of the fellowship.

STUDENTS AND POSTDOCTORAL FELLOWS, *cont.*

Vedanshi Vala (Ye Group)

L'Oreal Women of Worth Awards
L'Oreal's Women of Worth program honours "extraordinary women who selflessly volunteer their time to serve their communities." Vedanshi was recognized for her work as the founder, chairperson and executive director of BOLT Safety Society, a non-profit providing a technology-led platform focused on personal safety for women and seniors. Her mission for BOLT is to foster allyship for survivors of trauma, spread awareness, and provide educational programming focused on personal protection.

Stepan Fomichev (Berciu Group)

Igor Markovic (Damascelli Group)
Mitacs Accelerate Internship
The Mitacs Accelerate program ensures students, postdoctoral fellows, and recent graduates can apply their skills in a non-academic environment. Stepan is working with the Algorithms Team at Xanadu—a Canadian quantum computing hardware and software company—until summer 2023. Meanwhile, Igor is doing his internship at the Canadian Light Source—Canada's national synchrotron light source facility—working with the User Services Office.

Ehsanur Rahman (Nojeh Group)

NSERC Postdoctoral Fellowship
The Postdoctoral Fellowships (PDF) program provides support to a core of the most promising researchers at a pivotal time in their careers. The fellowships are intended to secure a supply of highly qualified Canadians with leading-edge scientific and research skills for Canadian industry, government and academic institutions.

Lucas Andrew (MacLachlan Group)
Paul Herringer (Raussendorf Group)
Daniel Wong (Rottler Group)
Michael Zurel (Raussendorf Group)

NSERC Graduate Scholarship—Doctoral Program
The NSERC Graduate Scholarships program is a federal program awarded through national competitions. It promotes continued excellence in Canadian research by rewarding and retaining high-calibre doctoral students at Canadian institutions, and strives to foster impacts beyond the research environment.

Ana Ciocoiu (Salfi Group)
Rio Weil (Raussendorf Group)

NSERC Graduate Scholarship—Master's Program
The goal of this NSERC program is to help develop research skills and assist in the training of highly qualified personnel by supporting students who demonstrate a high standard of achievement in undergraduate and early graduate studies.

Arnab Adhikary (Raussendorf Group)
Tim Branch (Bonn Group)
Mario González Rivas (Hallas Group)
Rysa Greenwood (Burke/Jones Groups)
Mukhlasur Tanvir (Salfi Group)

UBC Four-year Doctoral Fellowships
UBC's four-year doctoral fellowships ensure that UBC's best doctoral students have financial support over the course of their studies, and helps attract and support outstanding domestic and international doctoral students.

"BEST PAPER" AND "BEST POSTER" AWARDS

Ehsanur Rahman (Nojeh Group)

Shoulder-Gray-Spindt (SGS) Best Paper Award
Awarded at the 35th International Vacuum Nanoelectronics Conference (IVNC 2022) in Seoul, Republic of Awarded at the 35th International Vacuum Nanoelectronics Conference (IVNC 2022, Seoul, Republic of Korea), this award is named after the founders of the field of vacuum microelectronics/nanoelectronics: Ken Shoulders, Henry Gray, and Capp Spindt. IVNC is the premier annual conference of this field, and only one best paper award (the SGS award) is given every year. The award was given for the paper "A Multiphysics Approach to Modeling Thermionic Energy Converters."

Connor Rupnow (Berlinguette Group)

Best Poster Award at German Canadian Materials Acceleration Centre (GCMAC) 2022
2022 Acceleration Consortium Conference Best Poster Award
Connor received a Best Poster Award from EERA JP ES or his poster titled "Optimization of Scalable Coating Process Using a Self-Driving Laboratory". He also received the Best Poster award for this same poster at the Acceleration Consortium's annual conference.

PRINCIPAL INVESTIGATORS

Image: Completed in 2017, the Blusson QMI building is home to 50,000 square feet of state-of-the-art research infrastructure and facilities.

INVESTIGATOR EMERITUS
IAN AFFLECK

Ian Affleck received his B. Sc. in Physics and Mathematics in 1975 from Trent University in Ontario, Canada, and his PhD in Physics from Harvard University in 1979. As a PhD student, he trained under the supervision of legendary high-energy theoretical physicist Sidney Coleman, known for his work in quantum field theory.

After three years as a Junior Fellow at Harvard and then an Assistant Professor of Physics at Princeton University, Ian joined the University of British Columbia as a Professor within the Department of Physics & Astronomy in 1987, and joined Blusson QMI since its inception in 2010. He is known internationally for his ability to clarify theory and work closely with experimentalists in condensed matter physics.

Ian started his research career in high energy theory and applies methods from this field to low dimensional strongly correlated system in condensed matter theory. In particular, he has applied conformal field theory techniques to low dimensional magnetism, Kondo effects and quantum impurity problems. “I enjoy finding mathematically elegant solutions to problems,” Ian says. Most recently, he has been studying theoretical aspects of condensed matter physics, including high-temperature superconductivity, low dimensional magnetism, quantum dots and quantum wires.

According to Scopus, he has published more than 280 publications with over 27,000 citations and an h-index of 79.

Ian’s contributions to condensed matter physics has received extensive recognition, and he has received nearly all the physics awards available in Canada and many outside of Canada as well.

As a young physicist he received a Governor General’s Silver Medal for the highest undergraduate academic standing (1975), the Steacie Prize for remarkable scientific achievements in Canada (1988), the Canadian Association of Physicists (CAP) Herzberg Medal awarded to exceptional Canadian physicists under the age of 40 (1990), and the Royal Society of Canada’s Rutherford Memorial Medal for his contributions to mathematical physics (1991). He was also the recipient of the Senior Killam Research Prize and the Jacob Bieley Prize from the University of British Columbia in 1992, as well as the CAP Prize for Theoretical/Mathematical Physics (1997) and the CAP Brockhouse Medal (2014).

In 2011, Ian was awarded the Lars Onsager Prize (LOP) from the American Society of Physicists (APS) and delivered the LOP lecture “A Random Walk Through Theoretical Physics”, where he gave a historical account of his efforts to apply conformal field theory techniques to experimentally relevant condensed matter models. The LOP recognized his groundbreaking contributions in the advancement and practical application of the principles and techniques of conformal field theory. Specifically, his work has significantly impacted important issues in statistical and condensed matter physics such as the universal behavior of quantum impurity systems and the quantum critical behavior of spin chains.

Ian is a Fellow of the Royal Society of London, the Royal Society of Canada, the APS, and a Foreign Associate of the French Academy of Sciences. He received an honorary Doctor of Laws degree from his alma mater, Trent University, in 1998.

INVESTIGATOR EMERITUS
ROB KIEFL

Rob Kiefl, a Professor in the Department of Physics & Astronomy at the University of British Columbia (UBC), an Investigator at the Stewart Blusson Quantum Matter Institute (Blusson QMI), and an affiliate Scientist at Canada's particle accelerator centre TRIUMF, has retired from UBC and his position at Blusson QMI.

Kiefl is an expert in experimental condensed matter physics, particularly quantum materials and their interfaces. Most recently, his research has been focused on understanding the novel magnetic and electronic properties of quantum materials using nuclear methods such as muon spin rotation (μSR) and beta-detected nuclear magnetic resonance (βNMR).

After obtaining his PhD from the University of British Columbia in 1982, Kiefl spent two years at the University of Zurich as a Postdoctoral Fellow. In 1984 he returned to Canada and began working as a Research Scientist at TRIUMF. He started at UBC in 1987 as a University Research Fellow and has been a full Professor since 1995 and an Investigator at Blusson QMI since its beginning.

Kiefl is widely recognized for his contributions to scientific research. He was an Associate of the Canadian Institute of Advanced Research (Superconductivity) from 1990 to 2013. He was awarded the Herzberg Medal by the Canadian Association of Physicists in 1992 and became a Fellow of the American Physical Society in 2005.

In 2017, he was awarded the prestigious Yamazaki Prize by the International Society for mSR Spectroscopy (ISMS). The prize, awarded every three years, recognizes outstanding and sustained work in μSR science with long-term impact on scientific and/or technical μSR applications. Kiefl received the prize for his development and use of μSR and β-NMR in condensed matter physics. His contributions to the field have had a significant impact on a wide range of topics, including muonium in semiconductors, exotic superconductors and magnets and most recently, developments in beta-NMR at TRIUMF for use in studying electronic and magnetic properties of thin films and interfaces.

"At the beginning of my career, I worked mostly on developing and applying new methods to study muonium in semiconductors—particularly high transverse field muon spin rotation and level crossing resonance spectroscopy. The electronic structure of muonium is almost identical to that of hydrogen but is much easier to study than hydrogen, which is an important impurity in most semiconductors."

The discovery of high-temperature superconductivity in the late 1980s caused a dramatic shift in the direction of his research and the path of many others doing muSR. The muon was immediately recognized as a sensitive local probe for exploring the novel properties of this new collective state of matter.

Since about 2000, Kiefl's research focused on using radioactive nuclei to probe thin films and interfaces. This change in direction happened when Alan Astbury (TRIUMF director at the time) approached Kiefl about potential applications for TRIUMF's Isotope Separator and Accelerator facility (ISAC) in the area of condensed matter physics. This collective effort by Kiefl and other collaborators led to the building of a unique world-class β-NMR facility here at TRIUMF.

"It has been a thrilling experience, and I am very grateful for being a part of TRIUMF and Blusson QMI at UBC," Kiefl said.

The content used in this piece has been partially extracted from an earlier interview by TRIUMF.

MEIGAN ARONSON

RESEARCH FOCUS
Our group is focused on finding new materials that are at or near a quantum phase transition, where new phases of matter—including novel order—emerges at zero temperature. We carry out measurements of fundamental quantities, such as the transport of charge and heat, and especially their magnetic properties using a combination of lab-based techniques and also neutron scattering facilities. These materials form the basis of a number of different collaborations that leverage the experimental strengths within QMI.

CURRENT PROJECTS
- Search for metallic quantum spin liquids
- Moment compensation in topological materials
- Dimensional crossover in 1D and 2D heavy fermions
- Strongly interacting surface states in topological insulators

CAREER HIGHLIGHTS
PhD University of Illinois 1982 – 1988
Postdoc. Fellow Los Alamos National Laboratory 1987 – 1989
Asst. Professor University of Michigan 1990 – 1996
Assoc. Professor University of Michigan 1996 – 2002
Professor University of Michigan 2002 – 2006
Professor Stony Brook University 2007 – 2015
Group Leader, Brookhaven National Laboratory 2007 – 2015
Professor and Dean, Texas A&M University 2015 – 2018
Professor and Dean, UBC 2018 – present

UNDERGRADUATE STUDENTS
Divya Chari, Satyam Priyadarshi

GRADUATE STUDENTS
Joern Bannies

POSTDOCTORAL FELLOWS
Xiyang Li, Jannis Maiwald, Dalmau Reig-i-Plessis

SELECTED PUBLICATIONS
W.J. Gannon, I.A. Zaliznyak, L.S. Wu, A.E. Feiguin, A.M. Tsvelik, F. Demmel, Y. Qiu, J.R.D. Copley, M.S. Kim, M.C. Aronson. *Spinon confinement and a sharp longitudinal mode in Yb2Pt2Pb in magnetic fields.* Nat. Commun. **10**, 1123 (2019).

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

L.S. Wu, W.J. Gannon, I.A. Zaliznyak, A.M. Tsvelik, M. Brockmann, J.-S. Caux, M.-S. Kim, Y. Qiu, J.R. Copley, G. Ehlers, A. Podlesnyak, M.C. Aronson. *Orbital-Exchange and fractional quantum number excitations in an f-electron metal, Yb2Pt2Pb.* Science **352**, 1206 (2016).

MONA BERCIU

RESEARCH FOCUS
My current interests focus on developing accurate variational approximations for answering key questions that arise in the study of strongly correlated systems: what are the characteristics of the quasiparticle (polaron) that forms when a charge carrier becomes “dressed” by a cloud of excitations such as phonons, magnons; what effective interactions arise between such quasiparticles through exchange of excitations between their clouds; and what is their combined influence on the properties of the host material. We use these methods to study effective models of materials, such as the high-temperature cuprates and iron pnictides, rare-earth nickelates, and bismuthates in a wide region of the parameter space. Our work thus far has been for systems with few-particles (the extremely underdoped limit of insulators) at zero temperature. Very recently, we have made progress on expanding our expertise to cover finite temperatures and finite particle densities.

CURRENT PROJECTS
- Developing a variational method to calculate one-particle propagators in metals with strong electron-phonon coupling, away from the Migdal limit
- New mechanism for high-temperature superconductivity in models with Peierls-type electron-phonon couplings
- Cuprate critical temperatures calculated microscopically with a strongly-correlated three-band model
- ARPES signatures in liquids of pre-formed pairs.
- Investigating the use of pump-probe experiments to reveal the origin of the superconducting ‘glue’ in pnictides

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

UNDERGRADUATE STUDENTS
XiaoXiao (Alice) Xiong

GRADUATE STUDENTS
Stepan Fomichev, Yau-Chuen (Oliver) Yam

POSTDOCTORAL FELLOWS
Leon Ruocco

SELECTED PUBLICATIONS
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)

M. Jiang, M. Berciu, G.A. Sawatzky. *Critical Nature of the Ni Spin State in Doped NdNiO2*. Phys. Rev. Lett. **124**, 207004 (2020).

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).

CURTIS BERLINGUETTE

RESEARCH FOCUS
The Berlinguette Group designs and builds advanced electrochemical reactors to power the planet.

CURRENT PROJECTS
- Reactive CO_2 capture
- Electrification of the chemicals industry
- Advanced nuclear fusion
- Flexible automation and self-driving labs
- Carbon-neutral building materials

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

UNDERGRADUATE STUDENTS
Mohamad Abbas, Donde Chaitanya, Alisa Da Silva, Elija De Hoog, Alvin Hendricks, Tor (Oliver) Horner, Aditya Menon, Lukas Nering, Colin Parkyn, Akshi Valji, Vrisha Vyas

GRADUATE STUDENTS
Jana Caine, Arthur Fink, Aoxue Huang, Andrew Jewlal, Tengxiao (Alec) Ji, Cameron Kellett, Eric Lees, Natalie LeSage, Benjamin MacLeod, Thomas Morrissey, Benjamin Mowbray, Fraser Parlane, Douglas Pimlott, Shaoxuan Ren, Alexandra Rousseau, Connor Rupnow, Joanna Simon, Jessica Sperryn, Mia Stankovic, Danika Wheeler, Aubry Williams

POSTDOCTORAL FELLOWS
Kuo-Yi (Glori) Chen, Roxanna Delima, Kevan Dettelbach, Camden Hunt, Gaopeng Jiang, Yong Wook Kim, Aiko Kurimoto, Xin Lu, Ben Luginbuhl, Siwei Ma, Jannis Maiwald, Madeline Peterson, Shaoxuan Ren, Abhishek Soni, Yunzhou Wen, Georgia Wood, Zishuai (Bill) Zhang

SCIENTIFIC STAFF
Nathan Chiu, Sergey Issinski, Daniel Lin, Mehrdad Mokhtari, Karry Ocean, Ryan Oldford, Mike Rooney, Chris Waizenegger

ADMINISTRATION TEAM
Amanda Brown, Amber Herbert, Emilija Ilic, Monika Stolar, Kate Vasilchenko

SELECTED PUBLICATIONS
C.P. Berlinguette, Y.-M. Chiang, J.N. Munday, T. Schenkel, D.K. Fork, R. Koningstein, M.D. Trevithick. *Revisiting the Cold Case of Cold Fusion.* Nature **570**, 45 (2019).

T. Li, E.W. Lees, M. Goldman, D.A. Salvatore, D.M. Weekes, C.P. Berlinguette. *Electrolytic Conversion of Bicarbonate into CO in a Flow Cell.* Joule **3**, 1487 (2019).

R.S. Sherbo, R.S. Delima, V.A. Chiykowski, B.P. MacLeod, C.P. Berlinguette. *Complete Electron Economy by Pairing Electrolysis with Hydrogenation.* Nat. Catal. **1**, 501 (2018).

DOUG BONN

RESEARCH FOCUS
We synthesize ultraclean samples of quantum materials, particularly superconductors and topological materials, 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 with atom-scale spatial resolution.

CURRENT PROJECTS
- Quasiparticle interference of unconventional superconducting state in Fe-based superconductors
- Microwave spectroscopy of long-lived quasiparticles in Fe-based superconductors
- Microwave electrodynamics due to ballistic and hydrodynamic flow in high mobility materials (PdCoO2 and ReO_3)
- Quasiparticle interference in high mobility materials
- Development of ultra-low temperature STM

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
Graham Baker, Jeff Bale, Tim Branch, Dong Chen, Aaron Kraft

POSTDOCTORAL FELLOWS
Seokhwan Choi, Giang Nguyen

SCIENTIFIC STAFF
James Day, Jisun Kim, Mohamed Oudah

SELECTED PUBLICATIONS
J. Chang, E. Blackburn, A.T. Holmes, N.B. Christensen, J. Larsen, J. Mesot, R. Liang, D.A. Bonn, W.N. Hardy, A. Watenphul, M.v. Zimmermann, E.M. Forgan, S.M. Hayden. *Direct observation of competition between superconductivity and charge density wave order in YBa2Cu3O6:67*. Nat. Phys. **8**, 871 (2012).

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).

W.N. Hardy, D.A. Bonn, D.C. Morgan, R. Liang, K. Zhang. *Precision Measurements of the Temperature Dependence of λ in YBa2Cu3O6.95: Strong Evidence for Nodes in the Gap Function*. Phys. Rev. Lett. **70**, 3999 (1993).

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, our group investigates materials for organic electronics and optoelectronics, 2-dimensional materials, and materials where a nanoscale view offers the potential for new understanding.

CURRENT PROJECTS

- Energetic landscapes of organic heterojunctions
- Light-matter interactions in organic semiconductors on a single molecule level using SPM
- Quasiparticle interference: understanding interactions with defects and mapping electronic properties of novel 2D materials and electronic states
- Dynamics of charge separation in organic solar cells using time- and angle-resolved photoemission spectroscopy
- Development of a 4-proble STM for Quantum Materials Characterization

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, Jörn Bannies, Rysa Greenwood, Vanessa King, Alexandra Tully, Ashley Warner, Jiabin Yu

POSTDOCTORAL FELLOWS

Markus Altthaler

SCIENTIFIC STAFF

James Day, Jisun Kim

SELECTED PUBLICATIONS

M. DeJong, A. J. A. Price, E. Mårsell, G. Tom, G. D. Nguyen, E. R. Johnson S. A. Burke. *Small molecule binding to surface-supported single-site transition-metal reaction centers.* Nature Commun. **13**, 7407(2022).

D.M. Mayder, C.M. Tonge, G.D. Nguyen, R. Hojo, N.R. Paisley, J. Yu, G. Tom, S.A. Burke, Z.M. Hudson. *Design of High-Performance Thermally Activated Delayed Fluorescence Emitters Containing s-Triazine and s-Heptazine with Molecular Orbital Visualization by STM.* Chem. Mater. **34**, 2624 (2022).

P. Nigge, A.C. Qu, É. Lantagne-Hurtubise, E. Mårsell, S. Link, C. Gutiérrez, G. Tom, M. Zonno, M. Michiardi, M. Schneider, S. Zhdanovich, G. Levy, U. Starke, D. Bonn, S.A. Burke, M. Franz, A. Damascelli. *Room temperature strain-induced Landau levels in graphene on a wafer-scale platform.* Sci. Adv. **5**, eaaw5593 (2019).

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
- SiEPICfab consortium on chip prototyping and integration

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

GRADUATE STUDENTS

Abdelraman Afifi, Mohammed Al-Qadasi, Ahmed Atef, Adan Azem, Sheri Jahan Chowdhury, Adam Darcie, Omid Esmaeeli, Joshua Fabian, Daniel Francis Julien-Neitzert, Philip Kirwin, Becky Lin, Jake Osborne, Sayantani Podder, Jingxiang Song, Iman Taghavi, Alexander Tofini, Kithmin Wickremasinghe, Donald Witt, Shangxuan Yu

POSTDOCTORAL FELLOWS

Samantha Grist, Ata Khorami, Zhongjin Lin, Matthew Mitchell, Andreas Pfenning, Reza Sanadgol Nezami

SCIENTIFIC STAFF

Kashif Awan, Jaspreet Jhoja

PROJECT MANAGERS

Steven Gou, Serge Khorev, Stephen Lin

SELECTED PUBLICATIONS

L. Chrostowski, H. Shoman, M. Hammood, H. Yun, J. Jhoja, E. Luan, S. Lin, A. Mistry, D. Witt, N.A.E. Jaeger, S. Shekhar, H. Jayatilleka, P. Jean, S.B. Villers, J. Cauchon, W. Shi, C. Horvath, J.N. Westwood-Bachman, K. Setzer, M. Aktary, N.S. Patrick, R.J. Bojko, A. Khavasi, X. Wang, T.F.d. Lima, A.N. Tait, P.R. Prucnal, D.E. Hagan, D. Stevanovic, A.P. Knights. *Silicon photonic circuit design using rapid prototyping foundry process design kits.* IEEE J. Sel. Top. Quantum Electron. **25**, 8201326 (2019).

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 Blusson QMI in the UBC-Moore Centre for Ultrafast Quantum Matter 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, Blusson QMI 2015 – present

GRADUATE STUDENTS

Sydney Dufresne, Peter Moen, MengXing Na (became a Postdoctoral Fellow in Damascelli group since August 2022), Brian Pang, Cissy Suen (Joint PhD), Ching Au Yeung

POSTDOCTORAL FELLOWS

Martin Bluschke, Igor Marković, MengXing Na, Steef Smit, Dan Sun, Marta Zonno

SCIENTIFIC STAFF

Ilya Elfimov, Giorgio Levy, Matteo Michiardi, Arthur Mills, Sergey Zhdanovich

SELECTED PUBLICATIONS

M. Michiardi, F. Boschini, H.-H. Kung, M. X. Na, S. K. Y. Dufresne, A. Currie, G. Levy, S. Zhdanovich, A. K. Mills, D. J. Jones, J. L. Mi, B. B. Iversen, Ph. Hofmann, A. Damascelli. *Optical manipulation of Rashba-split 2-dimensional electron gas.* Nat. Comm. **13**, 3096 (2022).

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.* Science **366**, 1231 (2019).

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).

STEVE DIERKER

RESEARCH FOCUS

Our new Quantum Materials Electron Microscopy Centre will have a state of the art electron microscope for atomic imaging and characterization of materials and for carrying out electron energy loss measurements as a function of momentum with ultra-high energy resolution. Research with this latter capability may include measurements of the momentum dependence of the dielectric function of quantum materials, studies of collective excitations in inhomogeneous strongly correlated matter, and studies of the spectrum of confined optical modes in polaritonic media. We are also developing a nanospectroscopy laboratory for conducting optical spectroscopy measurements. This will aid in discovery of new polaritonic materials based on 2D electrides and layered transition metal oxides, and developing means for controlling them by integrating them with quantum materials.

CURRENT PROJECTS

- Development of the Quantum Materials Electron Microscopy Centre
- Development of a Nanospectroscopy Laboratory for studying polaritonic quantum materials
- Raman scattering studies of topological materials
- 2D electride materials and layered transition metal oxides

CAREER HIGHLIGHTS

PhD University of Illinois 1977 – 1983
Member of Technical Staff, AT&T Bell Laboratories 1983 – 1990
Assoc. Professor University of Michigan 1990 – 1999
Professor University of Michigan 1999 – 2006
Director, National Synchrotron Light Source, BNL 2001 – 2006
Director, National Synchrotron Light Source II Project, BNL 2006 – 2015
Associate Laboratory Director for Photon Sciences, BNL 2003 – 2015
Professor Texas A&M University 2015 – 2018
Professor UBC 2018 – present

POSTDOCTORAL FELLOWS

Ali Abdullah Husain, Hsiang-His (Sean) Kung

SCIENTIFIC STAFF

Miles Brodie

SELECTED PUBLICATIONS

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

E.M. Dufresne, T. Nurushev, R. Clarke, S.B. Dierker. *Concentration Fluctuations in the Binary Mixture Hexane-Nitrobenzene with Static and Dynamic X-ray Scattering.* Physical Review E **65**, 061507 (2002).

S.B. Dierker. *X-ray Photon Correlation Spectroscopy, in Light Scattering and Photon Correlation Spectroscopy*. Proc. NATO Adv. Res. Workshop (1997).

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.

CURRENT PROJECTS

- van der Waals 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
Professor UBC 2021 – present

UNDERGRADUATE STUDENTS

Anton Cecic, Nick Phillips, Diana Ryoo, Ray Su, Oliver Tong

GRADUATE STUDENTS

Tim Child, Johann Drayne, Zhenxiang Gao

POSTDOCTORAL FELLOWS

Christopher Coleman

SCIENTIFIC STAFF

Silvia Lüscher

SELECTED PUBLICATIONS

M. Kuiri, C. Coleman, Z. Gao, A. Vishnuradhan, K. Watanabe, T. Taniguchi, J. Zhu, A. H. MacDonald, J. Folk. *Spontaneous time-reversal symmetry breaking in twisted double bilayer graphene.* Nat. Comm. **13**, 6468 (2022)

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).

E. Sajadi, T. Palomaki, Z. Fei, W. Zhao, P. Bement, C. Olsen, S. Lüscher, 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 states of quantum matter, including topological insulators, superconductors and semimetals as well as models of strongly interacting many-body systems. The key criteria driving our research are: (i) cutting edge theoretical developments and (ii) relevance to real physical systems as studied by our experimental colleagues.

CURRENT PROJECTS

- Topological superconductivity in twisted double layer cuprates
- Quantum models of traversable wormholes
- Magic angle physics in dichalcogenides and nodal superconductors
- Majorana fermions for topological quantum computation

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, Shannon Egan, Rafael Haenel, Niclas Heinsdorf, Vedangi Pathak, Tarun Tummuru

POSTDOCTORAL FELLOWS

Tong Zhou

SCIENTIFIC STAFF

Alberto Nocera

SELECTED PUBLICATIONS

D. Yang, J. Wu, B.T. Zhou, J. Liang, T. Ideue, T. Siu, K. Awan, K. Watanabe, T. Taniguchi, Y. Iwasa, M. Franz, Z. Ye. *Spontaneous-polarization-induced photovoltaic effect in rhombohedrally stacked MoS_2.* Nat. Photon. **16**, 469 (2022).

T. Tummuru, S. Plugge, M. Franz. *Josephson effects in twisted cuprate bilayers.* Phys. Rev. B **105**, 064501 (2022).

A. Mercado, S. Sahoo, M. Franz. *High-Temperature Majorana Zero Modes.* Phys Rev Lett **128**, 137002 (2022).

ALANNAH HALLAS

RESEARCH FOCUS

Our group is focused on the design and discovery of new quantum materials using a broad range of crystal growth techniques, including metallic flux, vapour transport, high-pressure synthesis, and floating zone growth. We are particularly interested in establishing structure-function relationships in quantum materials via characterization of their structural, magnetic, and electronic behaviors in order to facilitate the targeted design of materials with novel or useful properties. This research is performed in our state-of-the-art crystal growth laboratories at Blusson QMI, as well as international neutron scattering, x-ray synchrotron, and muon spin relaxation user facilities.

CURRENT PROJECTS

- Design and crystal growth of new quantum materials
- Structural and magnetic properties of high entropy oxides
- Magnetic frustration in the local to itinerant crossover
- Multipolar interactions in rare earth magnets
- Hydrodynamic electron flow in high mobility metals

CAREER HIGHLIGHTS

PhD (Vanier Scholar) McMaster University 2013 – 2017
Smalley-Curl Postdoc. Fellow, Rice University 2017 – 2019
Asst. Professor UBC 2019 – present
CIFAR Azrieli Global Scholar 2020 – 2022

UNDERGRADUATE STUDENTS

Jocelyn Baker, Isaac Hoffman, Sam Mugiraneza, Gurleen Sandhu

GRADUATE STUDENTS

Mario Gonzalez-Rivas, Gargi Kodgirwar, Dhruv Kush, Megan Rutherford, Samikshya Sahu

POSTDOCTORAL FELLOWS

Solveig Stubmo Aamlid, Dalmau Reig-i-Plessis

SCIENTIFIC STAFF

Mohamed Oudah, Dongjoon Song

SELECTED PUBLICATIONS

G.H.J. Johnstone, M.U. Gonź alez-Rivas, K.M. Taddei, R. Sutarto, G.A. Sawatzky, R.J. Green, M. Oudah, A.M. Hallas. *Entropy engineering and tunable magnetic order in the spinel high-entropy oxide.* J. Am. Chem. Soc. **144**, 45, 20590-20600 (2022)

S. Mugiraneza, A.M. Hallas. *Tutorial: a beginner's guide to interpreting magnetic susceptibility data with the Curie-Weiss law.* Commun Phys **5**, 95 (2022).

A.M. Hallas, J. Gaudet, B.D. Gaulin. *Experimental insights into ground-state selection of quantum XY pyrochlores.* Annu. Rev. Condens. Matter Phys. **9**, 105 (2018).

DAVID JONES

RESEARCH FOCUS

Our research lies at the convergence of condensed matter physics, 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 and when they are in excited states. In a long-term scientific goal, we seek to implement photonic manipulation and control of quantum states/phases within solids.

CURRENT PROJECTS

- Next Generation Femtosecond XUV sources for TR-ARPES
- Flexible VUV femtosecond lasers sources for time-resolved photoemission
- Spatio-temporal characterization of interfacial charge separation in organic photovoltaics
- Multi-dimensional spectroscopy for studying coherence in solids
- Exciton dynamics in 2-D materials
- Frequency combs for mine sensing

CAREER HIGHLIGHTS

PhD MIT 1994 – 1999
NRC Research Assoc. NIST Boulder Labs 1998 – 2000
Senior Optical Engineer Photonex Corp. 2000 – 2001
Senior Research Assoc. CU Boulder 2001 – 2003
Asst. Professor UBC 2004 – 2010
Assoc. Professor UBC 2010 – 2020
Professor UBC 2020 – present

UNDERGRADUATE STUDENTS

Aileen Zhang

GRADUATE STUDENTS

Rysa Greenwood, Bradley Guislain, Mike Hemsworth, Alexandra Tully, Max Werner

POSTDOCTORAL FELLOWS

Christina Hofer, Philipp Sulzer

SCIENTIFIC STAFF

Arthur Mills, Evgeny Ostroumov, Sergey Zhdanovich

SELECTED PUBLICATIONS

A.K. Mills, S. Zhdanovich, M.X. Na, F. Boschini, E. Razzoli, M. Michiardi, A. Sheyerman, M. Schneider, T.J. Hammond, V. Suess, C. Felser, A. Damascelli, D. J. Jones. *Cavity-enhanced high harmonic generation for XUV time- and angle-resolved photoemission spectroscopy.* Rev. Sci. Instrum. **90**, 083001 (2019).

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.* Science **366**, 1231 (2019).

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).

ROMAN KREMS

RESEARCH FOCUS

Our work is at the intersection of quantum physics, machine learning and chemistry on problems of relevance to quantum materials and quantum technologies, including quantum computing, quantum sensing and quantum algorithms. We are particularly excited about applications of machine learning for solving complex quantum problems and applications of quantum hardware for machine learning.

CURRENT PROJECTS

- Exploring ways to accelerate quantum dynamics calculations with machine learning and combine quantum computing with machine learning for interesting applications

CAREER HIGHLIGHTS

PhD Goteborg University 1999 – 2002
SAO Predoc. Fellow Harvard-Smithsonian Centre for Astrophysics 2001 – 2002
Postdoc. Fellow Harvard University 2003 – 2005
Asst. Professor UBC 2005 – 2009
Assoc. Professor UBC 2009 – 2013
Professor UBC 2013 – Present

UNDERGRADUATE STUDENTS

Divya Chari, Ethan Rajkumar, Wucheng Zhang

GRADUATE STUDENTS

Kasra Asnaashari, Jun Dai, Philipp Elsaesser, Xuyang Guo, Katherine Herperger, Jonas Jager, Pranav Kairon, Dawn Mao, Elham Torabian

POSTDOCTORAL FELLOWS

Ludmila Szulakowska

SELECTED PUBLICATIONS

F. Suzuki, M. Lemeshko, W. H. Zurek, R. V. Krems. *Anderson localization of composite particles.* Phys. Rev. Lett. **127**, 160602 (2021).

R. V. Krems. *Bayesian Machine Learning for Quantum Molecular Dynamics.* Phys. Chem. Chem. Phys. **21**, 13392 (2019).

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

W. ANDREW MACFARLANE

RESEARCH FOCUS

Using radioactive beta-detected NMR, we study the electromagnetic properties of single crystals, thin films, and multilayers. Our main probe is the short-lived isotope ^{8}Li. 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 $LaNiO_3$ 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
- ^{31}Mg, a new beta NMR probe

CAREER HIGHLIGHTS

PhD UBC 1992 – 1997
NSERC 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
Professor (Chemistry) 2021 – present

UNDERGRADUATE STUDENTS

Areesha Rizwan

GRADUATE STUDENTS

Edward Thoeng, John Ticknor

SELECTED PUBLICATIONS

J. R. Adelman, D. Fujimoto, M. H. Dehn, S. R. Dunsiger, V. L. Karner, C. D. P. Levy, R. Li, I. McKenzie, R. M. L. McFadden, G. D. Morris, M. R. Pearson, M. Stachura, E. Thoeng, J. O. Ticknor, N. Ohashi, K. M. Kojima, and W. A. MacFarlane. *Nuclear magnetic resonance of ^{8}Li ions implanted in ZnO.* Phys. Rev. B **106**, 035205 (2022).

R.M.L. McFadden, A. Chatzichristos, K.H. Chow, D.L. Cortie, M.H. Dehn, D. Fujimoto, M.D. Hossain, H. Ji, V.L. Karner, R.F. Kiefl, C.D.P. Levy, R. Li, I. McKenzie, G.D. Morris, O. Ofer, M.R. Pearson, M. Stachura, R.J. Cava, W.A. MacFarlane. *Ionic and electronic properties of the topological insulator Bi2Te2Se investigated via β-detected nuclear magnetic relaxation and resonance of ^{8}Li.* Phys. Rev. B **99**, 125201 (2019).

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 ^{8}Li β-Detected Nuclear Magnetic Resonance.* Chem. Mater. **29**, 10187 (2017).

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
- Photonic liquids based on graphene oxide
- Supramolecular compounds for stimuli-driven molecular delivery
- Self-assembly of cellulose nanocrystals in confined spaces

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

UNDERGRADUATE STUDENTS

Tenniel Cowen, Emma Gillman, Betty Huang, Shine Huang, Jared Lim, Dorien Peng, Robert Plavan

GRADUATE STUDENTS

Amanda Ackroyd, Lucas Andrew, Mohammad Chaudhry, Madhureeta Das Gupta, Raksha Kandel, Zongzhe Li, Jeanette Loos, Gunwant Matharu, Andrea Ortiz Medrano, Seiya Ota, Yihan Shi

POSTDOCTORAL FELLOWS

Kyoungil Cho, Miguel Angel Soto Munoz, Soledad Roig, Joanna Szymkowiak, Allen (Zhen) Xu, Yitao Xu

SELECTED PUBLICATIONS

Y. Cao, P.-X. Wang, F. D'Acierno, W.Y. Hamad, C.A. Michal, M.J. MacLachlan. *Tunable Diffraction Gratings from Biosourced Lyotropic Liquid Crystals*. Adv. Mater. **32**, 1907376 (2020).

C.E. Boott, A. Tran, W.Y. Hamad, M.J. MacLachlan. *Cellulose Nanocrystal Elastomers with Reversible Visible Color.* Angew. Chem. Int. Ed. **59**, 226 (2020).

M.A. Soto, V. Carta, R.J. Andrews, M.T. Chaudhry, M.J. MacLachlan. *Structural Elucidation of Selective Solvatochromism in a Responsive-at-metal Cyclometalated Platinum(II) Complex.* Angew. Chem. Int. Ed. **59**, 10348 (2020).

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 and photon emission. Our work involves device design, micro/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 theory and simulation using methods ranging from continuum modelling 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 electron beam devices

CAREER HIGHLIGHTS

PhD Stanford University 2000 – 2006
Asst. Professor UBC 2006 – 2011
Assoc. Professor UBC 2011 – 2016
Professor UBC 2016 – present

UNDERGRADUATE STUDENTS

Alexander Dimitrakopoulos

GRADUATE STUDENTS

Daniel Bruns, Mike Chang, Mokter Mahmud Chowdhury, Mohab Hassan, Ehsanur Rahman

POSTDOCTORAL FELLOWS

Céline Ruscher

SCIENTIFIC STAFF

Casimir Kuzyk

SELECTED PUBLICATIONS

E. Rahman, A. Nojeh. *Semiconductor thermionics for next generation solar cells: photon enhanced or pure thermionic?.* Nat. Commun. **12**, 4622 (2021).

M.V. Moghaddam, P. Yaghoobi, G.A. Sawatzky, A. Nojeh. *Photon-impenetrable, electron-permeable: the carbon nanotube forest as a medium for multi-photon thermal-photoemission.* ACS Nano **9**, 4064 (2015).

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).

ANDREW POTTER

RESEARCH FOCUS
Our group combines techniques from quantum field-theory, quantum information theory, condensed matter and atomic physics to study novel phenomena emerging from the collective dynamics of quantum many-particle systems. Our focus is on understanding the fundamental rules governing quantum phases of matter, dynamics, and critical phenomena both in- and far-from- thermal equilibrium. We apply this understanding to design materials, devices, and algorithms for quantum computing applications to materials science and chemistry, and to predict experimentally testable signatures of new quantum coherent phenomena.

CURRENT PROJECTS
- Qubit-efficient quantum algorithms for materials modeling using quantum tensor networks
- Engineering tunable testbeds for correlated electron physics in 2d moire materials
- Statistical mechanics of quantum circuits
- Gapless topological phases of matter
- Floquet quantum error correction codes

CAREER HIGHLIGHTS
PhD Massachusetts Institute of Technology 2008 – 2013
Postdoc. Fellow Gordon and Betty Moore Foundation 2013 – 2016
Asst. Professor University of Texas at Austin 2016 – 2021
Principal Theoretical Physicist Honeywell Quantum Solutions, Broomfield, CO 2018 – 2019
Asst. Professor UBC 2021 – present

UNDERGRADUATE STUDENTS
Travis Hosack, Shahin Jahabani (UT Austin), Alice Xiong

GRADUATE STUDENTS
UBC: Guarav Tenkila, Rui Wen
UT Austin: Zihan Cheng, Ajesh Kumar, Daoheng Niu, Yuxuan Zhang

POSTDOCTORAL FELLOWS
Joseph Sullivan

SELECTED PUBLICATIONS
P.T. Dumitrescu, J. Bohnet, J. Gaebler, A. Hankin, D. Hayes, A. Kumar, B. Neyenhuis, R. Vasseur, A.C. Potter. *Dynamical topological phase realized in a trapped-ion quantum simulator.* Nature 607, **463** (2022).

F. Barratt, U Agrawal, AC Potter, S Gopalakrishnan, R Vasseur. *Transitions in the learnability of global charges from local measurements.* Phys. Rev. Lett. **129** (20), 200602 (2022).

J. Zhang, P. Hess, A. Kyprianidis et al. *Observation of a discrete time crystal.* Nature **543**, 217 (2017).

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 SPT ordered 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 – 2021
Professor UBC 2021 – present

GRADUATE STUDENTS
Arnab Adhikary, Luis Mantilla Calderon, Paul Herringer, Gabrielle Tournaire, Rio Weil, Michael Zurel

POSTDOCTORAL FELLOWS
Dmytro Bondarenko, Polina Feldmann, Wang Yang

SCIENTIFIC STAFF
Daniel Huerga

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 (2019).

X.-C. Yao, T.-X. Wang, H.-Z. Chen, W.-B. Gao, A.G. Fowler, R. Raussendorf, Z.-B. Chen, N.-L. Liu, C.-Y. Lu, Y.-J. Deng, Y.-A. Chen, J.-W. Pan. *Experimental demonstration of topological error correction*. Nature **482**, 489 (2012).

T.-C. Wei, I. Affleck, R. Raussendorf. *The 2D AKLT state is a universal quantum computational resource.* Phys. Rev. Lett. **106**, 070501 (2011).

JOERG ROTTLER

RESEARCH FOCUS
With computational techniques ranging from density functional theory (DFT), molecular dynamics and Monte Carlo simulations on the atomic scale, to field theoretic (phase field) methods on the mesoscale, the group studies a diverse range of materials that include amorphous solids, polymers, and nanomaterials. Computer simulations facilitate the discovery of emergent phenomena, test theories and generic trends, reveal quantities that are difficult or impossible to obtain in experiments, and thus provide essential input into the design of new functional materials. The group maintains close collaborations with several experimental groups at SBQMI.

CURRENT PROJECTS
- Statistical physics of driven amorphous materials
- Thermodynamics, morphology, mechanics and thermal transport in entropy stabilized polymer blends
- Nanoscale phononics and thermal transport in carbon nanotubes (collaboration with Nojeh group)
- Computational exploration of multiple principal component oxides (GC project, collaboration with Hallas group)
- Amorphous metal oxide coatings with low mechanical loss (GC project, collaboration with Young/Zou groups)

CAREER HIGHLIGHTS
PhD Johns Hopkins University 1999 – 2003
Chercheur Associé E.S.P.C.I. (Paris) 2003
Postdoc. Fellow Princeton University 2003 – 2005
Asst. Professor UBC 2005 – 2010
Assoc. Professor UBC 2010 – 2016
Professor UBC 2016 – present

UNDERGRADUATE STUDENTS
Genevieve Ke, Luna Liu, James We (supervised by Debasish Mukherji)

GRADUATE STUDENTS
Daniel Korchinski, Jared Popowski, Daniel Wong

POSTDOCTORAL FELLOWS
Solveig Aamlid, Daniel Bruns

SCIENTIFIC STAFF
Debashish Mukherji

SELECTED PUBLICATIONS
D. Bruns, A. Nojeh, A.S. Phani, J. Rottler. *Nanotube heat conductors under tensile strain: Reducing the three-phonon scattering strength of acoustic phonons.* Phys. Rev. B **104**, 075440 (2021).

J. Rottler, M. Müller. *Kinetic Pathways of Block Copolymer Directed 2 Self-Assembly: Insights from Efficient Continuum Modeling.* ACS Nano **14**, 13986 (2020).

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).

JOESEPH SALFI

RESEARCH FOCUS
My group's main research interest is the physical implementation of quantum information technologies. Our research expertise is in spin physics and quantum devices, with a growing interest in superconducting devices. We experimentally investigate prototypes of future large-scale quantum computers involving silicon materials of industrial relevance, and quantum simulators, which are anticipated to be one of the first technological applications of quantum information. Quantum simulators are also anticipated to enable laboratory tests of exotic aspects of many-body quantum theory, beyond that which can be tested by traditional experiments.

CURRENT PROJECTS
- Quantum computation
- Quantum simulation

CAREER HIGHLIGHTS
PhD University of Toronto 2005 – 2011
Postdoc. Fellow CQC2T University of New South Wales 2011 – 2015
ARC DECRA Fellow and Lecturer CQC2T University of New South Wales 2016 – 2018
Asst. Professor UBC 2019 – present

UNDERGRADUATE STUDENTS
Ashutosh Bhudia, Nabiha Khan

GRADUATE STUDENTS
Hanieh Aghaee, Ana Ciocoiu, Karim Elkholy, Daniel Francis Julien-Neitzert (co-supervised), Mohammad Khalifa, Phil Kirwin (co-supervised), Edward Leung (co-supervised), Mukhlasur Rahman Tanvir

POSTDOCTORAL FELLOWS
Ebrahim Sajadi

SELECTED PUBLICATIONS
T. Kobayashi, J. Salfi, J. van der Heijden, C. Chua, M.G. House, D. Culcer, W.D. Hutchison, B.C. Johnson, J.C. McCallum, H. Riemann, N.V. Abrosimov, P. Becker, H.-J. Pohl, M.Y. Simmons, S. Rogge. *Engineering long spin coherence times of spin-orbit qubits in silicon.* Nat. Mater. **20**, 38 (2021).

J. Salfi, J.A. Mol, D. Culcer, S. Rogge. *Charge-insensitive single-atom spin-orbit qubit in silicon.* Phys. Rev. Lett. **116**, 246801 (2016).

J. Salfi, J.A. Mol, R. Rahman, G. Klimeck, M.Y. Simmons, L.C.L. Hollenberg, S. Rogge. *Quantum simulation of the Hubbard model with dopant atoms in silicon.* Nat. Commun. **7**, 11342 (2016).

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 are particularly interested in using inelastic electron scattering, also known as electron energy-loss spectroscopy, to probe the static and dynamic interactions between charge degrees of freedom in solids, especially at short wavelengths. 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

- Q-resolved electron energy-loss spectroscopy of charge excitations in strongly-correlated systems
- Screening of short-range Coulomb interactions in materials with strongly non-uniform polarizability
- Dynamical charge fluctuations, bond disproportionation, and negative charge transfer gap in systems such as BaBiO3 and the perovskite rare-earth nickelates
- Electron-magnon-phonon coupling and their role in high Tc superconductors and topology
- Resonant soft x-ray reflectometry and the study of buried interfaces in heterostructures

CAREER HIGHLIGHTS

PhD University of Manitoba 1965 – 1969
Postdoc. Fellow Groningen University 1969 – 1971
Assoc. Professor Groningen University 1971 – 1979
Professor Groningen University 1979 – 2001
Professor UBC 2002 – present

GRADUATE STUDENTS

Nassim Derriche, Yau Chuen (Oliver) Yam

POSTDOCTORAL FELLOWS

Oliver Dicks, Ali A. Husain, Dan Sun, Srinivas Vanka

SCIENTIFIC STAFF

Fengmiao Li, Debashish Mukherji

SELECTED PUBLICATIONS

S. Johnston, A. Mukherjee, I. Elfimov, M. Berciu, G.A. Sawatzky. *Charge Disproportionation without Charge Transfer in the Rare-Earth-Element Nickelates as a Possible Mechanism for the Metal-Insulator Transition.* Phys. Rev. Lett. **112**, 106404 (2014).

M.T. Czyżyk, G.A. Sawatzky. *Local-density functional and on-site correlations: The electronic structure of* La_2CuO_4 *and* $LaCuO_3$. Phys. Rev. B **49**, 14211 (1994).

J. Zaanen, G.A. Sawatzky, J.W. Allen. *Band gaps and electronic structure of transition-metal compounds*. Phys. Rev. Lett. **55**, 418 (1985).

ZILIANG YE

RESEARCH FOCUS

We are an optical spectroscopy group studying light matter interaction in low-dimensional materials. We are currently focused on exploring how topology, correlation effects, and other emergent degrees of freedom interact with each other in two-dimensional van der Waals materials such as graphene, phosphorene, transition metal dichalcogenide, hexagonal boron nitride, high-Tc cuprates and their heterostructures. Our expertise includes ultrafast optical spectroscopy with diffraction-limited resolution at low temperatures and strong magnetic fields as well as nearfield optical microscopy. In the past, we have utilized ultrafast nonlinear optical spectroscopies to reveal the crystal and electronic structure of TMDCs. We are currently interested in developing novel optical microscopy techniques to interrogate the 2D material's intrinsic response and to control them with the strong optical field provided by coherent laser light. In the meantime, novel devices based on bulk photovoltaic effect and topological superconductivity are being actively explored in the group for classical and quantum applications.

CURRENT PROJECTS

- Shift current and bulk photovoltaic effect at low-symmetry interfaces
- Topological superconductivity in van der Waals heterostructures
- Bose-Einstein condensate of interlayer excitons
- Sliding ferroelectricty in twisted 2D semiconductors
- Multidimensional coherent spectroscopy of correlated materials

CAREER HIGHLIGHTS

PhD University of California, Berkeley 2008 – 2013
Postdoc. Fellow University of California, Berkeley 2014
Postdoc. Fellow Columbia and Stanford University 2014 – 2017
Asst. Professor UBC 2017 – present

UNDERGRADUATE STUDENTS

Sean Chen, Vinit Doke, Edmond Ng, Vedanshi Vala, Hawk Zhang

GRADUATE STUDENTS

Yunhuan Xiao, Yuan Xie, Dongyang Yang

POSTDOCTORAL FELLOWS

Christina Hofer, Jing Liang, Jingda Wu

SCIENTIFIC STAFF

Jerry Dadap

SELECTED PUBLICATIONS

D. Yang, J. Wu, B. T. Zhou, J. Liang, T. Ideue, T. Siu, K.M. Awan, K. Watanabe, T. Taniguchi, Y. Iwasa, M. Franz, Z. Ye. *Spontaneous polarization induced photovoltaic effect in rhombohedrally stacked MoS2.* Nat. Photon. **16**, 469 (2022).

J. Liang, D. Yang, J. Wu, J.I. Dadap, K. Watanabe, T. Taniguchi, Z. Ye. *Optically probing the asymmetric interlayer coupling in rhombohedral-stacked MoS2 bilayer.* Phys. Rev. X **12**, 041005 (2022).

J. Wu, D. Yang, J. Liang, M. Werner, E. Ostroumov, Y. Xiao, K. Watanabe, T. Taniguchi, J.I. Dadap, D.J. Jones, Z. Ye. *Ultrafast response of spontaneous photovoltaic effect in 3R-MoS2-based heterostructures.* Sci. Adv. **8**, eade375 (2022).

JEFF YOUNG

RESEARCH FOCUS

Our group develops new optical materials and devices by controlling composition on lengthscales from 5 nm -500 nm. Electron-beam, atomic-force-microscopy (AFM), and optical lithographies are used in conjunction with a variety of etching and deposition technologies to produce 3D-textured structures in which the electronic and photonic eigen states can be “designed” by judicious choice of patterns, lengthscales, and material combinations. The motivation is to offer optical device engineers a more diverse range of material options when developing next and next-next generation technologies.

CURRENT PROJECTS

- Nonlinear properties of high-Q SOI-based photonic microcavities
- Integrated non-classical light sources in SOI based on parametric down conversion
- Integrated superconducting single photon detectors on silicon waveguides in SOI
- Scalable architectures for fault-tolerant photon-spin enabled quantum computing

CAREER HIGHLIGHTS

PhD University of Toronto 1979 – 1983
Research Assoc., Asst., Assoc. Research Officer, NRC 1983 – 1988
Section Head, NRC 1988 – 1990
Senior Research Officer and Group Leader, NRC 1990 – 1992
Assoc. Professor UBC 1992 – 1996
Professor UBC 1996 – present
Professor Emeritus UBC 2022 – present

UNDERGRADUATE STUDENTS

Julie Belleville, Stephen Cashen, Alexi Garbuz, Sarvin Gill, Felix Klose, Bridget Meyboom, Ruixin Qiu, Ray Su, James Wu, Dora Yang

GRADUATE STUDENTS

Abdelrahman E. Afifi, Adan Azem, Adam Darcie, Joshua Fabian, Sebastian Gitt, Phillip Kirwin, Becky Lin, Donald Witt, Xiruo Yan

POSTDOCTORAL FELLOWS

Kirsty Gardner, Matthew Mitchell, Andreas Pfenning

SCIENTIFIC STAFF

Kashif Awan

SELECTED PUBLICATIONS

X. Yan, W. Asavanant, H. Kamakari, J. Wu, J.F. Young, R. Raussendorf. *A quantum computer architecture based on silicon donor qubits coupled by photons.* Adv. Quantum Technol. **3**, 2000011 (2020).

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

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).

KE ZOU

RESEARCH FOCUS

Our research interests are in the growth of complex oxide and chalcogenide films by molecular beam epitaxy and the studies of their properties and functions. We aim to achieve scientific and technological breakthroughs in new materials and new functional devices. We 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

- Superconducting oxide thin films and heterostructures
- Emergent magnetism in oxide thin films and heterostructures
- 2D monolayer and multilayer ferromagnetic chalcogenide films
- Fe-based high temperature superconductors

CAREER HIGHLIGHTS

PhD Pennsylvania State University 2006 – 2012
Postdoc. Fellow Yale University 2012 – 2018
Asst. Professor UBC 2018 – present

UNDERGRADUATE STUDENTS

Valeed Hamza, Gor Nahapetyan

GRADUATE STUDENTS

Simon Godin, Gargi Kodgirwar, Rebecca Pons, Ryan Roemer, Hyungki Shin

POSTDOCTORAL FELLOWS

Yaping Qi, Srinivas Vanka

SCIENTIFIC STAFF

Bruce A. Davidson, Fengmiao Li

SELECTED PUBLICATIONS

Y. Zou, H. Shin, H. Wei, Y. Fan, B.A. Davidson, E.J. Guo, Q. Chen, K. Zou, Z.G. Cheng. *Transport behaviors of topological band conduction in KTaO3’s two-dimensional electron gases.* npj Quantum Mater. **7**, 122 (2022).

C. Liu, R.P. Day, F. Li, R.L. Roemer, S. Zhdanovich, S. Gorovikov, T.M. Pedersen, J. Jiang, S. Lee, M. Schneider, D. Wong, P. Dosanjh, F.J. Walker, C.H. Ahn, G. Levy, A. Damascelli, G.A. Sawatzky, K. Zou. *High-order replica bands in monolayer FeSe/SrTiO3 revealed by polarization-dependent photoemission spectroscopy.* Nat. Commun. **12**, 4573 (2021).

C. Liu, H. Shin, A. Doll, H.H. Kung, R.P. Day, B.A. Davidson, J. Dreser, G. Levy, A. Damascelli, C. Piamonteze, K. Zou. *High-temperature superconductivity and robustness against magnetic polarization in monolayer FeSe on EuTiO3.* npj Quantum Materials **6**, 85 (2021).

FABIO BOSCHINI

RESEARCH FOCUS
Our research goals encompass the use of intense long-wavelength light excitations to selectively explore and drive the emergence of novel quantum phases of matter with no equilibrium counterpart. This research will be accomplished by tracking light-induced changes in the electronic properties of complex systems via state-of-the-art time-and angle-resolved photoemission spectroscopy (TR-ARPES) at the Advanced Laser Light Source (ALLS) facility, INRS-EMT, and Blusson QMI-UBC, as well as large-scale international user facilities, such as synchrotrons and free-electron lasers.

CURRENT PROJECTS
- Exploration of the dynamical nature of the charge order in high-temperature superconductors via equilibrium and out-of-equilibrium x-ray scattering
- Track light-induced Floquet physics in Dirac-like systems via time-resolved photoemission spectroscopy
- Mapping resonant phonon pumping effects in complex materials via TR-ARPES imaging

CAREER HIGHLIGHTS
PhD Politecnico di Milano 2012 – 2014
Postdoc. Fellow 2015 – 2020
Asst. Professor INRS-EMT 2020 – present
Affiliate Asst. Professor Blusson QMI 2021 – present

UNDERGRADUATE STUDENTS
Leon Roob at INRS

GRADUATE STUDENTS
Sydney Dufresne at UBC (co-supervised with A. Damascelli at UBC)
Benson Kwaku Frimpong (INRS)
Jean-Michel Parent at INRS (co-supervised with F. Légaré at INRS)

POSTDOCTORAL FELLOWS
Gaetan Jargot at INRS (co-supervised with F. Légaré at INRS)

SELECTED PUBLICATIONS
S. Wandel, F. Boschini, E. H. da Silva Neto, L. Shen, M.X. Na, S. Zohar, Y. Wang, G. B. Welch, M. H. Seaberg, J. D. Koralek, G. L. Dakovski, W. Hettel, M-F. Lin, S.P. Moeller, W.F. Schlotter, A. H. Reid, M. P. Minniti, T. Boyle, F. He, R. Sutarto, R. Liang, D. Bonn, W. Hardy, R. A. Kaindl, D. G. Hawthorn, J.-S. Lee, A.F. Kemper, A. Damascelli, C. Giannetti, J. J. Turner, and G. Coslovich. *Enhanced charge density wave coherence in a light-quenched high-temperature superconductor.* Science **376**, 860 (2022).

F. Boschini, M. Minola, R. Suarto, E. Schierle, M. Bluschke, S. Das, Y. Yang, M. Michiardi, Y.C. Shao, X. Feng, S. Ono, R.D. Zhong, J.A. Schneeloch, G.D. Gu, E. Weschke, F. He, Y.D. Chuang, B. Keimer, A. Damascelli, A. Frano, E.H. Da Silva Neto. *Dynamic electron correlations with charge order wavelength along all directions in the copper oxide plane.* Nat. Comm. **12**, 597 (2021).

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).

ROBERT GREEN

RESEARCH FOCUS
Our group studies quantum materials using a combination of synchrotron x-ray spectroscopy and quantum many-body theory. We focus strongly on correlated oxide thin films and heterostructures, aiming to understand and develop control over their functionalities. In alignment with the goals of Blusson QMI, we strive to pave the way for upcoming generations of electronic and magnetic devices based on the quantum materials we study.

CURRENT PROJECTS
- Orbital and electronic reconstruction at correlated oxide interfaces studied with resonant x-ray reflectometry
- Multi-q, non-collinear magnetic order in $SrFeO_3$ heterostructures
- The impact of atomic physics on fluctuations in heavy fermion systems and correlated oxides
- Orbital imaging in multipolar-ordered compounds
- Resistive memories in correlated oxides

CAREER HIGHLIGHTS
PhD University of Saskatchewan 2009 – 2013
Postdoc. Fellow UBC 2013 – 2017
Research Assoc. UBC 2017
Affiliate Asst. Professor Blusson QMI 2017 – present
Asst. Professor University of Saskatchewan 2017 – 2022
Assoc. Professor University of Saskatchewan 2022 – present

UNDERGRADUATE STUDENTS
Sarah Khalid

GRADUATE STUDENTS
Patrick Braun, Jessie Freese, Grant Harris, Niyusha Hosseini, Lucas Korol, Skylar Koroluk

SELECTED PUBLICATIONS
R.J. Green, V. Zabolotnyy, M. Zwiebler, Z. Liao, S. Macke, R. Sutarto, F. He, M. Huijben, G. Rijnders, G. Koster, J. Geck, V. Hinkov, G.A. Sawatzky. *Intrinsic versus extrinsic orbital and electronic reconstructions at complex oxide interfaces.* Phys. Rev. Mater. **5**, 065004 (2021).

J. Li, R.J. Green, Z. Zhang, R. Sutarto, J.T. Sadowski, Z. Zhu, G. Zhang, D. Zhou, F. He, S. Ramanathan, R. Comin. *Sudden collapse of magnetic order in oxygen-deficient nickelate films.* Phys. Rev. Lett. **126**, 187602 (2021).

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).

KENJI KOJIMA

RESEARCH FOCUS

Our group utilizes and develops muon spin rotation/relaxation/resonance (μSR) and beta-decay detected nuclear magnetic resonance (β-NMR) at the TRIUMF laboratory on UBC campus, to understand the roles of spin and charge degrees of freedom in various kinds of quantum matter. They are sensitive magnetic probes; we utilize μSR and Li-NMR to probe and characterize magnetism and superconductivity. Muon is also a light isotope of hydrogen, having the ability to investigate its role in quantum materials.

CURRENT PROJECTS

- Frustrated quantum magnets and their ground states
- Unconventional superconductivity with spin-orbit couplings and strong correlations
- Hydrogen roles in wide gap semiconductors
- Characterization of carrier motion and density via the Li β-NMR in semiconductors.

CAREER HIGHLIGHTS

PhD University of Tokyo 1991 – 1996
Postdoc. Fellow Columbia University 1996 – 1998
Research Assoc. University of Tokyo 1998 – 2009
Assoc. Professor High Energy Accelerator Research Organization 2009 – 2018
Research Scientist TRIUMF 2018 – present
Affiliate Assoc. Professor Blusson QMI 2018 – present

GRADUATE STUDENTS

Dhruv Kush, Janna Machts (Edinburgh), Takato Sugisaki (Osaka), Marta-Villa de Toro Sanchez (Edinburgh)

POSTDOCTORAL FELLOWS

Yipeng Cai

SELECTED PUBLICATIONS

Q. Sheng, T. Kaneko, K. Yamakawa, Z. Guguchia, Z. Gong, G. Zhao, G. Dai, C. Jin, S.L. Guo, L. Fu, Y. Gu, F. Ning, Y. Cai, K.M. Kojima, J. Beare, G.M. Luke, S. Miyasaka, M. Matsuura, S. Shamoto, T. Ito, W. Higemoto, A. Gauzzi, Y. Klein, Y.J. Uemura. *Two-step Mott transition in Ni(S,Se)2: muSR studies and charge-spin percolation model.* Phys. Rev. Research, **4**, 033172, (2022).

J.R. Adelman, D. Fujimoto, M.H. Dehn, S.R. Dunsiger, V.L. Karner, C. D. Philip Levy, R. Li, I. McKenzie, R.M.L. McFadden, G.D. Morris, M.R. Pearson, M. Stachura, E. Thoeng, J.O. Ticknor, N. Ohashi, K.M. Kojima, W.A. MacFarlane. *Nuclear magnetic resonance of 8Li ions implanted in ZnO.* Phys. Rev. B, **106**, 035205, (2022).

R. Okuma, M. Kofu, S. Asai, M. Avdeev, A. Koda, H. Okabe, M. Hiraishi, S. Takeshita, K. Kojima, R. Kadono, T. Masuda, K. Nakajima, Z. Hiroi. *Dimensional reduction by geometrical frustration in a cubic antiferromagnet composed of tetrahedral clusters.* Nat. Commun. **12**, 4382 (2021).

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 Blusson QMI'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.

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.

STEPHEN BARTLETT

Professor of Physics, Centre for Engineered Quantum Systems, School of Physics, University of Sydney

Stephen Bartlett is a Professor of Physics at the Centre for Engineered Quantum Systems at the University of Sydney's School of Physics.

He is a theoretical quantum physicist who leads a team pursuing both fundamental and applied research in quantum information theory, including the theory of quantum computing. He is a Chief Investigator in the Australian Research Council Centre of Excellence in Engineered Quantum Systems (EQUS), where he leads a research program on Designer Quantum Materials. He is also the inaugural Lead Editor of the APS journal PRX Quantum.

GEORGE CRABTREE*

Distinguished Fellow, Argonne National Laboratory
Distinguished Professor of Physics, Electrical and Mechanical Engineering, University of Illinois at Chicago
Director of the Joint Centre 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 Centre for Energy Storage Research (JCESR). He has testified before the U.S. Congress on the hydrogen economy, meeting sustainable energy challenges, and energy storage. His research interests include energy storage, materials science, nanoscale superconductors and magnets, superconductivity, and highly correlated electrons in metals.

*Blusson QMI is grateful for the outstanding contributions made to the Institute by past member Dr. George Crabtree who passed away unexpectedly on Jan 23, 2023. He was 78.

J.C. SÉAMUS 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

Séamus Davis is a Professor of Physics at Oxford University, Professor of Quantum Physics at the University of College Cork, and Emeritus Professor of Physics at Cornell University. 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, and space-time; as well as developing new techniques for visualization and measurement of complex quantum matter.

BENJAMIN EGGLETON

Professor of Physics, University of Sydney
Pro-Vice-Chancellor (Research), The University of Sydney
Co-Director, NSW Smart Sensing Network (NSSN)

Benjamin Eggleton is a Professor of Physics at the University of Sydney, the Pro-Vice-Chancellor (Research) of The University of Sydney, and the co-Director of the NSW Smart Sensing Network (NSSN). He is a Fellow of the Australian Academy of Science (AA), the Australian Academy of Technology and Engineering (ATSE), the Optical Society of America, IEEE and SPIE. 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. Eggleton is Editor-in-Chief of APL Photonics.

ANTOINE GEORGES

Director, Centre for Computational Quantum Physics, Flatiron Institute (New York)
Professor, Collège de France (Paris)

Antoine Georges is a theoretical physicist with expertise in condensed matter and quantum physics. He is one of the co-inventors of dynamical mean field theory, for which he shared the 2006 Europhysics Condensed Matter Prize and the 2020 Aneesur Rahman prize of the American Physical Society. This theory has deeply transformed our understanding of quantum materials with strong electronic correlations 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.

STUART PARKIN

Max Planck Institute for Microstructure Physics, Halle (Saale), Germany

Stuart Parkin is a Director of the Max Planck Institute for Microstructure Physics, Halle, Germany, and an Alexander von Humboldt Professor, Martin Luther University, Halle-Wittenberg. His research interests include spintronic materials and devices for advanced sensor, memory, and logic applications, oxide thin-film heterostructures, topological metals, exotic superconductors, and cognitive devices. Parkin's discoveries in spintronics enabled a more than 10000-fold increase in the storage capacity of magnetic disk drives. For his work that thereby enabled the "big data" world of today, Parkin was awarded the Millennium Technology Award from the Technology Academy Finland in 2014 (worth 1,000,000 Euro) and, most recently the King Faisal Prize for Science 2021 for his research into three distinct classes of spintronic memories. Parkin is a Fellow/ Member of: Royal Society (London), Royal Academy of Engineering, National Academy of Sciences, National Academy of Engineering, German National Academy of Science—Leopoldina, Royal Society of Edinburgh, Indian Academy of Sciences, and TWAS—academy of sciences for the developing world and has received numerous awards from around the world.

KRYSTA M. SVORE

General Manager, Quantum Architectures and Computation (QUARC), Microsoft Research

Krysta Svore received her Ph.D. with Highest Distinction in Computer Science from Columbia University. Her research focuses on quantum algorithm. She leads a team working on designing scalable, fault-tolerant software architecture for translating a high-level quantum program into a low-level, device-specific quantum implementation. She serves as a representative for the Academic Alliance of the National Center for Women and Information Technology, and is a member of the American Physical Society and the Association for Computing Machinery. Her work has received recognitions such as a Kavli Fellowship of the National Academy of Sciences and an AAAS Fellowship. She was also named to the "39 Most Powerful Female Engineers 2018" list by Business Insider.

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 Centre 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 EETimes 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.

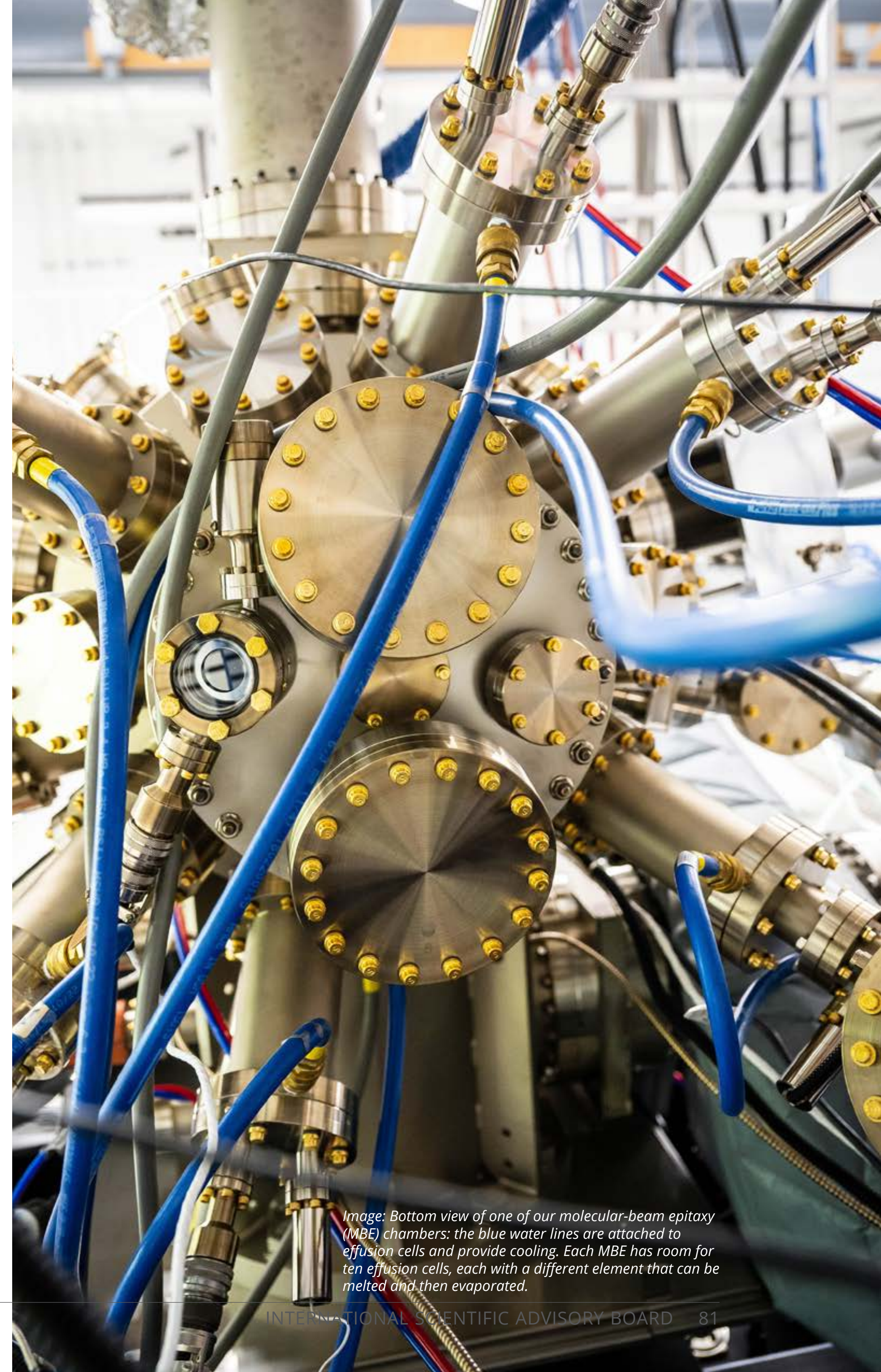


Image: Bottom view of one of our molecular-beam epitaxy (MBE) chambers: the blue water lines are attached to effusion cells and provide cooling. Each MBE has room for ten effusion cells, each with a different element that can be melted and then evaporated.

2022 PUBLICATIONS

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