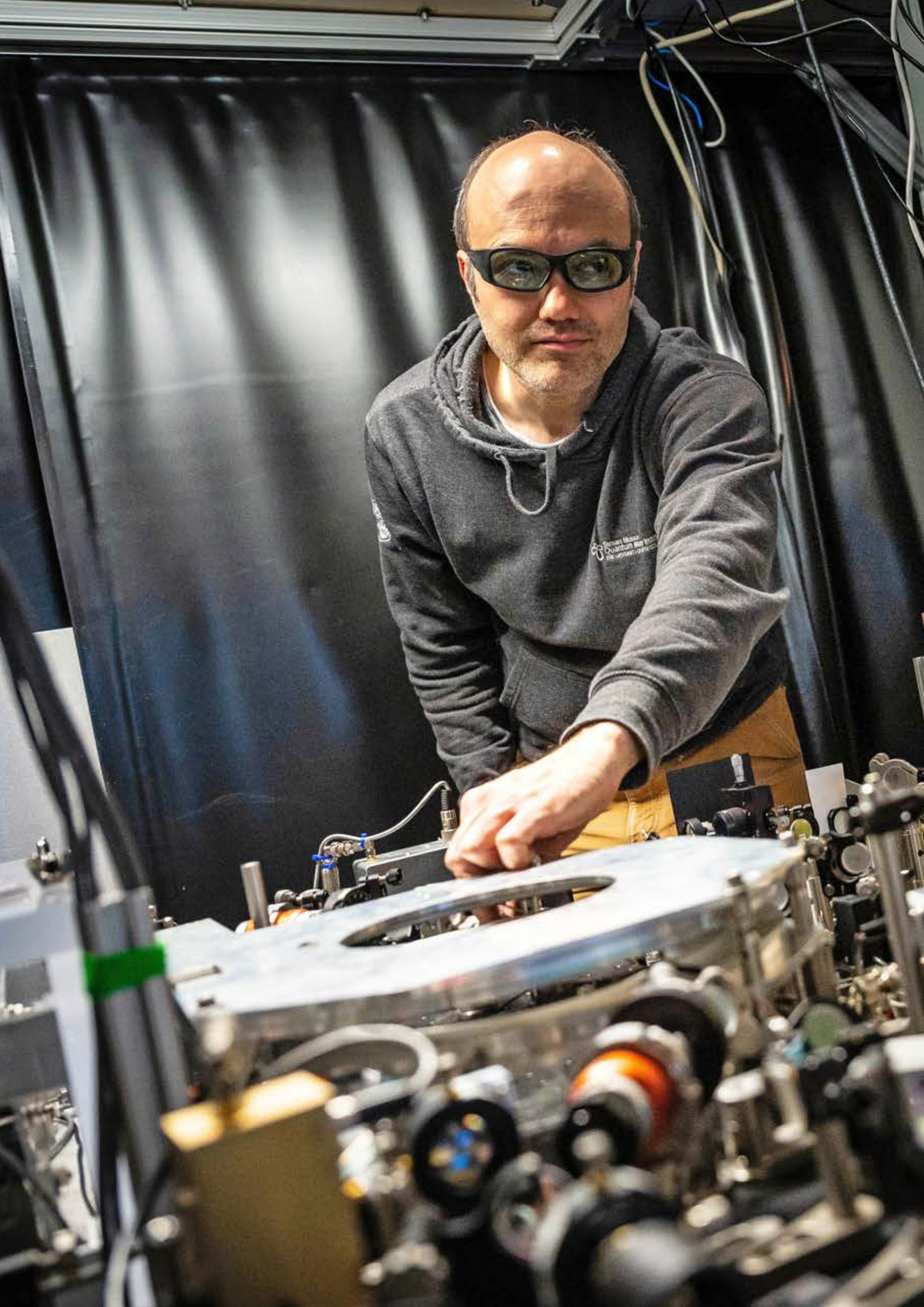
Stewart Blusson

Quantum Matter Institute

THE UNIVERSITY OF BRITISH COLUMBIA

ANNUAL REPORT 2023



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 **xwmə0–kwəy’əm** (Musqueam) people.

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MESSAGE FROM THE SCIENTIFIC DIRECTOR

Andrea Damascelli, Scientific Director, Blusson QMI

The year 2023 marked a pivotal period of strategic transformation for UBC's Stewart Blusson Quantum Matter Institute (UBC Blusson QMI). We realized our founding vision by completing the establishment of a fully operational and purpose-built quantum materials research infrastructure, bringing together twenty-five groups of physicists, chemists, and engineers in synergistic collaboration.

As we look back on our achievements in 2023, our community is reminded of the significant strides enabled by the investment of $66.5 million through the Government of Canada in UBC Blusson QMI under the first round of the Canada First Research Excellence Fund (CFREF) in 2015.

I'm pleased to be joined by our new Managing Director Paola Baca (see page 4 for more) and Facilities Director Pinder Dosanjh in implementing the next phase of our strategy to activate impactful partnerships with industry and government.

Across 2023, our research made key advancements spanning the full cycle of innovation, from theory and material characterization all the way to nanofabrication and device development. UBC Blusson QMI Early Career Investigators — Alannah Hallas, Andrew Potter, Joe Salfi, Ziliang Ye, and Ke Zou — continued to pursue innovative solutions under the institute's Grand Challenges program, all the while inspiring the next generation of quantum professionals through excellence in teaching and hands-on training opportunities.

In 2023, Hallas was awarded a Sloan Fellowship as well as UBC's Killam Prize for Excellence in Teaching (see pages 58–59 for more) and worked with Investigator Joerg

Rottler on breakthrough projects advancing our knowledge of disordered materials (see page 14 for more). Potter and his collaborators made significant advancements in quantum computing (see page 12 for more). Salfi established a pan-Canadian consortium funded under the National Quantum Strategy (see page 31 for more). Ye was reappointed as a Tier 2 Canada Research Chair in Two-Dimensional Quantum Materials, and reported on results that observed avalanches occur not only in the mountains but also in 2D materials (see page 15 for more). Zou and his group made advances in designing new topological features into the superconducting material KTaO3 (see page 15 for more), and supported a Quantum Pathways student to research success in materials in solid-state batteries (see page 16 for more).

Theoretical predictions made by our Deputy Scientific Director Marcel Franz on topological superconductivity in 2021 were experimentally demonstrated by our collaborators at Harvard University, marking an important moment in the history of quantum science (see page 10 for more). In 2023, Franz and his collaborators also reported on an innovative approach to designing a novel superconducting qubit architecture (see page 11 for more).

My team was honoured with the opportunity to conduct a major review paper on the state of time- and angle-resolved photoemission spectroscopy (TR-ARPES), illustrating that TR-ARPES has rapidly matured into a highly effective technique over the last two decades (see page 8 for more). Corresponding advancements in various laser source technologies were detailed in another major review paper led by UBC Blusson QMI Investigator David Jones and his team (see page 9 for more).

Collaboration within and outside academia has been a cornerstone of our success. Completed in 2023, our Advanced Nanofabrication Facility continues to catalyze impactful industry partnerships that translate scientific discoveries into practical applications (see pages 24–26 for more).

Together with our partners at the University of Stuttgart and the Max Planck Society, we celebrated the first graduate of our joint international PhD program in Quantum Materials, Rafael Haenel. Translating his skills into tangible solutions for the industry, Rafael is now a Quantum Software Engineer at the quantum computing company Photonic Inc (see page 29 for more).

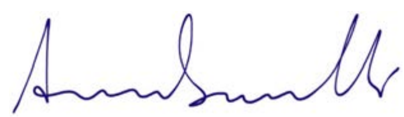
Our work is only possible thanks to our funders and supporters' commitment to advancing science and technology. In 2023, among other honourable visits, we were thrilled to host our champion philanthropists Stewart and Marilyn Blusson (see page 35 for more), the 17th President and Vice-Chancellor of the University of British Columbia Benoit-Antoine Bacon (see page 40 for more) and B.C. Premier David Eby (see page 38 for more).

Equity, Diversity, and Inclusion (EDI), as well as training and science outreach, are foundational to UBC Blusson QMI's mission. This year, among various other initiatives, we partnered with UBC Geering Up, DIGITAL, the Quantum Algorithms Institute (QAI), and D-Wave to launch the Diversifying Talent in Emerging Technologies (DTET) program, aiming to introduce diverse young people in Canada to the technologies that will shape our future (see page 48 for more).

DTET builds on the success of the Diversifying Talent in Quantum Computing (DTQC) program, an educational and outreach initiative led by UBC Blusson QMI and Geering Up. Launched in 2019, DTQC's programming reached over 3,400 youth (46% girls), 800 educators, and 3,600 members of the public, benefiting thousands from diverse groups. DTQC concluded in 2022 after three impactful years.

As our institute solidifies its role as a fully operational research and training powerhouse, I extend my heartfelt gratitude and appreciation to everyone who supported us on this journey—including our scientific and technical staff, many of whom have transitioned into positions beyond UBC Blusson QMI as our CFREF funding concludes.

Warmest regards,



Andrea Damascelli
Scientific Director, Stewart Blusson Quantum Matter Institute
Faculty of Science, University of British Columbia

BLUSSON QMI ANNOUNCES THE APPOINTMENT OF PAOLA BACA AS MANAGING DIRECTOR

Paola Baca, Managing Director, UBC Blusson QMI.
Credit: Martin Dee.

UBC Blusson QMI has announced the appointment of a new Managing Director, Paola Baca, effective June 7, 2023. As Managing Director, Baca oversees the Institute's overall administrative, operational, and partnership strategy. She leads UBC Blusson QMI's diverse team of professional staff, who ensure QMI has the talent, infrastructure, and resources required to undertake world-leading research in quantum materials and forge impactful partnerships with industry and government.

"Paola has more than 20 years of leadership experience in higher education, including undergraduate admissions, strategic enrolment management, research and data analysis, student academic services, change management, and international student recruitment," said UBC Blusson QMI Scientific Director Andrea Damascelli. "She is highly regarded for her collegiality, team leadership, and strategic management. I am thrilled that she has joined the UBC Blusson QMI team."

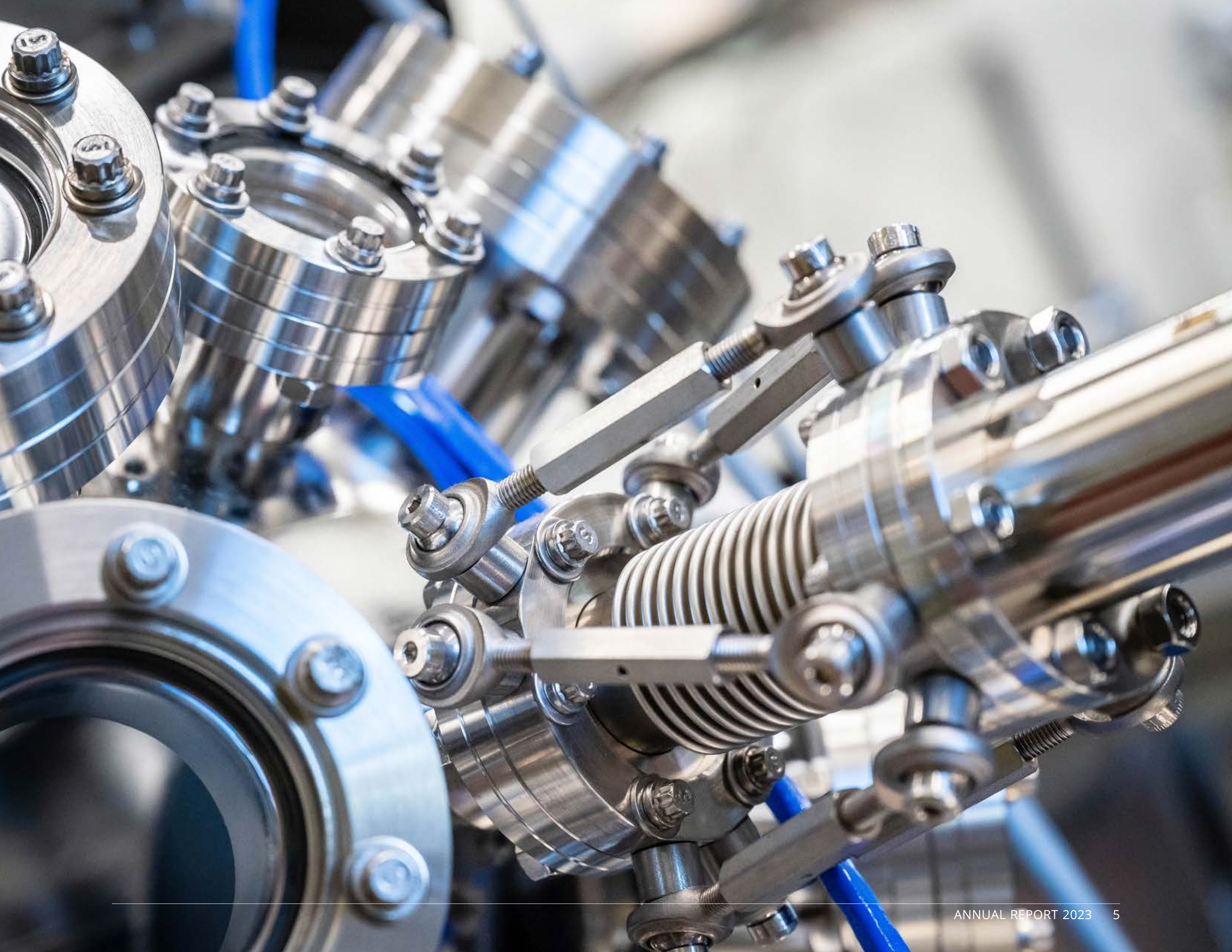
Baca is deeply committed to co-creating engaging, inclusive, people-centred communities that thrive in the face of ongoing change. Prior to joining UBC Blusson QMI, she served as the Associate Director of UBC's Undergraduate Admissions Office (Enrolment Services). She has also held leadership roles at the Sauder School of Business and the UBC International Student Initiative.

"I'm delighted to join Blusson QMI to work with Andrea Damascelli, the Executive Committee and the Institute's diverse team of professional staff who ensure we have the talent, infrastructure, and resources required to undertake world-leading research in quantum materials and devices," said Baca.

"Blusson QMI has established itself as a recognized leader in quantum materials R&D internationally. The investment of a $66.5 million grant received in 2015 through the Canada First Research Excellence Fund (CFREF) has positioned us for expanding impact.

"Our partnerships with academia, industry, and government have led to impactful outcomes for BC and Canada. As we advance, we will continue expanding our outreach programs to activate collaborative projects with industry and government partners who could leverage our expertise for commercial applications. Together, we will continue to co-create an engaging, inclusive, people-centered scientific community that thrives in the face of ongoing change."

Baca holds an M.Ed. in Higher Education and a BA (Hons.) in Political Science with International Relations from UBC, and is an alumnus of the BC Legislative Internship Program. She is also the Leadership Campaign Co-Chair on UBC's United Way Executive Team and is an internal UBC coach. She was awarded UBC's highest staff award, the President's Service Excellence Award, in 2014.



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.

140
Graduate Students

30
QuEST Students

54
Postdoctoral Fellows

4
Affiliate Members

25
Faculty

3
Canada Research Chairs

15
Administrative Staff

32
Scientific & Technical Staff

5
CIFAR Scholars

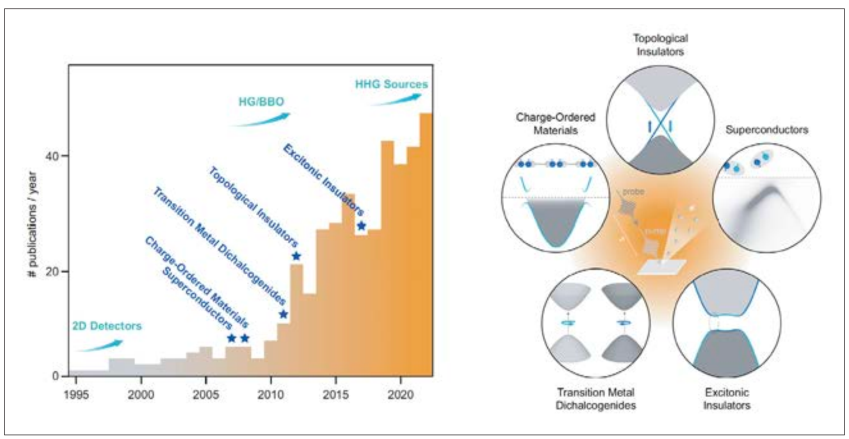
RESEARCH

TR-ARPES USHERS IN A NEW ERA OF QUANTUM MATERIALS RESEARCH

Fabio Boschini

Marta Zonno

Andrea Damascelli



The rapid adoption of time- and angle-resolved photoemission spectroscopy.
Left panel: increase of the approximate number of annual TR-ARPES publications over the past three decades. Exponential technological progress (milestone advancements in cyan arrows) and interest in new materials (blue stars marking the initial TR-ARPES publications for various classes of materials) have fueled the growth of the TR-ARPES technique over the past two decades.
Right illustration: key classes of quantum materials extensively studied via TR-ARPES.

Research in quantum materials is paving the way for groundbreaking discoveries at the forefront of science and is poised to drive technological advancements, redefining the future of industries such as mining, energy, transportation, and MedTech.

A technique called time- and angle-resolved photoemission spectroscopy (TR-ARPES) has emerged as a powerful tool, enabling researchers to explore equilibrium and dynamical properties of quantum materials via light-matter interaction.

Published in the world's premier physics review journal, Review of Modern Physics, a recent review paper by Fabio Boschini from the Institut national de la recherche scientifique (INRS), Marta Zonno from Canadian Light Source (CLS), and Andrea Damascelli from UBC's Stewart Blusson Quantum Matter Institute (UBC Blusson QMI), illustrates that TR-ARPES has rapidly matured into a highly effective technique over the last two decades.

"TR-ARPES has ushered in a new era of quantum materials research, allowing us to 'knock on the system' and observe how it responds, and push materials out of equilibrium to uncover their hidden properties," said Damascelli.

The study provides a comprehensive review of undertaking research using TR-ARPES and its evolving significance in exploring light-induced electron dynamics and phase transitions in a wide range of quantum materials.

"TR-ARPES is an effective technique not only for fundamental studies but also for characterizing out-of-equilibrium properties of quantum materials for future applications," said Fabio Boschini, who is also a QMI Affiliate Investigator.

"The scientific community is currently investigating new 'tuning knobs' to control the electronic transport and magnetic properties of quantum materials on demand. One of these 'tuning knobs' is the light-matter interaction, which promises to exquisitely control the properties of quantum materials on ultrafast timescales," Boschini said.

"TR-ARPES is the ideal technique for this purpose since it provides direct insight into how light excitation modifies electronic states with time, energy, and momentum resolution."

TR-ARPES combines condensed matter spectroscopy (ARPES) with ultrafast lasers (photonics), bringing together research groups from both fields. The technique owes much of its success to significant advancements in developing new laser sources capable of producing light with precise characteristics.

Advancements in various laser source technologies were detailed in another major review paper published in Physics Reports in 2023 by UBC Blusson QMI researchers MengXing Na, Arthur Mills, and Investigator David Jones. "In this review, we aim to survey the development of TR-ARPES and its capabilities to identify prominent trends in its use as a probe of quantum materials, as well as areas that need further innovation to meet the needs of the community," said Na.

"In TR-ARPES, we take advantage of the interaction between light and matter to both manipulate the material and study it. This review paper highlights the various ways we have pushed the expansion of parameter space — from intensity to polarization, photon energy, and much more. This allows us to interact with the material in new and interesting ways to control and probe its behavior."

"When developing laser sources for TR-ARPES, there are many competing technical aspects that, in turn, directly impact what characteristics of quantum materials can be studied. Thus, a tight collaboration between teams is critical," said Jones.

"The advances and breakthroughs we describe in the review paper would not have been possible without multidisciplinary teams collaborating across the board," added Damascelli.

"Laser and spectroscopy experts develop and commission the instrumentation, while experimentalists and theorists design the experiments and identify the suitable materials."

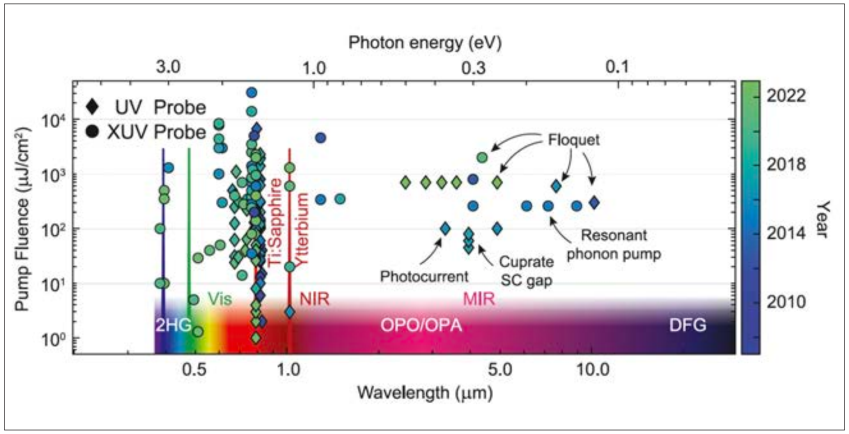
Similarly, UBC Blusson QMI's achievements in creating a state-of-the-art TR-ARPES facility at the UBC-Moore Centre for Ultrafast Quantum Matter are a result of decades of close scientific collaborations between research groups led by Jones and Damascelli, as well as many others from QMI and the Max Planck-UBC-UTokyo Centre for Quantum Materials.

"Collaboration is at the heart of all UBC QMI activities — and our TR-ARPES program is exemplary of teamwork at its best," Damascelli said.

MengXing Na

Arthur Mills

David Jones



Overview of pump sources used in TR-ARPES experiments. The pump fluence is plotted as a function of photon energy. Many studies have been performed with the pump at the Ti:sapphire fundamental frequency (FF) (780–840 nm) at all fluences. More recently, the OPO/OPA has extended the tunability of the pump into the mid-infrared. This regime has been used to demonstrate Floquet physics and the resonant pumping of bosonic modes. The second harmonic of the FF and OPA outputs and the 2H-driven OPA reaches most of the visible spectrum. Excitons and carrier dynamics in semiconductors and molecules are accessible here.

F. Boschini, M. Zonno, A. Damascelli. Time-resolved ARPES studies of quantum materials. Rev. Mod. Phys. **96**, 015003 (2024).
M.X. Na, A.K. Mills, D.J. Jones. *Advancing time- and angle-resolved photoemission spectroscopy: The role of ultrafast laser development.* Phys. Rep. **1**, 1036 (2023).

EXPERIMENT CONFIRMS UBC BLUSSON QMI'S PREDICTIONS ON TOPOLOGICAL SUPERCONDUCTORS

In a study published in Nature Physics in 2021, UBC Blusson QMI researchers led by Marcel Franz predicted a route to creating the first high-temperature topological superconductor by stacking two monolayer-thin sheets of a copper-based material on top of each other with a twist. Now, a team of researchers from Harvard has confirmed the predictions through successful experimental observations in a study co-authored with Franz and his group published in the journal Science.

"Our work shows that high-temperature superconducting diodes are in fact possible without the application of magnetic fields and opens new doors of inquiry toward exotic materials study," said Philip Kim, who led the Harvard research group.

Using a uniquely low-temperature device fabrication method, Kim and his team demonstrate a promising candidate for the world's first high-temperature superconducting diode — a switch that makes the current flow in one direction — made out of thin cuprate crystals. Such a device could theoretically fuel industries like quantum computing, which rely on fleeting quantum mechanical phenomena that are difficult to sustain in any meaningful way. Also, the observed diode effect indicates that time-reversal symmetry must be broken in the device in support of the theoretical prediction.

"Thanks to the visionary work by Frank Zhao, Alex Cui, and the whole experimental team led by Philip Kim at Harvard, we now have clear experimental evidence for broken time-reversal symmetry at the interface between two flakes of a high-temperature cuprate superconductor assembled with a twist," said Franz.

"The observed time-reversal symmetry breaking is a key prerequisite for topological superconductivity to occur in a twisted cuprate bilayer close to the 45-degree twist angle predicted by our team at Blusson QMI.

"Topological superconductors are extremely rare in nature and occur typically at very low temperatures close to absolute zero. This tends to hamper their proposed utility as platforms for quantum computation. The twisted cuprate bilayer would be the first high-temperature topological superconductor with the effect potentially observable at much higher temperatures."

The Harvard team discovered that the maximum supercurrent that can be passed without resistance through the interface is different depending on the current's direction. Crucially, the team also demonstrated electronic control over the interfacial quantum state by reversing this polarity. This control was what effectively allowed them to make a switchable high-temperature superconducting diode — a demonstration of foundational physics that could one day be incorporated into a piece of computing technology such as a quantum bit.

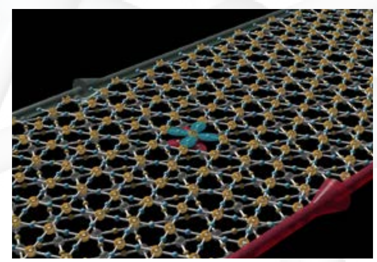
Topological superconductors, in general, are regarded as a promising platform for robust quantum computation. Currently, the menu of existing topological superconductors is rather limited. Prof. Franz considers having a newly confirmed family of materials that function at higher temperatures and could be used for technological applications as "a definite breakthrough."

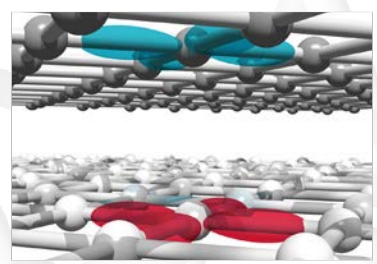
"Some of the ideas advanced in the Blusson QMI 2021 theory paper have inspired a new collaboration on a proposal for an improved transmon qubit. This type of qubit powers nearly all superconducting quantum computers currently in existence, including those operated by IBM and Google," Franz said.

"We are also currently involved in theoretical work and discussions with colleagues at Blusson QMI whose goal is to devise ways for unambiguous detection of the non-trivial topology in cuprates. At Blusson QMI, we now have several projects under the umbrella of our 2D Grand Challenge that are animated by this idea."

O. Can, T. Tummuru, R.P. Day, I.S. Elfimov, A. Damascelli, M. Franz. *High-temperature topological superconductivity in twisted double-layer copper oxides.* Nat. Phys. **17**, 519 (2021).

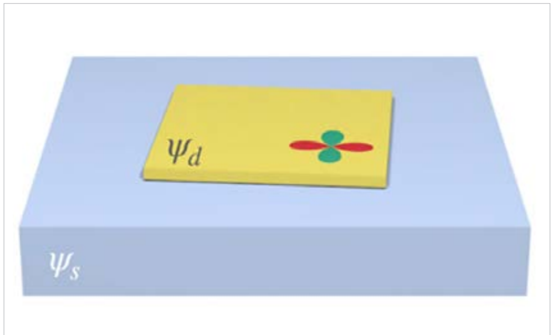
F. Zhao, X. Cui, P.A. Volkov, H. Yoo, S. Lee, J.A. Gardener, A.J. Akey, R. Engelke, Y. Ronen, R. Zhong, G. Gu, S.Plugge, T. Tummuru, M. Kim, M. Franz, J.H. Pixley, N. Poccia, P. Kim. *Time-reversal symmetry breaking superconductivity between twisted cuprate superconductors.* Science **382**, 1422-1427 (2023).





NEW D-MON QUBIT WITH POTENTIAL TO ENHANCE QUANTUM COMPUTING OPERATIONS

Marcel Franz



A transmon with Strong Anharmonicity based on planar c-Axis tunneling junction between d-Wave (high-Tc cuprate) and a conventional s-Wave Superconductors

Led by UBC Blusson QMI Deputy Scientific Director Marcel Franz, researchers at UBC Blusson QMI are studying innovative approaches for qubit design using advanced materials with significant potential impact for applications in quantum computing.

Superconducting qubits, and in particular transmon-type qubits, have led the charge over the past decade in the development of hardware for practical quantum computers. The transmon addressed one of the major technical challenges of its predecessor, the Cooper Pair Box (CPR) qubit, which was sensitive to offset charge. Many of the industry leaders today, including Google, IBM, and Rigetti, use the transmon architecture for their qubits.

Both types of qubits have similar designs, featuring a capacitor in parallel with a Josephson Junction (JJ). However, the key improvement with transmon qubits is that they operate in a way that makes them less sensitive to this offset charge noise, although this also makes them less precise in their operations (a property known as weak anharmonicity).

A qubit, like a tiny switch, can be in an "off" (0) or "on" (1) state to process binary information. The system's ground state is labeled as (0) and the first excited state as (1). For qubit operations, we need to drive transitions between these states. For effective operations, the energy needed to switch between these states must be distinct to avoid errors. Transmon qubits, being weakly anharmonic, need slower operations to maintain accuracy.

The new "d-mon" qubit is a transmon-type device that aims to solve this issue by being strongly anharmonic. Unlike the original transmon, which used two similar superconductors, the d-mon uses different types of superconductors to create a more stable and accurate qubit. Specifically, it relies on the so-called d-s junction formed between a d-wave cuprate superconductor and a conventional s-wave superconductor.

By performing numerical modeling, the researchers show that the achieved spectrum is indeed strongly anharmonic and insensitive to the offset charge. In fact, the anharmonicity and offset-charge insensitivity are highly tunable using magnetic fields and junction areas in d-mon. They demonstrate that the setup is also immune to quasiparticle poisoning, ensuring coherent tunneling of Cooper pairs through the JJ.

Many groups around the world, including UBC Blusson QMI teams led by Investigator Doug Bonn and Scientific Director Andrea Damascelli, have made pioneering strides in fabricating ultra-clean samples of d-wave cuprate superconductors. However, d-s junctions have yet to be made with these ultra-clean techniques. This work, which is the result of a collaboration with Investigator Andrew Potter, demonstrates the potential of such junctions in quantum computing, and hopes to motivate its experimental realization.

H. Patel, V. Pathak, O. Can, A.C. Potter, Franz. *d-Mon: A Transmon with Strong Anharmonicity Based on Planar c-Axis Tunneling Junction between d-Wave and s-Wave Superconductors.* Phys. Rev. Lett. **132**, 017002 (2024).

INNOVATIVE METHOD TO ENHANCE QUANTUM SIMULATIONS

Modeling the dynamics of quantum systems driven out of thermal equilibrium in contact with an environment that can dissipate energy is a critical task for simulating electrical and thermal conductivity of materials and designing future generations of electronic, thermoelectric, photonic, and photoelectric devices.

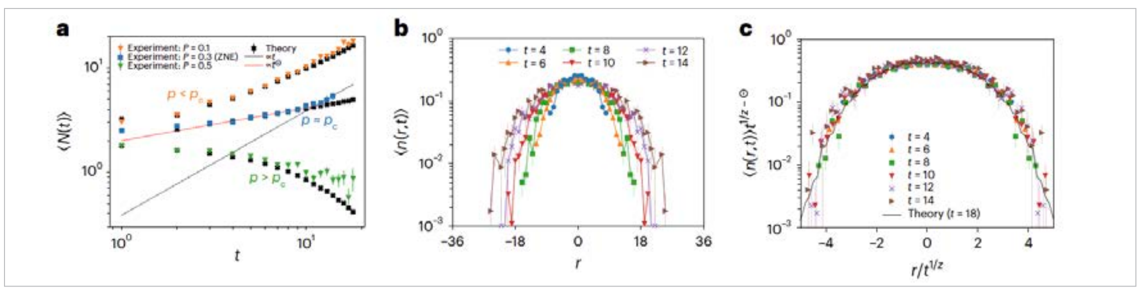
Treating the interplay of quantum coherence, strong correlations, and dissipation is challenging for conventional computational tools. In the long-term, quantum computers can solve these technical hurdles; however, in the near-term, nascent quantum computers will be limited in the scale and precision of calculations.

Andrew Potter

"In this work, we leverage newly-developed methods to strategically reset and recycle quantum bits (qubits) during computation in order to dramatically expand the accessible simulation size available in existing trapped-ion-based quantum computer prototypes," said UBC Blusson QMI Investigator Andrew Potter.

The work explores a non-equilibrium dynamical phase transition in a "quantum contact model," which is the competition between the ability of quantum-coherent dynamics to produce and propagate quantum dynamics and the tendency for dissipation and errors to drive the system towards a low-entangled classical state with limited computational power.

"The model is a quantum version of classical models for the survival or extinction in populations of animal species, or spread or containment of infectious diseases, where quantum entanglement replaces the classical concepts of population or infections," Potter said.



Experimental observation of critical scaling in a quantum computer. a, The number of active sites ⟨N(t)⟩ versus time t on a log-log scale for p = 0.1, 0.3, 0.5, as measured in experiments (coloured markers) and obtained from noise-less 10,000-shot quantum trajectory simulations (black crosses). As a guide to the eye, curves showing ballistic (black dotted line) and DP power-law (red dashed line) growth of active sites are also depicted. b, The experimentally measured active site density ⟨n(r,t)⟩ versus position r for fixed times t near the critical point p = 0.3 ≈ pc. c, Scaling collapse of the experimental data at p = 0.3 using known DP exponents Θ ≈ 0.31 and z ≈ 1.58 (the solid black line is the t = 18 noise-less simulation). All p = 0.3 data have ZNE applied44,45 (Supplementary Information). All error bars are standard errors of the mean obtained from bootstrap resampling with 100 resamples.

"While this model is not directly related to electronic materials and device simulation tasks, it demonstrates many of the key capabilities needed to make progress towards such tasks."

Together with industry partner Quantinuum—who developed and built the trapped-ion quantum processors—and researchers in Potter's group at UBC and collaborators at Princeton University, this study implemented a large-scale simulation of phase transitions in the model.

Using qubit recycling techniques and developing new methods to actively detect and suppress errors in the quantum circuit, the team was able to perform quantitatively accurate simulations of the quantum contact model on circuits involving 72 layers of computation on 72 logical qubits on Quantinuum's system model H1, using only 20 physical trapped-ion hardware qubits.

"While the simulated system does not yet exceed the capability of conventional classical computers, it begins to challenge even state-of-the-art methods that run on large-scale computing clusters," said Potter.

"As quantum hardware continues to scale and improve in accuracy, we anticipate that these types of qubit recycling and error-suppression techniques will be crucial to shortening the barriers to achieving a quantum computational advantage over classical supercomputers on problems of practical scientific and technological interest."

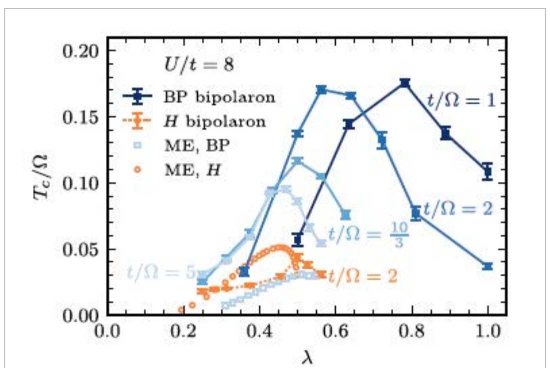
E. Chertkov, Z. Cheng, A.C. Potter, S. Gopalakrishnan, T.M. Gatterman, J.A. Gerber, K. Gilmore, D. Gresh, A. Hall, A. Hankin, M. Matheny, T. Mengle, D. Hayes, B. Neyenhuis, R. Stutz, M. Foss-Feig. Characterizing a non-equilibrium phase transition on a quantum computer. Nat. Phys. **19**, 1799 (2023).

NOVEL THEORETICAL APPROACH TO ACHIEVE HIGH-TEMPERATURE SUPERCONDUCTIVITY

An international collaboration of researchers including UBC Blusson QMI Investigator Mona Berciu have reported on results advancing the field of high-temperature superconductivity in a study published in Physical Review X.

"The pursuit of superconductivity at relatively higher temperatures is a major driver of research in the physics community. In this study, we challenge the 'conventional wisdom' according to which superconductivity mediated by the motion of atoms can only occur at extremely low temperatures at ambient pressure," said Berciu.

Mona Berciu



Superconductivity was discovered in 1911 by Dutch physicist Heike Kamerlingh Onnes, while studying the electrical properties of solid mercury at very low temperatures. Above the so-called critical temperature, the materials behave like a normal conductor with resistance.

In regular conductors like copper wires, electricity flows with some resistance causing energy to be lost in the form of heat. Superconductors, on the other hand, allow electricity to travel with no resistance at all. As superconductors can carry electricity without losing energy, they have potential applications in creating highly efficient electronics, powerful electromagnets (like those used in MRI machines), and advanced technologies like quantum computers.

To this day, superconductivity can only be induced by either cooling materials to very low temperatures and/or by subjecting them to extreme pressures, a challenge that has motivated major efforts worldwide to find a solution for high-temperature superconductivity at ambient pressure.

In the standard theory of superconductivity, the electron pair binding comes from interactions of electrons with the motion of atoms. The critical temperature below which superconductivity appears is very low because typically this interaction is very weak. Increasing the strength of the interaction usually also vastly increases the mass of the bound electron pairs, so they move extremely slowly and cannot superconduct.

Left: Predicted critical temperatures as a function of the strength of the electron-lattice coupling for our model (blue square symbols; different shades correspond to different lattice stifnesses) and the most studied electron-lattice coupling (orange square symbols), showing a significant enhancement in our model. Circles show estimates of the critical temperature obtained with the Migdal-Eliashberg approximation, which works well for the established model but is not accurate for our model.

"Our work showed that a different type of interaction between electrons and atoms, which had not been considered in the context of superconductivity, can lead to strongly bound electron pairs that remain very light. The estimated critical temperatures can be well above the upper bounds expected for the more conventional interaction, suggesting that superconductivity could be achieved through this type of mechanism at significantly higher temperatures than we thought possible before," Berciu said.

According to the researchers, this approach is most effective when the electron pairs are spread out without much overlap. The team are now applying the theory to models with higher densities and aiming to identify candidate materials.

"There is a lot of work to do in terms of identifying the best possible type of such interaction that maximizes the critical temperatures, of figuring out in which materials this interaction is dominant, and in understanding the interplay between this interaction and various other complications that are always present in actual quantum materials. The development of numerical methods that are able to study such complicated models accurately is also necessary. All this was exemplified by the current collaborations, which combined experts in numerical methods together with experts in studying electron binding in various types of electron-atom interactions and experts in material sciences," Berciu said.

C. Zhang, J. Sous, D.R. Reichman, M. Berciu, A.J. Millis, N.V. Prokof'Ev, B.V. Svistunov. *Bipolaronic High-Temperature Superconductivity*. Phys. Rev. X **13**, 011010 (2023).

UNLOCKING THE POTENTIAL OF DISORDERED MATERIALS

High entropy oxides (HEOs) flip traditional materials science paradigms on their head by exploring how mixing a large number of different elements from the periodic table together in a single material can lead to new discoveries. Research has shown useful properties in HEOs, but there are still fundamental questions about how this mixing of elements, or—configurational disorder—works its magic.

UBC Blusson QMI researchers have investigated the topic more widely in a perspective paper published in JACS. The paper is the result of years of discussion between investigators Alannah Hallas and Joerg Rottler as part of a UBC Blusson QMI Grand Challenge focused on the Atomistic Approaches to Emergent Properties of Quantum Materials.

Disorder and defects, in low concentrations, can both generate and suppress the functional properties of materials. For instance, silicon in technological applications is famous for its exquisite purity, but without a finite level of substitutional disorder, it would not exhibit the requisite electronic properties needed for its widespread use as the backbone of all modern electronics.

“A disordered material is like a messy bedroom. We know that there’s just one way for a bedroom to be completely tidy and for everything to be in its proper location. But there are infinitely many ways that the bedroom can be messy,” said Hallas. “Disordered materials are exactly the same: they have infinitely many ways to be disordered, and that’s what makes them so challenging to study.”

All crystalline solids have a lattice that defines how the atoms are positioned relative to one another. In an ordered material, each unique position in the lattice is occupied by just a single chemical element.

“In an HEO, there’s no special arrangement of the first element relative to the second relative to the third. Every time you get to one of those sites, you roll a five-sided dice, and whatever element comes up, it is placed in that site to ensure randomness,” Hallas said.

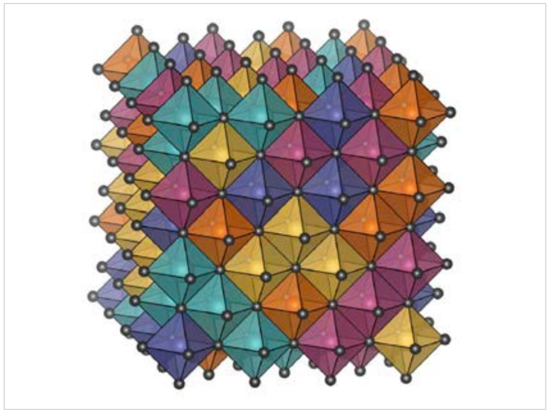
The study’s first author and postdoctoral fellow, Solveig Aamlid, believes the perspective paper’s clear separation of the ‘high entropy’ and ‘entropy stabilized’ categories has proven to be beneficial to the field.

“In our paper, we also emphasize the importance of kinetics in addition to thermodynamics, which is something that has an effect on these materials but is hard to measure or model,” Aamlid said.

Hallas and her group continue to investigate how extreme disorder helps stabilize materials and improve their performance to harness the power of entropy in HEOs and unlock their full potential for technological applications.

Alannah Hallas

Joerg Rottler



High entropy oxides (HEOs) are characterized by a random distribution of metal cations across an ordered crystalline lattice, as represented here for five different elements in a rock salt structure, illustrated using VESTA.

Solveig Aamlid and Alannah Hallas

S.S. Aamlid, M. Oudah, J. Rottler, A.M. Hallas. *Understanding the Role of Entropy in High Entropy Oxides.* J. Am. Chem. Soc. **145**, 5991 (2023).

MECHANICAL EXFOLIATION TRIGGERS SLIP AVALANCHES IN 2D MATERIALS

Slip avalanches are ubiquitous phenomena occurring in three-dimensional materials under shear strain, and their study has contributed immensely to our understanding of plastic deformation, fragmentation, and earthquakes. Now, a new research collaboration between UBC Blusson QMI Investigators Ziliang Ye and Joerg Rottler published in Nano Letters reports on a world-first observation of shear strain-induced avalanches at the atomic scale in two-dimensional (2D) materials.

Shear strain is a type of deformation in materials that occurs when an applied force causes the material's layers to slide past each other in a parallel manner. In avalanches, shear strain occurs when different layers or sections of snow slide past each other, leading to the rupture or failure of the snowpack. In earthquakes, it refers to the deformation caused by the shearing or sliding motion of rocks along a fault plane.

"In recent years, 2D materials have provided a unique platform for studying new science and technology at the atomic level, but we don't know much about the effects of shear strain in these materials," said Blusson QMI Investigator and Assistant Professor in UBC's Department of Physics and Astronomy, Ziliang Ye.

"In this study, we find that the stacking order in 2D materials can be changed due to the shear strain during the mechanical exfoliation stage. The stacking order determines many important properties of 2D materials and therefore it's significant for us to know what can affect it and how we can control it," said Ye.

Mechanical exfoliation is a method used for producing 2D materials where researchers use adhesive tape to chip away a sample from the bulk of the crystal.

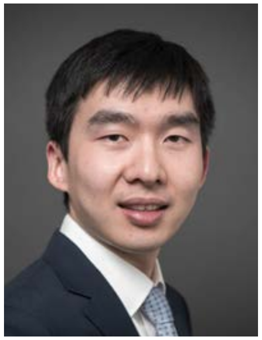
Postdoctoral Fellow and the study's first author, Jing Liang, said the emergence of 2D materials from van der Waals (vdW) crystals has turbo-charged atomic-level investigations in various scientific and technological domains.

"These materials exhibit weaker interlayer bonding forces, making them a great platform for studying the effects of in-plane shear strain in two dimensions," said Liang.

"Our study focuses on exfoliated rhombohedral MoS2 as this lab-grown material allows us to differentiate between various stacking configurations through interfacial polarization in 3R-MoS2. On the other hand, mechanical exfoliation involves shear strain, making it a promising process to explore the interplay of shear strain and slip avalanches."

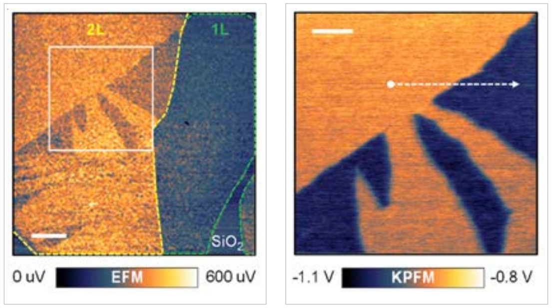
By utilizing advanced surface potential-sensitive characterization techniques such as electrical force microscopy (EFM) and Kelvin probe force microscopy (KPFM), the team was able to visualize polarization domains and directly observe a highly abnormal distribution of polarization domain sizes in 3R-MoS2.

"This distribution, following a power-law pattern, indicates the occurrence of interlayer slip avalanches triggered by shear strain near the threshold during the mechanical exfoliation process," Liang said.



Ziliang Ye

Jing Liang



EFM mapping of a 3R-MoS2 flake with both mono- and bilayer regions. Scale bar, 2 μm. (D) Surface potential mapping of the 3R-MoS2bilayer region enclosed by the white box in the figure to the left]

J. Liang, D. Yang, Y. Xiao, S. Chen, J.I. Dadap, J. Rottler, Z. Ye. *Shear Strain-Induced Two-Dimensional Slip Avalanches in Rhombohedral MoS2*. Nano Lett. **23**, 7228 (2023).

INTRODUCING TOPOLOGICAL FEATURES IN A NEWLY DISCOVERED SUPERCONDUCTOR

Material scientists at the UBC Blusson QMI have designed new topological features into a superconducting material called KTaO3 (KTO). The study was published in npj Quantum Materials.

KTO, which belongs to a class of oxide materials known as tantalates, has gained popularity among researchers since 2021 when two-dimensional (2D) superconductivity was discovered on its surface.

"This is probably one of the first instances that topological features have been observed in this material," said UBC Blusson QMI Investigator Ke Zou, who leads the research team.

"We've added another material on the surface of KTO to be able to control its properties, and our design has revealed the topological features we hoped to see," Zou said.

Electrons come together in pairs to move through a superconducting material. This behaviour, known as Cooper pairing, allows the pairs to move without any collision, or in other words, with zero resistance. In topological superconductors, the pairs enjoy an extra layer of protection (provided by the topology) that makes them immune to certain deviations or 'perturbations.'

"A major issue with the current generation of quantum computers is decoherence. Topological superconductors are a prime area of study for building quantum computers that could be potentially immune to decoherence," said Zou. "Of course, we are yet to confirm if the superconductivity and the topological features are indeed coupled in the material we are studying."

The study tackles two of Blusson QMI's Grand Challenges—engineering exotic phases in two-dimensional (2D) materials, and pushing the boundaries of Noisy Intermediate Scale Quantum (NISQ) computing by focusing on quantum materials—a program aimed at activating collaborations among different research groups at the institute.

"Blusson QMI is a great place to study novel quantum materials such as topological superconductors and to work with other researchers with niche expertise and capability in quantum materials research," Zou said.

The study builds on the findings of a world-renowned theory group led by Marcel Franz, who are expert in studying topological insulators, topological superconductors, Dirac and Weyl semimetals, and other topological or otherwise exotic states of quantum matter.

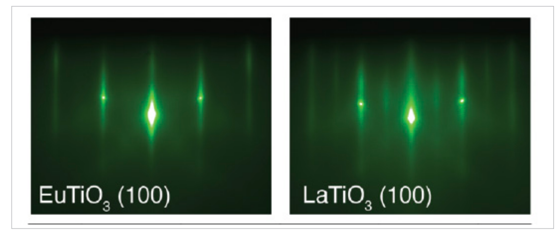
Zou continues to collaborate with Franz and other experimental groups at UBC Blusson QMI to confirm the findings of this study.

Zou's group at UBC Blusson QMI are experts in growing complex oxide and chalcogenide films. With access to research talent, specialized equipment and a world-leading research infrastructure, the group aims to achieve scientific and technological breakthroughs in new materials and new functional devices.

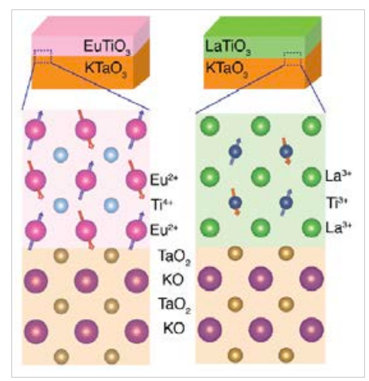
Y. Zou, H. Shin, H. Wei, Y. Fan, B.A. Davidson, E.J. Guo, Q. Chen, **K. Zou**, Z.G. Cheng. *Transport behaviors of topological band conduction in $KTaO_3$'s two-dimensional electron gases*. npj Quantum Mater. **7**, 122 (2022).

Ke Zou

Ke Zou and students stand in UBC Blusson QMI's MBE facility as staff scientist Bruce Davidson speaks about the team's work.



In-situ reflection high-energy electron diffraction (RHEED) intensity picture of ETO and LTO after 10 u.c. growth.



Schematic picture of ETO/KTO (left) and LTO/KTO (right) heterostructures and their atomic and antiferromagnetic spin structures (below). The size of spins on the Eu2+ and Ti3+ indicates the relative magnitude of magnetic moments (7μB/Eu and 0.5μB/Ti).

POSITIONING CANADA AS A WORLD LEADER IN SELF-DRIVING LABS

The University of British Columbia is home to Project Ada, Canada's first self-driving lab to fast-track the discovery of clean energy materials.

In 2018, an $8 million Natural Resources Canada grant enabled UBC professors Curtis Berlinguette and Jason Hein, along with Alán Aspuru-Guzik of the University of Toronto, to assemble the AI-driven "Ada."

Self-driving labs like Ada think for and work by themselves, combining automation with machine learning to plan, conduct, and analyze experiments much faster than humans can. Once the scientist defines the search space and presses "go," AI plans the experiments for the automated hardware.

The resulting data then informs the design of subsequent experiments in a closed loop. Error correction is built into the process, and results are fed back to the algorithm to prevent a disconnect between what the AI says should happen and what the robot actually delivers.

The first Ada platform consisted of modules linked together to autonomously make and test thin films for solar cells. "We were able to pivot to explore different materials and applications by reconfiguring and adding new modules to meet the evolving needs of our experiments," said Blusson QMI Investigator Curtis Berlinguette. "To date, we've focused on making and testing thin-film materials because they're a key component of basically any clean energy technology."

Hein and Berlinguette lead the Vancouver branch of the Acceleration Consortium, which recently received a $200-million grant for self-driving lab development from the Canada First Research Excellence Fund (CFREF). The boost will help researchers at UBC and the University of Toronto to accelerate research translation from early-phase discovery to real-life deployment of new materials and molecules—from life-saving medications and biodegradable plastics to low-carbon cement and renewable energy.

Some of Hein's and Berlinguette's graduate students and postdoctoral fellows have already moved directly into senior positions in industry. Several members of the Ada team now work at UBC spin-off enterprises.

Decarbonization research is also a key priority for the Berlinguette Group.

"We design and build electrochemical reactors to convert CO2 into useful products, to drive nuclear fusion at low temperature, and to electrify the fuels, chemicals, and cement industries," says Berlinguette. "We view flexible automation and self-driving labs as an enabler to accelerate discovery and translation of new technologies in these areas from lab to market."

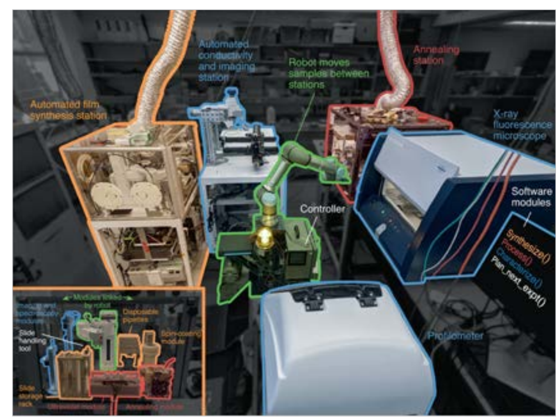
With support from Natural Resources Canada and the National Research Council of Canada, the Berlinguette Group expanded their first Ada platform to build a self-driving lab for the discovery and optimization of materials used in CO2 electrolyzers. Millions of formulations are available for the catalysts, and several different process parameters need to be optimized, such as temperature, pressure, and flow rates.

"All of these different parameters are why the development of fuel cells, for example, has taken so long to commercialize," Berlinguette said.

Continue reading this piece here: https://focus.science.ubc.ca/an-ai-powered-revolution-in-clean-energy-chemistry-a721d7168bbe.

*This story is an excerpt from a longform article originally authored by Geoff Gillard and published online in UBC Science's **Focus** magazine.*

Jason Hein (left), UBC Chemistry; Curtis Berlinguette (right), UBC Blusson QMI and UBC Chemistry.



J. Gillard. *An AI-powered revolution in clean energy chemistry.* Focus (2024).

RESEARCH EXCELLENCE CLUSTERS
ARS SCIENTIA

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 to develop clusters of research excellence led by researchers. Blusson QMI is honoured to host two such clusters: ***Ars Scientia*** and the ***Quantum Computing Research Cluster***.

ARS SCIENTIA

At the intersection of arts and science, *Ars* (skill, technique, craft) *Scientia* (knowledge, experience, application) presents an opportunity to foster new modes of knowledge exchange intended to invigorate art, science, and pedagogy in search of profound exchange and collaborative research outcomes.

Fusing the praxes of arts and science in the emergent fields of interdisciplinary research, *Ars Scientia*, a tripartite partnership between UBC's Blusson QMI, the Department of Physics & Astronomy, and the Morris and Helen Belkin Art Gallery, presents an opportunity to foster new modes of knowledge exchange across the arts, sciences and their pedagogies.

encou(n)ters: blending arts and science through meaningful collaborations

Ars Scientia's second annual symposium: encou(n)ters, took place at UBC Botanic Gardens Reception Centre on May 15. Principal Investigators Shelly Rosenblum, Jeremy Heyl and Andrea Damascelli opened the event, followed by artist talks by resident investigators jg mair*, Alannah Hallas, Timothy Taylor, Kelly Lycan, Josephine Lee, and Scott Billings.

As part of the event, Blusson QMI Principal Investigator Alannah Hallas and media/visual artist jeff mair provided a talk on their project Quantum Materials Paintings, showcasing art produced with a special kind of paint made of lab-formed crystals mixed with clear acrylic medium.

"During our first walk through my lab, I showed jeff [jg mair] and Timothy the literal skeletons in my closet, the hundreds of sample vials containing the results of our synthesis attempts some of which had succeeded, but the majority of which had not," said Hallas who leads Blusson QMI's Materials Design Lab.

"To my great surprise, while most visitors are captivated by our crystal samples that have an appearance that resembles natural gemstones, jeff was particularly interested in some of our powder samples, which look like flour or fine sand. Off the cuff, he asked me a provocative question: 'I want to turn the samples into paint if that's okay with you?'"

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

below (left to right): jg mair, visual/media artist and Alannah Hallas, Principal Investigator at Blusson QMI.

bottom (left to right): jg mair, Investigators Jeremy Heyl, Alannah Hallas, Andrea Damascelli, Sarah Burke (behind), Shelly Rosenblum, former QMI Managing Director Kim Kiloh.

At first, Hallas said no. She worried about safety concerns and thought it was improper to permanently remove samples from the lab, even if they were unsuccessful synthesis attempts.

"But over the next couple of weeks, the idea sat in my brain and continued to nag at me. I thought about the historic connection between pigments and chemistry. And in fact, historically, the distinction between a chemist and an artist was really nonexistent, and one of the most important goals of chemistry was to produce new pigments.

"I began to feel a genuine excitement at the prospect of one of our materials finding a second life on an artist's paintbrush."

Hallas and mair reconvened at Blusson QMI for a trial run where they mixed a quantum material with clear acrylic paint, which mair took to his studio to produce the first painting in the series.

"For choosing the colors, I completely removed myself from the equation and asked if Alannah was comfortable making those calls. Since these materials are her life's work, I was curious to see what criteria informed her choices," said mair.

"This relinquishing of control for me as an artist put me squarely outside of my comfort zone, but it was also oddly liberating."

The Symposium was concluded with a keynote lecture by the President's Excellence Chair in Network Cultures and Professor in UBC's Department of English Language and Literatures, Kavita Philip.

**jg (jeff) mair wishes for his name to be written free from capital letters.*

ARS SCIENTIA INSPIRES A NEW WRITING COURSE AT UBC

Students visit QMI labs with their course instructor and Ars Scientia resident Timothy Taylor.

"Only on a few occasions, you discover something that is really mind-opening, something that you really wouldn't have known how to predict, and that's how I feel about my experience [with Ars Scientia].

— Timothy Taylor

In 2023, Ars Scientia partnered with UBC Creative Writing to launch a new nonfiction writing course—*Storytelling, Persuasion, and Physics*—convening physics and creative writing students to produce engaging and accessible science stories.

Course Instructor and Associate Professor at the School of Creative Writing, Timothy Taylor, said the program was inspired by his art residency with Ars Scientia.

"All of my career in magazine writing has involved going into strange rooms where I didn't know the professional details of what's going on inside, and that sense of the unknown is something that I'm very comfortable with," said Taylor.

"Only on a few occasions, you discover something that is really mind-opening, something that you really wouldn't have known how to predict, and that's how I feel about my experience [with Ars Scientia].

"I've had an incredible time exploring the various parts of Blusson QMI, talking to practitioners in various different research realms, and getting to know that little introductory bit of what is going on there, enough to convince me that it's deeply fascinating."

The course provides the students with practical skills and writing techniques that Taylor has acquired through his career as a multiple award-winning nonfiction writer.

"The course enables the students to venture into unfamiliar territory and ask good questions that could lead to truthful accounting of important scientific discoveries," Taylor said.

WHY SCIENTISTS NEED ARTISTS: THE BENEFITS OF COLLABORATIVE CREATIVITY

Presented below is an excerpt from a long-form piece produced by Blusson QMI Senior Research Associate and Ars Scientia Program Manager Dr. James Day as part of the Ars Scientia-inspired creative writing course Storytelling, Persuasion, and Physics at UBC (see above for more on the course).

WHEN BONGOS MET BRUSHES

There is a famous anecdote about a renowned scientist. The telling begins in the late 1950s, with a party that was in full swing. The room was alive with energy, as people chatted, danced, and drank to the sounds of rock and roll and jazz.

Suddenly, the beat changed, and a small group gathered around future Nobel Prize-winning physicist Richard Feynman, playing the bongo drums with intricate rhythms. As Feynman played, artist Jirayr Zorthian was inspired to transform himself into a living canvas, smearing shaving cream across his chest in wild designs. This spontaneous act led to an intimate conversation between the two, where they vowed to share and teach each other their respective crafts. Over time, Feynman found himself diving into art, grasping the nuances of drawing from Zorthian, while Zorthian ventured into the abstract world of quantum mechanics.

Their collaboration went beyond casual exchange. Feynman's sketches, influenced by Zorthian, showcased a developing understanding of form and movement. Zorthian's practice began reflecting hints of quantum-inspired patterns. It wasn't just about combining two fields; it was about how they infused and transformed each other.

This union of art and science is more than an entertaining tale: it set a precedent. Their experimental blending of worlds became an archetype for subsequent collaborations. Unions between scientists and artists have persisted into the present era. Through personal involvement, I know that the results, while perhaps less renowned, carry the same potential for brilliance and innovation, challenging and reshaping our perceptions of what's achievable when worlds converge.

In recent years Feynman's relationship with Zorthian has loomed in importance to me as I've become involved in a program called Ars Scientia, which embodies the excitement of what those two found possible in collaboration.

Merging the practices of art and science in the growing field of interdisciplinary research, Ars Scientia is a research partnership at UBC between Blusson QMI, the Department of Physics & Astronomy, and The Morris and Helen Belkin Art Gallery.

Despite the geographical separation between the Ars Scientia team, with my physics colleagues and I situated in the south and the gallery group in the north, the Main Mall that bisects the campus serves as a symbolic representation of our project's aim. It embodies our intention to unite these seemingly disparate parts, creating a cohesive whole from the different elements. As a core practice on a university campus, Ars Scientia is a special example of science and art interacting.

Continue reading on the Ars Scientia website here: https://tinyurl.com/yy92bfrd.

THE QUANTUM COMPUTING RESEARCH CLUSTER

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 52 students and graduated two cohorts.

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 (see page 33 for more on Quantum BC).

Other highlights of the year included a Quantum Photonics workshop that attracted 45 people from across Canada to learn how to design, fabricate and test their own quantum silicon photonic circuits, a six-day virtual workshop on Quantum Chemistry using IBM's gate-based quantum computer, a one-of-a-kind workshop on how to design, fabricate and test superconducting devices.

The cluster has also been a proud champion and sponsor of the UBC Quantum Computing Club, a student-led organization that is dedicated to bridging the gap between undergraduate and graduate-level studies in quantum computing and creating a diverse community of learners. In September 2023, the UBC Quantum Computing Club and the University of Toronto co-hosted Q-SITE, a student-driven quantum technologies conference. The event proved to be a huge success, attracting over 580 students and featured talks from Blusson QMI Investigators Roman Krems, Joe Salfi and Lukas Chrostowski.

The cluster has remained steadfast in its commitment to build an equitable, diverse and inclusive research and training environment. Some key actions have included expanding the female CREATE scholar mentorship program to all underrepresented CREATE students, increasing awareness of 3,100 K-12 students [of which 1,446 (46%) are girls] to quantum computing through the Diversifying Talent in Quantum Computing program (see page 48 for more on this program), and hosting an EDI dinner at the 2023 Quantum BC Research Day to provide a safe space for students and faculty to share their experiences and discuss EDI-related issues.

INFRASTRUCTURE

Senior Research Associate Mario Beaudoin (right) provides hands-on training to students at UBC Blusson QMI's Advanced Nanofabrication Facility (ANF).

UBC'S ADVANCED NANOFABRICATION FACILITY: BOOSTING CANADA'S NATIONAL R&D INFRASTRUCTURE AS PART OF THE QUANTUM COLABORATORY

The University of British Columbia's Advanced Nanofabrication Facility (ANF) is a world-leading device manufacturing facility that brings together partners from academia, industry, and government to reinforce Canada's position as a leader in developing next-generation quantum devices and quantum technologies. The facility is part of UBC Blusson QMI and is located on UBC's Vancouver campus.

The facility also complements Canada's growing national quantum infrastructure as part of the Quantum Colaboratory, a partnership between UBC Blusson QMI, Institut Quantique at Université de Sherbrooke, and Transformative Quantum Technologies (TQT) at the University of Waterloo aimed at accelerating quantum research and technology development by providing access to world-leading research expertise and facilities that exist within the universities.

ANF's focus on next-generation quantum materials has directly resulted in usage by key companies in Canada's rapidly growing quantum computing industry. The facility also enables Canadian researchers to compete at the international level in fields such as quantum computing, quantum devices, and photonics, among other impactful research areas.

ANF's success in attracting key industry users can be attributed to its cost-effective access to advanced tools—such as Canada's only photonic wire bonder—and providing high-level professional expertise for operating them. This is complemented by a short turnaround time for rapid research and development processes, and flexibility in tailoring to specific requirements.

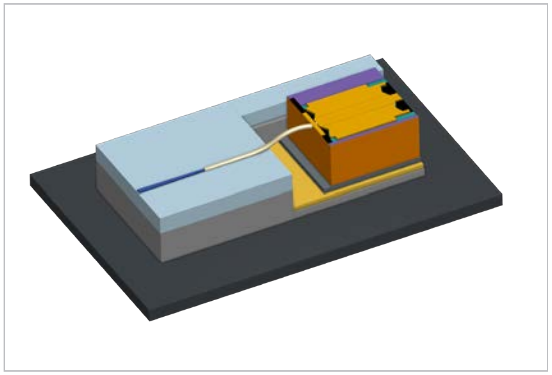
Services are offered on a per-use fee basis, which includes equipment training and professional assistance from the facility's technical staff, Facilities Director Pinder Dosanjh, and Scientific Director Jeff Young.

Industry clients use the ANF for the design, hybrid integration, and testing of chips for applications in quantum computing, quantum networking, biomedical sensing, automotive LiDAR, and data communications.

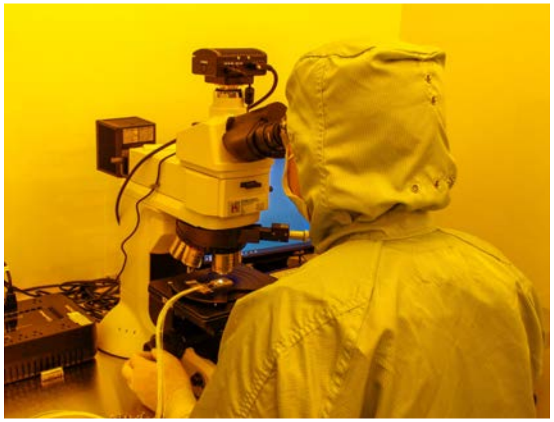
As part of UBC Blusson QMI, ANF business and government partners also have access to 25 multidisciplinary teams of physicists, chemists, and engineers with expertise in areas including, but not limited to, materials synthesis, quantum sensing, clean energy, quantum algorithms, and quantum computation.

AbCellera
APPLIED NANOTOOLS INC.
BioProducts Institute
Blue-O Technology Inc.
CMC MICROSYSTEMS
DREAM PHOTONICS
Djavad Mowafaghian CENTRE FOR BRAIN HEALTH
D-Wave The Quantum Computing Company
NORCADA
META Go Beyond.
NRC-CNRC NRC-IRAP Industrial Research Assistance Program
SiEPIC
SFU 4D LABS
sonus Microsystems
TRIUMF

PHOTONIC WIRE BONDING: INNOVATIVE ON-CHIP LASER INTEGRATION TO ADVANCE PHOTONICS TECH



Schematic of a DFB laser photonic wire-bonded to silicon on chip.



Dream Photonics Scientist Matthew Mitchell inspecting a fiber-array to chip sample that was photonic wire bonded at ANF's cleanroom. An optical microscope is used to qualitatively examine the device after bonding, before any subsequent processing steps. Image by Emily Mitchell.

UBC Blusson QMI researchers, led by Investigator Lukas Chrostowski, have developed a pioneering method for integrating lasers into photonic circuits, overcoming longstanding technical challenges and opening up new avenues in optical communication, quantum computing, and sensing technology.

The team uses ANF's photonic wire bonder—which employs a femtosecond pulsed laser acting like a precision laser printer—to create low-loss pathways (waveguides) directly on a chip using 3D printing. What makes this approach significant is that the results are comparable to measurements traditionally conducted using bulky and expensive bench-top (off-chip) lasers.

"Laser integration is something the silicon photonics community has been waiting for 20 years. Many foundries offer passive components like waveguides and optical filters, and active components like switches, modulators, and detectors, but the inclusion of lasers has remained a challenge," said Chrostowski.

"Today, most silicon photonics systems use external lasers, making the silicon chip an incomplete solution. The patented hybrid integration approach we developed has advantages over monolithic or heterogeneous integration approaches. Specifically, we can use known good die, namely laser chips that have previously been tested," Chrostowski said.

"We can work with any semiconductor laser type over a broad range of infrared wavelengths. These lasers can come from many different laser manufacturers, and have different sizes and output profiles. These features mean that research groups, startups, and industry users can prototype photonic circuits for various applications using a range of laser types."

Sheri Jahan Chowdhury, a graduate research assistant at UBC Blusson QMI, said the approach not only simplifies the measurement process but also enhances the accessibility of advanced photonic integration techniques, paving the way for more cost-effective and practical applications in various industries.

"Using basic lithography and etching techniques, we create small pockets on the chip with consideration of the dimension of the lasers to be integrated. This allows for the straightforward placement of established high-quality laser dies into these pockets, followed by photonic wire bonding to connect them seamlessly to adjacent silicon waveguides. This approach eliminates alignment issues and ensures efficient coupling," Chowdhury said.

The team welcomes opportunities to partner with foundries and industry users to scale their innovative on-chip integration solution.

FABRICATING QUBITS FOR D-WAVE QUANTUM

D-Wave Quantum is primarily known for its quantum annealing (QA) technology based on superconducting flux Qubits. Fluxonium, a relatively modern member of the flux-like qubit family, has also become an attractive candidate qubit for D-Wave Quantum.

Given the growing interest in fluxonium and D-Wave Quantum's deep experience in building flux-like qubit quantum technologies, the company has embarked upon a research program that harnesses the unique properties of fluxonium for all of D-Wave Quantum's technology development.

D-Wave has been collaborating with the ANF to prototype gate model quantum computing (GMQC) architectures based on fluxonium qubits. D-Wave's scientific and engineering personnel work closely with ANF staff to design, fabricate, and package circuits using the facility's state-of-the-art electron beam lithography (EBL) equipment and world-class EBL expertise.

MANUFACTURING PRECISION CRYO-EM GRIDS FOR BRAIN HEALTH TECH

Diseases, disorders, and injuries of the brain have a profound influence on our communities; the direct and indirect costs of neurological and mood disorders to the Canadian economy total more than $61 billion per year, and place enormous strain on affected individuals and their families. Understanding how a healthy brain works is essential to preventing and treating brain diseases, and both are essential to the health and well-being of Canadians.

Cryo-EM imaging technology, combined with AI, is an emerging method that could transform drug discovery by providing atomic resolution insights into the native structures of proteins implicated in disease. With cryo-EM, drugs and vaccines can be designed to specifically target and map precisely the desired sites for drug interaction on protein surfaces. One factor that is key to the success of the technology is preparing suitable specimens for imaging using cryo-EM. There is currently a major worldwide gap in the supply of suitable specimen supports (called grids) and limited options for customized design and manufacture of these grids.

By partnering with the UBC ANF, researchers from Djavad Mowafaghian Centre for Brain Health are now beginning to address this gap, both by leveraging existing technology for grid manufacture and by engineering novel methods to manufacture new grid supports for cryo-EM. This partnership allows the researchers to develop an efficient manufacturing process for the development of customized grids that meet stringent quality control measures. It also enables them to be independent of supply chain problems while simultaneously driving a successful and innovative interdisciplinary collaboration.

NEW NATIONAL FACILITY UNDER DEVELOPMENT: MID-INFRARED QUANTUM SENSING AND SPECTROSCOPY

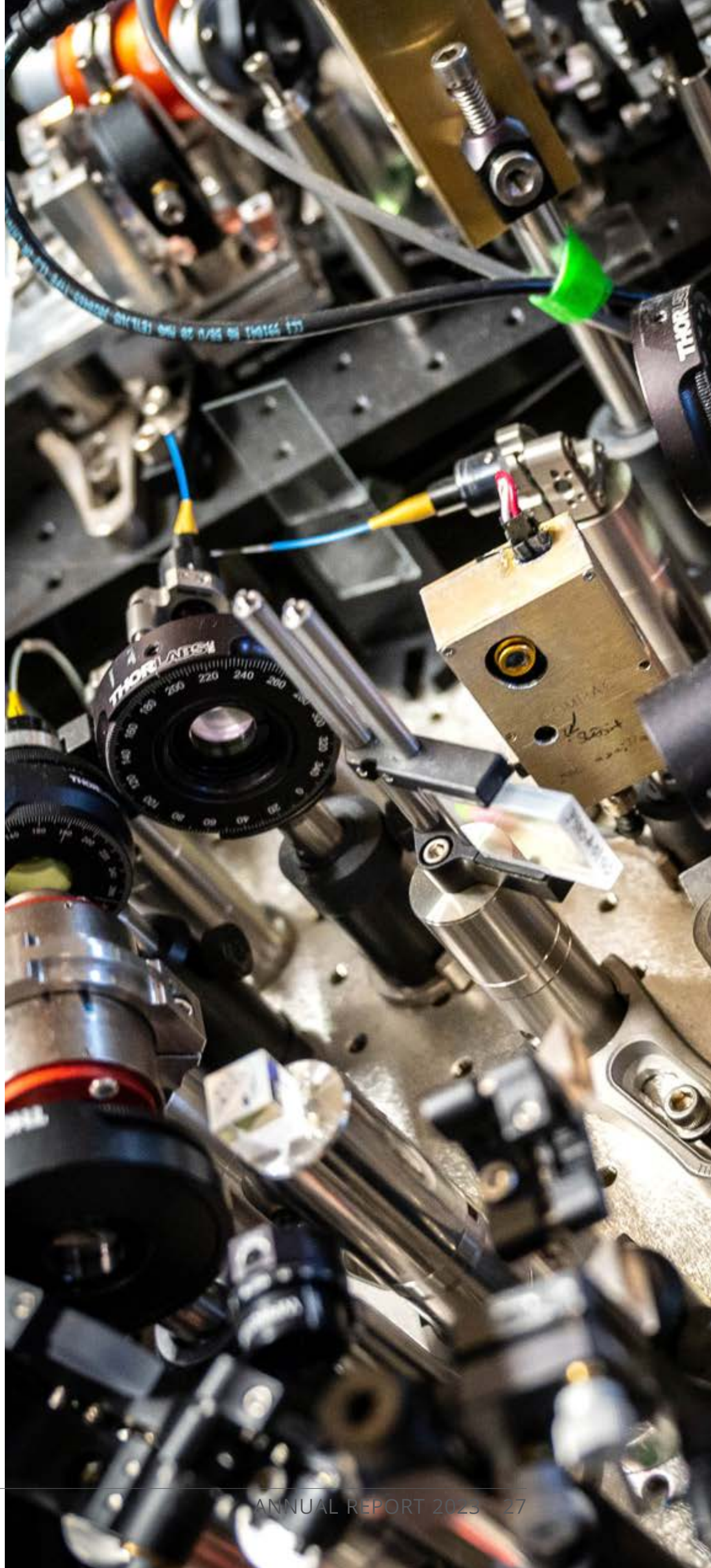
UBC Blusson QMI Investigator David Jones is a co-lead developing a new national Mid-Infrared Quantum Sensing and Spectroscopy (MIR-QUEST) facility, thanks in part to funding from the Canada Foundation for Innovation (CFI), the Government of Quebec (MEI), and the British Columbia Knowledge Development Fund (BCKDF). Investigator Ziliang Ye is part of the core multidisciplinary team in this project, contributing his expertise in quantum materials and devices.

The project brings together Polytechnique Montréal, Université de Montréal, McGill University, and the University of British Columbia in a multi-institutional effort that enables advanced capabilities for mid-infrared quantum technologies and applications by focusing on:

- Efficient single-photon and bright quantum light sources
- Cost-effective single-photon avalanche photodiodes and field-based detectors
- Novel spectroscopy modalities
- Sensing technology demonstrators in trace gas detection

Quantum photonic technologies promise to revolutionize communications, computing, and sensing. In particular, sensing in the mid-infrared is an emerging global priority that will enable applications including the synthesis of advanced materials (pharmaceuticals, polymers), quality assurance of chemical products (crop protection, fertilizers), health (disease diagnosis), and climate change (real-time analysis of greenhouse gases).

The infrastructure aims to address the urgent need for MIR quantum sensing and spectroscopy capabilities, resulting in robust market-ready sensing technologies. The team has laid out a detailed roadmap to usher in new fundamental knowledge, enable disruptive quantum technologies, and help train the workforce in this emerging strategic sector. Infrastructure development is expected to begin in 2024.



PARTNERSHIPS

Investigator Joseph Salfi and group at UBC Blusson QMI's Quantum Science and Technology Laboratory.

Rafael Haenel, PhD graduate, UBC

Alannah Hallas (Killam Prize for Teaching), Investigator; Andrea Damascelli, Scientific Director; Rafael Haenel, PhD graduate; Stepan Fomichev, PhD graduate; Mona Berciu, Investigator.

MAX PLANCK-UBC-UTOKYO CENTRE FOR QUANTUM MATERIALS

The Max Planck-UBC-UTokyo Centre for Quantum Materials (CQM) is a world-leading collaborative venture between the Max Planck Society (Germany), The University of British Columbia (Canada), and the University of Tokyo (Japan). It features 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 Centre 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.

International Joint PhD Program in quantum materials

The Joint PhD Program in Quantum Materials is a unique academic program between UBC and the University of Stuttgart, with participation from the Max Planck Society. The program offers unparalleled opportunities to study in the fields of quantum materials and quantum materials-based devices. Its highly collaborative nature exposes graduate student scientists to a wide variety of experimental and theoretical techniques and materials systems, preparing them to contribute to a rapidly evolving research frontier.

The first graduate of the Joint PhD Program, Rafael Haenel, was celebrated at UBC's November 2023 convocation. Now a Quantum Software Engineer at the quantum computing company Photonic Inc., Rafael credits his international PhD experience for providing a solid foundation.

"My current role involves doing quantum physics for half of the time and computer engineering in the other half, which is not too different from my work as a PhD student that also involved running numerical simulations and writing scientific codes," said Rafael.

"As part of the joint PhD, I got to spend time at both Blusson QMI in Vancouver and the Max Planck Institute for Solid State Research in Stuttgart, allowing me to participate in cutting-edge research at both institutions and interact with many people during summer schools and conferences."

Although Rafael's studies have been primarily focused on theory, he has made several forays into experimental physics and engineering during his joint PhD. Notably, he has designed and built an electrical circuit simulating a Chern insulator — a type of topological insulator that behaves as an insulator in its interior but conducts electricity along its edges or surfaces.

In another project, Rafael worked with Oguz Can (also a PhD student at Blusson QMI) to build a highly efficient Josephson diode — a superconducting electronic device with unique properties. Rafael and Oguz not only devised the idea but were also able to implement it as a practical design by participating in the workshop "Build Your Own Superconducting Quantum Device," organized jointly by Blusson QMI and CMC Microsystems. As a result, a chip now exists with the Josephson diode circuit imprinted on it and awaiting its test run.

"The joint PhD program does an excellent job of fostering a collaborative research environment. By creating conditions that allow students to interact with supervisors and researchers in two different institutions, it succeeds in broadening their horizons significantly," said Blusson QMI Investigator Marcel Franz, who supervised Rafael's research at UBC. Franz's counterpart in supervising Rafael's research was Dirk Manske from the Max Planck Institute in Stuttgart.

Valentin Zimmermann, PhD student, UBC

The CQM summer school from September 27 to 29 in Dresden, Germany

CQM Summer School: Accelerating the training of future quantum workforce

The Max Planck-UBC-UTokyo Centre for Quantum Materials (CQM) community came together for the Centre's annual summer school from September 27 to 29 in Dresden, Germany.

Hosted by the Max Planck Institute for Chemical Physics of Solids, this year's event focused on X-rays for the study of quantum materials. Blusson QMI Scientific Director Andrea Damascelli and Professor Emeritus George Sawatzky were among the speakers at this event.

"The summer school is a signature event of the Centre, bringing together students, postdoctoral fellows, and thought leaders in quantum materials from across the world to share updates and discuss opportunities for collaboration," said Damascelli.

"Learning about the new techniques developed for the study of quantum materials from leaders with direct expertise not only enables the students to apply the techniques in their research but also positions them effectively to further develop these techniques.

"The unique partnership provides an exceptional training environment for the future quantum workforce by positioning students to engage in cross-institutional projects of international significance geared towards impactful knowledge generation and experimental progress in quantum materials."

Joint PhD student Valentin Zimmermann, who attended the summer school, said: "For me, the CQM Summer School was a fantastic event to hear from experts in the field of X-ray spectroscopy and also a great networking opportunity among other students and principal investigators. I learned a lot about techniques that I hadn't worked with previously and got a lot of ideas which I can also apply to my own research projects."

The CQM annual meeting at the University of Tokyo

Boasting a dynamic three-day program of research showcases and scientific gatherings, members of the Max Planck-UBC-UTokyo Centre for Quantum Materials (CQM) came together at the University of Tokyo from Dec 11-13, 2024.

Among the speakers were Blusson QMI Scientific Director Andrea Damascelli, Deputy Scientific Director Marcel Franz, Investigators Alannah Hallas, Mona Berciu, Andrew Potter, Ke Zou, Ziliang Ye, Staff Scientist Dongjoon Song, and PhD students Niclas Heinsdorf and Cissy Suen.

UBC BLUSSON QMI AWARDED $5.8M TO ADVANCE CANADA'S NATIONAL QUANTUM STRATEGY

UBC Blusson QMI researchers were awarded more than $5.8 million under the 2023 round of the Natural Sciences and Engineering Research Council of Canada (NSERC) Alliance grants to realize the ambitious missions set by Canada's National Quantum Strategy (NQS).

UBC Blusson QMI Scientific Director Andrea Damascelli congratulated the grant recipients and said the investment is a testament to the key role that quantum materials research will play in the success of the NQS, and in cementing Canada's position as a global leader in the quantum arena.

"In the early days, we engaged with the government to lay the foundation for the NQS. Today, we're proud to be a key research partner supporting the implementation of the Strategy through delivering high-impact R&D programs that bring together our researchers with local and international partners," Damascelli said.

Joe Salfi, Investigator, UBC Blusson QMI

"BC has a strong ecosystem of world-leading researchers and quantum technology companies. By working together and sustained investment, the province could become a key driver of quantum science in the world."

UBC Blusson QMI Investigator Joseph Salfi was awarded $4.9 million to lead a pan-Canadian consortium with the Universite de Sherbrooke, the University of Waterloo, Ecole Polytechnique de Montreal, and McGill University.

The consortium aims to advance the science and technology of quantum computation in Canada via the design, fabrication, and investigation of a new quantum processor, the key technological component of a quantum computer.

"If we can unlock its power, quantum computing could revolutionize how we tackle problems like energy conversion, storage, and climate change," said Salfi.

"Imagine if we could model molecules to help us discover new drugs, design new materials, or simulate how to capture and transform greenhouse gases into something useful. Classical computing can't perform those types of complex calculations – but quantum computing holds the potential to do this.

"Our goal is to investigate and demonstrate a new quantum computer architecture that is designed from the ground up for reliable and flexible simulation of materials and chemistry, long before general-purpose quantum computation can solve difficult computational problems."

Key partnerships enable the consortium to move quickly along its science and technology roadmap: the National Research Council of Canada, CMC Microsystems, the Canadian company 1QBit Information Technologies, the Leibniz-Institut für Kristallzüchtung in Germany, multinationals Keysight Technologies, and Oxford Instruments, and strategic partners called the Sherbrooke Innovation Zone in Quebec and the Quantum Algorithms Institute of British Columbia.

Another funded research program ($911,400) led by UBC Blusson QMI Deputy Scientific Director Marcel Franz, brings together researchers with industry leader D-Wave Systems to answer key questions about the power of a specific model of quantum computation called quantum annealing.

"Our objective is to show that the quantum annealer can efficiently solve optimization problems that cannot be solved by the currently available classical computers," said Franz.

"The hope is to firmly establish the "quantum advantage" of the D-Wave hardware by benchmarking its performance against the most powerful known classical algorithms."

D-Wave Systems was founded in 1999 as a UBC offshoot. Two of the four founders—Geordie Rose (former CEO/CTO) and Alexandre Zagoskin (former VP Research and Chief Scientist)—studied at UBC's Department of Physics & Astronomy. Rose was a PhD student and Zagoskin was a postdoctoral fellow. They named the company after their first cubit designs, which used d-wave superconductors.

"It is very fitting that the NSERC Alliance Quantum program is now enabling significantly expanded collaborations between UBC and D-Wave researchers aimed at what increasingly looks like a successful practical implementation of deep ideas originally conceived here at the UBC Vancouver campus," Franz said.

Also funded was a project by Damascelli and a second project by Salfi under the Alliance International Quantum grants category aimed at supporting researchers to establish and grow international collaborations in quantum science and technology.

Under the recent round of the NSERC Alliance grants and Collaborative Research and Training Experience (CREATE) grants announced today, the federal government has committed a total investment of nearly $51 million awarded to 75 recipients to turbocharge Canada's quantum capabilities. The grants will also enable the advanced training of more than 900 graduates and postdoctoral fellows in the field.

QUANTUM BC: EMPOWERING THE QUANTUM ECOSYSTEM THROUGH COLLABORATION AND TRAINING

A joint partnership led by UBC Blusson QMI, Simon Fraser University (SFU), and the University of Victoria (UVic), Quantum BC has established itself as a leader in building an ecosystem to strengthen and showcase collaborative efforts in research, training, and innovation in quantum computing across British Columbia.

In 2023, Quantum BC held its inaugural annual Quantum BC Research event at the University of Victoria, attracting over 70 faculty, students, and industry professionals from the Quantum BC community. The event featured research and industry talks from the Quantum Algorithms Institute and Good Chemistry Company (now acquired by SandboxAQ), student poster presentations, and an EDI-focused dinner sponsored by the cluster.

Quantum BC has also organized ten seminars with speakers from across British Columbia and beyond, covering a wide variety of topics in quantum computing theory, hardware, and software. Quantum BC's annual online workshop, in collaboration with Université de Sherbrooke and CMC Microsystems, took place in January, focusing on Quantum Chemistry and benefiting students and trainees from across Canada.

In October, a Career Fair was held at the Quantum Algorithms Institute, providing students with the opportunity to hear from quantum computing companies about available opportunities and the skills that will help them in their future careers.

Quantum computing courses at both the graduate and undergraduate levels were offered by Quantum BC at UBC, SFU, and UVic in dynamic formats covering beginner-friendly topics as well as hands-on fabrication. Supported by Quantum BC, the UBC Quantum Club hosted the Q-Site conference in September, bringing together over 100 students, faculty, and industry professionals.

Javiera Tejerina-Risso, Quantum Studio artist-in-residence

Left to right: Geraldine Dantelle, Embassy of France; James Day, UBC Blusson QMI; Javiera Tejerina-Risso, Quantum Studio, artist-in-residence; Shelly Rosenblum, the Belkin Art Gallery.

QUANTUM STUDIO ARTS-SCIENCE RESIDENCY

The Embassy of France in Canada, in partnership with UBC Blusson QMI and the Morris and Helen Belkin Gallery (the Belkin), has launched Quantum Studio, a new Art-Science residency.

Opened to all art forms, the Quantum Studio residency builds exchanges between art and quantum science, immersed at the renowned UBC campus and in the rich local artistic ecosystem, creating new synergies and strengthening the bond between Western Canada and France.

Blusson QMI and the Belkin provide the selected artist with a space in which the artist and researchers connect, discuss their interests, and learn from one another to create a project at the junction between art and science.

Multidisciplinary French-Chilean artist Javiera Tejerina-Risso was Quantum Studio's first artist-in-residence, joining us at Blusson QMI in November 2023 from Marseille, France. Having worked in art and science for more than 15 years, Javiera has developed a collaborative approach in her creative practice, enabling her to work with researchers. She recently showed her work at the Bienal Tlatelolca in CDMX. Javiera's work unfolds in the exhibition space primarily in the form of installations and videos, and engages deeply with the scientific imagination, notably relying on the vocabulary and research in Physics.

As part of the Quantum Studio residency, Javiera interacted closely with Ars Scientia Program Manager James Day and other UBC Blusson QMI Investigators, and delivered two talks on her experience as a Quantum Studio artist in Vancouver. The next round of this residency program will take place in November 2024.


THE BRIMACOMBE BUILDING
2355 East Mall
Stewart Blusson
Quantum Matter
Institute

SIGNATURE EVENTS

We were delighted to welcome Dr. Stewart Blusson and Marilyn Blusson to UBC Blusson QMI for a tour of our labs and briefing on our R&D and training programs in August 2023. Marilyn and Stewart are among the most generous philanthropists in Canadian history and some of the country's most committed advocates of crucial basic research that can lead to world-changing discoveries.

UBC BLUSSON QMI'S RESEARCH HIGHLIGHTED AS PART OF THE GERMAN PRESIDENT'S VISIT TO UBC

(Left to right): Scientific Director Andrea Damascelli; joint PhD students Cissy Suen, Niclas Heinsdorf, Valentin Zimmerman; First Lady Elke Büdenbender; and President Frank-Walter Steinmeier.

The University of British Columbia hosted Frank-Walter Steinmeier, the President of Germany, as part of his first official visit to Canada on April 25, 2023.

President Steinmeier toured UBC's soon-to-open hydrogen research platform and met researchers working on clean energy and climate change solutions, as well as members from Blusson QMI involved in the Max Planck-UBC-UTokyo Centre for Quantum Materials (see page 29 for more on this partnership).

"We were delighted to welcome President Steinmeier to UBC and to showcase our commitment to sustainable energy and advancing research that addresses climate change," said [former] UBC President and Vice-Chancellor Dr. Deborah Buszard. "President Steinmeier's visit underscores the importance of international collaboration in the field of clean energy, and we look forward to continued partnerships with German institutions."

"What we saw here during our visit to British Columbia is the close cooperation between science institutions at UBC and in Germany and Canada, and this is encouraging for the future," said President Steinmeier. "Germany and Canada are working together to make the world a better place, and that means changing our daily behavior and developing innovative technology."

The 70-member German delegation included the Minister of Education and Research Bettina Stark-Watzinger, First Lady Elke Büdenbender, German Ambassador to Canada Ms. Sabine Sparwasser, and representatives from parliament, business, science, and culture.

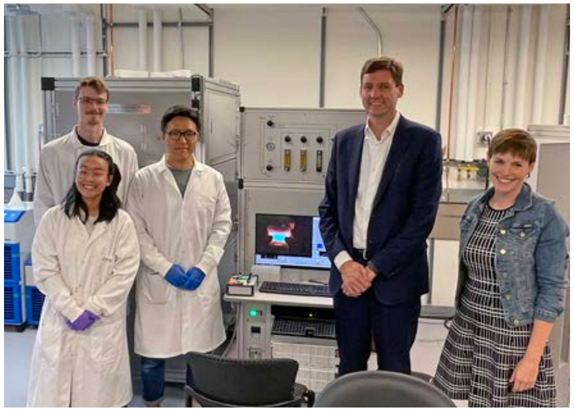
As part of UBC's research showcase, President Steinmeier attended Blusson QMI's booth, where he was welcomed by Blusson QMI Scientific Director Prof. Andrea Damascelli and four joint PhD students — Cissy Suen, Valentin Zimmerman, Niclas Heinsdorf, and Rafael Haenel — from UBC, the Max Planck Institute for Solid State Research, and the University of Stuttgart.

"The program gives me the chance to experience a second academic environment. I get to meet interesting people and participate in cutting-edge research and collaboration between two institutes, two cultures," said Rafael Haenel, a joint PhD student who's part of the program between UBC, Max Planck, and the University of Stuttgart.

The Blusson QMI research showcase included a demonstration of superconductivity using Blusson QMI's levitation track by Research Associate James Day and Facilities Director Pinder Dosanjh, and a live experimental demonstration of entanglement and interference using a quantum physics science kit called 'Quantenkoffer.'

Canada welcomes several thousand German students every year, and the German visit highlights how these students can tap into opportunities to engage in top-tier research, particularly at UBC.

(Left to right): Andrea Damascelli, Scientific Director, Blusson QMI; Pinder Dosanjh, Operations Manager, Blusson QMI; Premier David Eby, BC Government; Gail Murphy, Vice-President Research & Innovations, UBC; Meigan Aronson, Dean of Science, UBC.



B.C. PREMIER DAVID EBY VISITS UBC BLUSSON QMI

British Columbia Premier David Eby visited UBC Blusson QMI on July 24 to tour the state-of-the-art research facilities and hear about the Institute's training, research, and technology development programs.

The tour began with a stop at UBC Blusson QMI's Quantum Science and Technology Laboratory, which is led by Assistant Professor Joseph Salfi, an expert in the physical implementation of quantum computers and quantum simulators. The Premier was briefed on the Institute's world-leading quantum computing research and industry partnerships.

In April 2023, Salfi was awarded $4.9 million to lead a pan-Canadian consortium with the Université de Sherbrooke, the University of Waterloo, Polytechnique Montréal, and McGill University to advance quantum computation in Canada via the design, fabrication, and investigation of a new quantum processor, the key technological component of a quantum computer. The consortium is anticipated to attract a number of highly qualified research personnel, including students and postdoctoral fellows, to BC for training (see page 31 for more).

Next, the group visited the Quantum Materials Design Lab, led by Assistant Professor Alannah Hallas, a crystal growth expert and a 2023 UBC Killam Prize winner for excellence in teaching.

Hallas and her students showcased highlights of their research and expanded on the critical impacts of quantum materials discovery and design for building future quantum technologies, and the potential for such R&D to create multi-million-dollar industries and jobs. Hallas has crafted an ambitious plan to develop high-pressure synthesis capabilities, including a high-pressure image furnace apparatus that will be the first of its kind in Canada.

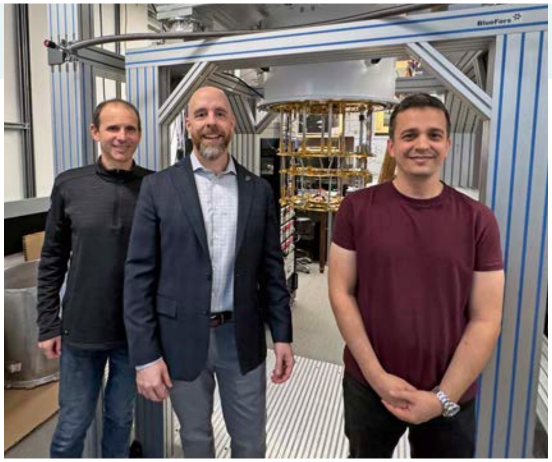
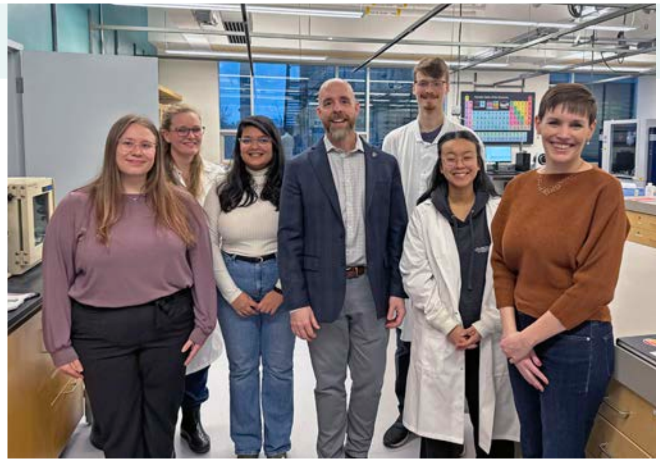
After engaging with Hallas and her students, the tour stopped by the Berlinguette Lab, where researchers build reactors that convert CO2 into useful products, drive nuclear fusion at low temperatures, and electrify the fuels, chemicals, and cement industries.

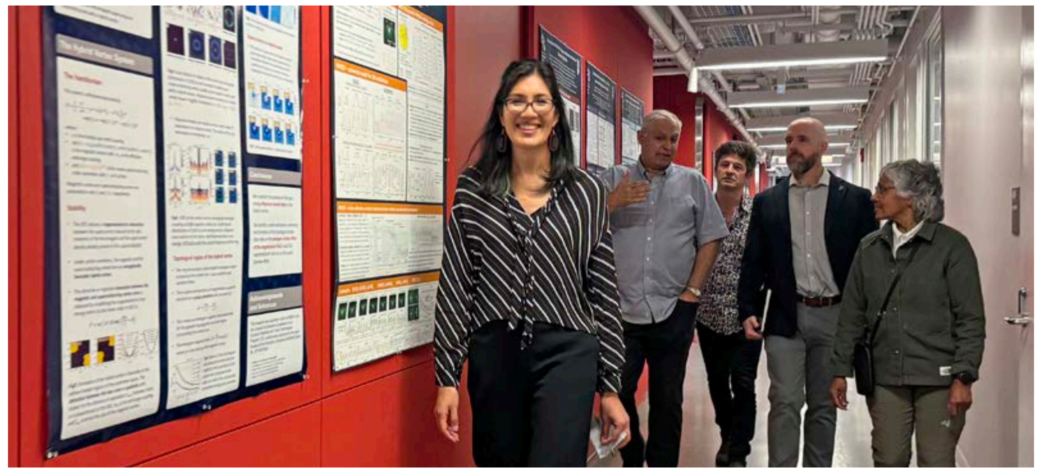
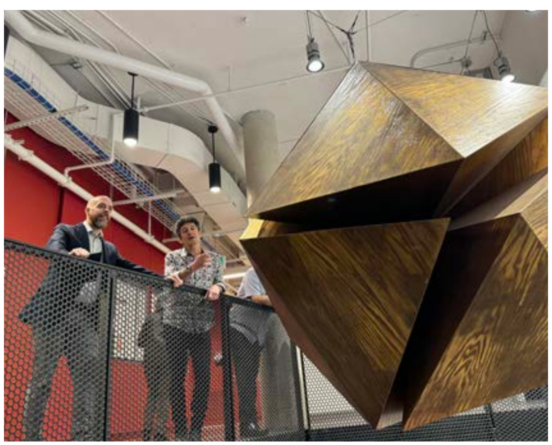
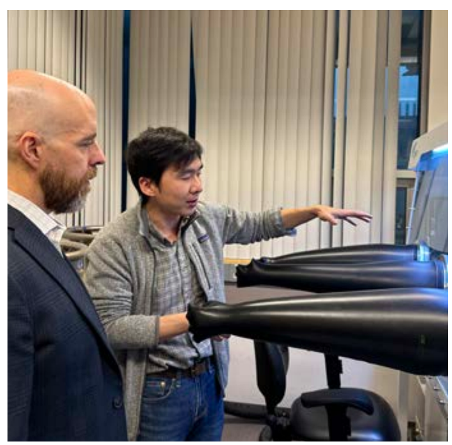
Stops that followed included the molecular beam epitaxy (MBE) lab and the angle-resolved photoemission spectroscopy (ARPES) facility, which are used to study and fine-tune quantum materials for applications in high-tech industries.

The tour concluded with a visit to Blusson QMI's Advanced Nanofabrication Facility (ANF) and its recently upgraded cleanrooms. The Premier heard about ANF's partnerships with industry users and companies who utilize the facility and the expertise of its research scientists for tech support, hands-on training for their staff, and device development.

WELCOMING UBC PRESIDENT AND VICE-CHANCELLOR TO BLUSSON QMI FOR A RESEARCH SHOWCASE AND TOUR

We were honoured to host UBC President and Vice-Chancellor, Prof. Benoit-Antoine Bacon, for a tour of our state-of-the-art facilities, a showcase of our research capabilities, and industry partnerships. Hosted by UBC Science Dean Prof. Meigan Aronson and Scientific Director Prof. Andrea Damascelli, along with Managing Director Paola Baca and Facilities Director Pinder Dosanjh, President Bacon met with various members of the Institute, including our students, business operations & scientific staff, early career researchers, principal investigators, and the executive committee.


INVESTING IN THE 'UNIMAGINABLE BREAKTHROUGHS OF THE NEXT FEW DECADES'

Hosted by the Canadian Science Policy Centre, quantum thought leaders and industry experts from across Canada came together this week for a panel discussion on Canada's National Quantum Strategy (NQS). Blusson QMI Scientific Director Andrea Damascelli and Investigator Sarah Burke were part of the panel.

Damascelli regarded the launch of the quantum strategy as a significant milestone for Canada.

"In 2015, the federal government made major investments in quantum R&D by creating three research institutes under the Canada First Research Excellence Fund (CFREF), which brought together academia, industry, and government, and positioned the country at the forefront of the field," said Damascelli.

"The strength of the NQS is that it recognizes Canada's position as a leader in quantum technology and further unites the quantum community to work towards focused missions. The strategy is also important for strengthening international connections with other countries that are pushing forward this field, highlighting our strengths in Canada across the globe."

Backed by an investment of $360 million, the NQS was launched in January 2023 to cement Canada's position as a leading country in quantum research and technology development, expand the industry, and train the future quantum workforce.

Blusson QMI Investigator Sarah Burke acknowledged the importance of the newly formed Quantum Advisory Council.

"The Advisory Council is well-positioned to identify particular needs of the industry and advise the research community and the government about those needs and use cases for future R&D," said Burke.

"Coming from a quantum materials perspective, our institute is focused on the discovery and engineering of materials that are the building blocks for the quantum technologies targeted in the NQS.

"Collaboration is key and central to a lot of our work. Emerging quantum technologies require fundamental science to be done behind them, which can then accelerate the industry forward."

The Quantum Advisory Council was established by the federal government this summer to provide impartial advice to Innovation, Science, and Economic Development Canada and monitor the progress of the NQS. The council draws on expertise from industry, the academic, not-for-profit, and investment communities.

Speaking to the potential challenges of realizing the NQS, Prof. Damascelli said an area that requires further investment is the training of the future quantum workforce and the retention of the scientific staff that operate the labs.

"A huge challenge is ensuring that we have the quantum workforce that we will need in the future to support the industry. In parallel to that, which I think is critical, is also supporting the technical and scientific personnel that not only enable the translation effort to industry but also provide hands-on training to students and businesses," Damascelli said.

"It's crucial that we maintain our intellectual capacity in Canada, making sure we retain the people that we've trained and the people that we brought here to build up our strengths," added Burke.

"Having sustained funding for fundamental research and training will be critical to our future so we can ensure that we have the next technology in our pockets, that it's not somebody else developing it. We need to invest in areas that can lead to tangible outcomes in the short term, but most importantly in areas that could lead to unimaginable breakthroughs in the next few decades."

Other panel speakers included Aimee K. Gunther, Deputy Director of the Quantum Sensors Challenge Program at the National Research Council Canada; Nick Werstiuk, CEO of Quantum Valley Ideas Lab; and Eric Miller, Fellow of the Canadian Global Affairs Institute.-

QUANTUM DAYS 2023: SHAPING CANADA'S FUTURE WITH QUANTUM TECHNOLOGY

Featuring a lineup of prominent speakers from across academia, industry, and government, Quantum Days 2023 took place online between January 17-19, 2023.

Minister of Innovation, Science, and Industry, the Hon. François-Philippe Champagne, officiated the event with a video recording, noting that Canada's newly launched Quantum Strategy will amplify Canada's existing strength in quantum.

"We're already doing impressive work in the science and research behind quantum, but now is the time to take our spot at the forefront of the quantum revolution," said Minister Champagne.

"From batteries in electric vehicles to electricity grids to supply chains or even how drugs and medicine are developed, the benefits of quantum technologies are really infinite and so are the opportunities."

As part of the event's program, Principal Investigator at UBC Blusson QMI and Professor at Department of Physics & Astronomy, Jeff Young, presented a talk on Quantum Interfaces focused on integrated silicon photonic components for quantum information processing. Postdoctoral Fellow at Blusson QMI, MengXing (Ketty) Na, moderated a session on Quantum Materials featuring speakers from universities across Canada.

(left to right): Blusson QMI's Pinder Dosanjh, Sarah Burke, Alannah Hallas, and Jeff Young with ISAB Members Stephen Bartlett (University of Sydney), Lesley Cohen (Imperial College London), Seamus Davis (Cornell University), Stuart Parkin (Martin Luther University), and Blusson QMI Scientific Director Andrea Damascelli.

BLUSSON QMI'S INTERNATIONAL SCIENTIFIC ADVISORY BOARD VISIT TO VANCOUVER

We were delighted to welcome the distinguished members of Blusson QMI's International Scientific Advisory Board (ISAB) to Vancouver on September 19-20 for a robust program of scientific talks, lab tours, and discussions. The two-day event was opened by UBC VP of Research & Innovation, Prof. Gail Murphy, and included talks on Blusson QMI's Grand Challenges, a tour of our research facilities, and a poster competition.

(left to right): Ritu Thombre, Abhishek Abhishek, Marcus Edwards from the UBC team.

BC TEAMS SHINE AT XANADU'S CANADIAN QUANTUM CUP

Students from across 15 Canadian universities came together this month at Xanadu's Canadian Quantum Cup to showcase their quantum programming skills. British Columbia was represented by two teams from the University of British Columbia (UBC) and University of Victoria (UVic). Of the 15 teams, the University of Victoria team came in second place, followed by the UBC team, which came third.

Members of the UBC team included Marcus Edwards, Ritu Thombre, and Abhishek Abhishek. Members of the UVic team included Jose Ossorio, Prashanti Priya Angara, Mohammad Kashfi Haghighi, and Sajed Karimy.

Members of both BC teams are scholars in the NSERC CREATE in Quantum Computing program. Led by Blusson QMI in collaboration with UVic and Simon Fraser University, the NSERC CREATE in Quantum Computing program provides students with highly specialized technical expertise and commercial skills in both quantum computing hardware and software (see page 22 for more on this program).

UBC BLUSSON QMI ANNUAL RETREAT 2023

The UBC Blusson QMI community gathered at Loon Lake Lodge in Maple Ridge for our annual retreat from September 22 to 24. The weekend was filled with team-building outdoor activities, scientific presentations, short lightning talks, unconference discussions, and panel sessions.

This year, our retreat placed a special focus on equity, diversity, and inclusion (EDI). We were honored to host Dr. Eden Hennessy from Wilfrid Laurier University, who delivered an insightful talk on diversity and inclusion in Physics in Canada. Dr. Hennessy also facilitated a panel discussion on EDI featuring Blusson QMI members including Andrea Damascelli, Kirsty Gardner, and Dong Chen.

Student Mario Ulises Gonzalez Rivas sets up a new measurement using the powder diffractometer in the Hallas lab.

EQUITY, DIVERSITY AND INCLUSION / OUTREACH

Graduate Research Assistant Gargi Kodgirwar at UBC Blusson QMI MBE Lab.

'QUANTUM PATHWAYS' LEADS UNDERGRADUATE STUDENT TO RESEARCH SUCCESS

In the summer of 2023, Joan Weng, an undergraduate student who joined Ke Zou's Group through UBC Blusson QMI's *Quantum Pathways* program, began growing an inorganic material using the Institute's molecular beam epitaxy (MBE) facility.

Joan's study was published in the *Journal of Vacuum Science and Technology A* and reported on progress made toward fine-tuning the atomic structure of an electrolyte for use in solid-state lithium-ion batteries.

"This study is the first step in our approach to exploring the potential of MBE synthesis for lithium-ion battery materials," said UBC Blusson QMI Investigator Ke Zou. "It is still at an early stage, but the materials we are studying have the potential to improve the technology and make it more accessible."

MBE is a thin-film deposition technique that allows individual atoms or molecules to be deposited onto a crystalline substrate one layer at a time, resulting in well-ordered and atomically precise thin films.

"Joan is an exceptional undergraduate student with a strong research drive. Over the summer, she successfully completed this paper and has already begun collaborating with other researchers at UBC," Zou said. "She is poised to independently continue the project in the next year."

Describing the process of working with MBE to grow the thin films for this study, Joan said she first prepares the vacuum chamber by introducing oxygen and other required elements into the environment.

"After the atmosphere is right, the growth starts, and we allow the heated particles in the chamber's atmosphere to evaporate and condense on a substrate. Once the calibration process is done, we let the material rest to form ordered layers. Meanwhile, we observe the material using diffraction techniques — which at first glance reminded me of the aurora borealis [northern lights]," Joan said.

"I'm excited to have published my first academic paper, but what I'm most grateful for are the friends I made along the way and the incredible support and training I received."

In future studies, researchers will attempt to introduce lithium into this material and conduct various tests in collaboration with other groups at UBC to bring the research one step closer to real-world applications. Notably, the study draws on the expertise of several graduate students and senior researchers at Zou's lab, and others from the Canadian Light Source in Saskatoon and the Max Planck Institute for Solid State Research in Germany.

Created by UBC Blusson QMI, *Quantum Pathways* provides multi-year summer research scholarships to undergraduate students whose backgrounds and identities are underrepresented in STEM.

J. Weng, H. Shin, S. Godin, M. Oudah, R. Sutarto, R. Pons, B.A. Davidson, K. Zou. *Ordered deficient perovskite La2/3TiO3 films grown via molecular beam epitaxy.* J. Vac. Sci. Technol. A Vac. Surf. Films **41**, 062703 (2023).

ADDRESSING DIVERSITY GAPS IN QUANTUM COMPUTING AND EMERGING TECHNOLOGIES

In 2022, McKinsey reported that only one-third of Canadian quantum roles were filled, and EGBC noted that only 20.6% of new Professional Engineers in Canada were women as of 2020. This disparity is set to grow unless we take active measures to engage new learners in the field of quantum computing. To address this, we've launched the Diversifying Talent in Emerging Technologies (DTET) program, aiming to introduce diverse young people in Canada to the technologies that will shape our future.

DTET brings together UBC Geering Up, Blusson QMI, DIGITAL, the Quantum Algorithms Institute (QAI), and D-Wave with a mission to bridge the gap between industry demand and diverse Canadian talent by offering mentors, developing curriculum, providing student exposure to STEM, and ensuring active representation. Through early exposure and sustained support, DTET is dedicated to closing the diversity gap in emerging technologies.

DTET builds on the success of the Diversifying Talent in Quantum Computing (DTQC) program, an educational and outreach initiative led by UBC Blusson QMI and Geering Up. Launched in 2019, DTQC's programming reached over 3,400 youth (46% girls), 800 educators, and 3,600 members of the public, benefiting thousands from diverse groups. DTQC concluded in 2022 after three impactful years.

In its initial years, DTQC focused on pilot curriculum development, establishing long-term industry and academic partnerships, and delivering both online and in-person sessions. We created the first version of our Quantum Computing Masterclass, which evolved into a for-credit course with the University of Ottawa. Collaborating with the UBC Geering Up InSTEM team, we engaged with various Indigenous community partners across the province, co-delivering programs and supporting visits to 13 different communities.

In the latter years, we refined our curriculum and delivery methods, targeting grades 6-12 alongside professional development and public outreach. We published two free courses on EdX: *Quantum Computing for Your Classroom* (for educators) and *Introduction to Quantum Computing* (for students). Our partnerships expanded, allowing us to present at five different conferences including the Canadian Association of Physicists (CAP), the Institute of Electrical and Electronics Engineers (IEEE), and the Argonne National Laboratory.

With DTET, we aim to continue our commitment to creating a more inclusive future by equipping diverse young minds with the skills and opportunities to thrive in emerging technologies.

UBC Geering Up
Engineering Outreach

QUANTUM PROGRAMMING SNAPSHOT

YEAR-ROUND

- Asynchronous online learning
- General public initiatives
- Guest lecture work for other partners

FALL

- Clubs
- Events

WINTER

- Clubs
- Events
- Conferences
- Workshops

SPRING

- Conferences
- InSTEM
- Conferences
- Course launches

SUMMER

- Camps
- InSTEM in-community trips

Ella Meyer, Program Manager, DTET

MEET DTET PROGRAM MANAGER ELLA MEYER

Ella Meyer is the Quantum Computing Outreach Coordinator at UBC Geering Up and the Project Manager for the Diversifying Talent in Quantum Computing initiative. She graduated with a B.Sc. in Astronomy from the University of British Columbia in 2020 with a research focus on the Cosmic Microwave Background and radio wave detection. Ella has been working in science education and communication for the last three years in partnership with industry and academic partners worldwide, including UBC Blusson QMI, Microsoft, D-Wave Systems, and QAI.

Ella welcomes opportunities for partnerships with collaborators from across industry and government looking to support initiatives such as the Diversifying Talent in Emerging Technologies (DTET). Get in touch with Ella here: ella.meyer@ubc.ca.

WOMEN IN PHYSICS CANADA CONFERENCE (WIPC)

In July 2023, UBC Blusson QMI Investigator and Chair of the EDI Committee Sarah Burke spoke as part of the Women in Physics Canada Conference in Winnipeg, Manitoba. UBC Blusson QMI was a proud sponsor of the 2023 event. In her talk, Burke invited the audience on a journey through the world of atoms and molecules with scanning tunnelling microscopy (STM).

"I spoke about my own journey into the field of quantum materials through the 'lens' of STM, while showing some of the different materials we've explored and the insights gained by this atomic-scale view. We've seen how defects serve as a powerful probe of the electronic structure of quantum materials and how probing the local electronic states can help us understand and design devices and even chemical reactions," said Burke.

"All speakers did an amazing job of weaving together their work and stories. Enormous thanks go to the organizing committee for assembling such an engaging and interactive program with ample opportunity to build community. It's been an honour to contribute my story to this celebration of Women in Physics in Canada."

SCIENCE WORLD'S GIRLS & STEAM SUMMIT

In November 2023, UBC Blusson QMI Investigator Alannah Hallas was a mentor at Science World's Girls & STEAM Summit in Vancouver. This is a program that encourages young girls and women ages 12-14 to pursue their scientific interests and explore careers in STEAM (science, technology, engineering, art & design, and math), by expanding their knowledge of and access to STEAM opportunities.

"The best part of being a mentor is seeing what things spark curiosity. I showed photos of my lab and crystals we grow, as well as videos of chemical reactions, and the questions that the students asked were so interesting and thought-provoking — they are already thinking outside the box," said Hallas.

"We need to do a better job of encouraging girls at these early stages to keep their options open — there are so many amazing careers in science that they may not know about yet. As a high school student, I never imagined myself as a future physicist," Hallas said. "To future scientists: Keep following the path that excites you most and keep asking questions."

Kirsty Gardner, Postdoctoral Fellow, Science World.

Shad students at UBC Blusson QMI, June 2023

Geering up students at UBC Blusson QMI, August 2023

FUTURE SCIENCE LEADERS: UBC BLUSSON QMI GOES TO SCIENCE WORLD

UBC Blusson QMI Postdoctoral Fellow Kirsty Gardner was a guest lecturer at Science World as part of their Future Science Leaders (FSL) in October 2023.

The FSL is an after-school science enrichment program for teens designed to unleash creative potential and build a lifelong network of like-minded peers while engaging curious minds with the nature of STEAM in sessions led by diverse experts and professionals. Gardner spoke about her research at UBC Blusson QMI in the larger context of optics and, in particular, about designing advanced optical coatings for the Laser Interferometer Gravitational-Wave Observatory (LIGO), and tasked the students with building their own interferometers in groups.

“As part of Science World’s FSL program, I presented to four different groups of students to share with them the science and research that I work on with the aim of demonstrating that life as a physicist is fun and exciting,” said Gardner. “It was exciting to see how students could translate the concepts we had discussed during the presentation to the experimental system they built in class.”

TOURING UBC BLUSSON QMI TO INSPIRE CANADIAN YOUTH

Throughout 2023, we were energized by multiple visits to UBC Blusson QMI by high school students. Highlights included a visit by Shad students in June, followed by a tour attended by UBC Geering Up students in August.

Shad is a month-long program for grade 10 and 11 students who can attend classrooms with university-level STEAM courses, entrepreneurship content, and access to mentors.

UBC Geering Up is an Engineering Outreach program on a mission to provide the youth of British Columbia with the opportunity to investigate engineering, science, and technology in a fun, educational, and safe environment.

Staff Scientist and Research Associate Dongjoon Song from the Hallas group working on a material synthesis furnace.

PEOPLE

Andrew Potter and students at UBC Blusson QMI.

HANIEH AGHAEE RAD

A former student at Joseph Salfi's group, Hanieh Aghaee Rad has joined Xanadu as a Device Engineer, where she contributes her expertise to advancing Canada's quantum computing industry. During her time at UBC Blusson QMI, Hanieh was an NSERC Create Quantum Computing Program scholar, gaining hands-on experience in designing, fabricating, and measuring quantum processors.

"During my research at QMI, I investigated a new quantum simulator to predict the properties of quantum materials based on the spin of individual holes in solids with a new scheme for accurate and scalable spin/charge read-out," Hanieh says.

"As part of my research, I gained experience in designing and testing PCB boards, sample holders, and sample shielding parts, as well as wiring a dilution fridge, programming data acquisition card, and testing the noise level in the system. I was also involved in designing devices, fabricating them in QMI's cleanroom, and measuring them in the few-spin regime.

"All of those experiences have provided me with a deep understanding of the quantum computing field. Most importantly, I also developed the ability to think outside the box, which is very relevant to my current role in the industry."

Hanieh completed a Dual Bachelor's Degree in Physics and Materials Science and Engineering from Sharif University of Technology in 2019, and earned her Master of Applied Science in Electrical and Computer Engineering from UBC in 2022.

CHRISTINA HOFER

Christina Hofer is a Postdoctoral Fellow at UBC Blusson QMI, collaborating with Investigators David Jones and Ziliang Ye. Her research centers on ultrafast lasers, focusing on the development of advanced spectrometers for applications in both mining and the exploration of low-dimensional materials developed at the Institute.

A passionate quantum materials researcher, Christina says: "I love the versatility of using ultrafast lasers for the study of new materials. This kind of research has the potential to enable the development of more sustainable technologies, which is an area I would like to focus on after my post-doctoral studies."

Christina's academic journey began at the University of Innsbruck, where she completed a Bachelor's Degree in Physics in 2014. She then continued her studies with a Master's Degree in Condensed Matter Physics from TU Munich. In 2021, she completed her PhD at the Max Planck Institute for Quantum Optics/Ludwig Maximilian University of Munich. During her PhD, she specialized in developing field-resolved spectrometers in the mid-infrared spectral range that are used to detect changes in the composition of human blood samples for early cancer detection.

Since joining the UBC Blusson QMI community in 2022, Christina has found the Institute's collaborative environment enriching: "[It is] unique how people from theory to material growth to spectroscopy work together and benefit from broad knowledge. I've learned a lot about materials and their exotic quantum properties."

KYLE MONKMAN

Kyle Monkman is a Postdoctoral Fellow at Blusson QMI working with Deputy Scientific Director Marcel Franz and Investigator Mona Berciu. A member of the Métis Nation in Manitoba, he also leads a reading group bringing together the Blusson QMI community to learn about various topics, such as local history and Indigenous issues, as well as issues facing other groups, such as newcomers to Canada.

“A reading group is smaller scale than many of the other initiatives. It can be done in a department or other workplaces. Indigenous students and allies can run the group without necessarily being experts in all the different topics,” Kyle says. “The idea is to read and try to understand the topics together.”

In 2012, he joined the Engineering Access Program (ENGAP) for Indigenous students in engineering at the University of Manitoba. There, he was introduced to physics in an upgrading course for Indigenous students. Years later, he came full circle when he was asked to come back to the program to teach the same upgrading physics course he once took as a student.

“At the moment, my research is centered around quantum protection against noise. One example is states with symmetry-protected topology, which are robust to certain types of symmetric noise. Another example is understanding how non-Hermitian physics describes a system coupled to an external bath,” Kyle says.

VEDANGI PATHAK

Vedangi Pathak is a PhD candidate in condensed matter theory at UBC Blusson QMI, working under the guidance of Professor Marcel Franz. Her research is focused on the interplay of superconductivity and magnetism in engineered quantum materials. During her PhD, Vedangi has contributed to understanding various signatures of topology in both conventional and high-temperature superconductors, as well as other 2D materials.

Vedangi began her studies in Electrical and Electronics Engineering at the Birla Institute of Technology and Science in Goa, India. She soon transitioned to a dual degree program, earning a Master of Science in Physics alongside her engineering degree. This pivotal decision allowed her to merge practical engineering skills with a deep exploratory understanding of physics.

“My journey in physics started with experimental quantum optics during my undergraduate years. This experience led to a Mitacs fellowship for an internship at UBC and a scholarship at the Max Planck Institute for Gravitational Physics. It was during this time that I realized my passion for the theoretical and computational aspects of research,” says Vedangi. “This motivated me to pursue a PhD in condensed matter theory, which lets me explore theories that unravel the complexities of various quantum phenomena while staying grounded in experiments.”

“Today, as I continue to pursue my PhD in condensed matter physics, I am continually learning and discovering new aspects of this fascinating field. Currently, I am studying Majorana quasiparticles, high-temperature superconductivity, signatures of topology, and other exciting topics that help me better understand the fundamental principles that govern quantum materials,” Vedangi says.

Recently, Vedangi has expanded her expertise by joining IBM as a Quantum Computational Scientist Intern, where she works on applications of quantum algorithms.

HYUNGKI SHIN

"I'm currently working on a project to develop the first large-scale quantum computer at PsiQuantum," says Hyungki Shin, former PhD student at Ke Zou's group at Blusson QMI, who is now with PsiQuantum as a Materials Scientist. "Experiencing the impact of quantum science on our current industry landscape is incredibly fascinating and stimulating."

During his PhD studies, Hyungki focused on synthesizing various titanium-based oxide thin films using molecular beam epitaxy (MBE) and characterizing their fundamental physical properties through spectroscopy and electrical transport measurements.

"This research background directly relates to my current position as a Materials Scientist, where I explore and apply the properties of oxide epitaxial thin films in computer components," Hyungki says.

"My time at UBC Blusson QMI was a period of significant personal growth and research development. The QMI community is made up of people with various backgrounds and research interests, and we had multidisciplinary courses, numerous conferences, and the annual retreat.

"These interactions helped me understand how to connect my fundamental physics research to applications, fostering collaboration and teaching me how to navigate conflicts constructively. This experience of embracing diversity in people and research has proven invaluable in my current role."

Hyungki earned his PhD in condensed matter and materials physics from UBC in 2022, following his Master's Degree in physics in 2018. His journey into the world of physics began at Yonsei University in Seoul, South Korea, where he completed his Bachelor of Science in 2014.

JINGDA WU

"My research experiences in silicon photonics directly prepared me for my current role in the industry," says Jingda Wu, Senior Photonics Engineer at Analog Photonics and former UBC Blusson QMI Postdoctoral Fellow.

Jingda came to UBC from the University of Washington in 2017. He spent his first three years at Blusson QMI working with Jeff Young and Lukas Chrostowski, where he put his background in photonics to work with the goal of developing qubits on a silicon photonic platform; in 2020, he joined Ye's team, venturing off in a different yet familiar direction.

"I was lucky enough to apply my interest in light-matter interaction research towards vastly different research projects. I first worked on quantum photonics with a focus on enabling interactions between cavity photons and defects in silicon. This project was designed for quantum computing. Later, I worked on studying the 2D ferroelectric material 3R-MoS2 and 2D superconductor BSCCO with optical methods," says Jingda.

"My silicon photonics background is very related to my current industry position. But more importantly, it's the mindset for problem-solving and the attention to detail which I obtained through rigorous training at UBC Blusson QMI that helped me thrive in my current position," Jingda adds.

"The advice I have for Blusson QMI students is to keep digging; there is always something interesting in the details."

AWARDS AND RECOGNITION

UBC Blusson QMI Investigator Alannah Hallas receives the 2023 Killam Award for Teaching Excellence from UBC Provost and Vice-President, Academic Gage Averill.

FACULTY

ANDREA DAMASCELLI RECEIVES UBC'S PREMIER RESEARCH AWARD

Andrea Damascelli and UBC Associate Vice-President for Research and Innovation Matthew Evenden

Blusson QMI Scientific Director Andrea Damascelli was awarded UBC's Jacob Biely Research Prize in 2023. The Prize is awarded annually to a full-time tenure-stream UBC faculty member in recognition of a distinguished record of research that has substantially enhanced UBC's stature as a leading research institution.

"Andrea's research on the electronic structure of quantum materials has bolstered and refocused the international community, making Canada a leader in photoelectron spectroscopy. His study of superconducting cuprates and other novel complex oxides, as well as his research on the ultrafast dynamics of quantum materials, are groundbreaking," said Blusson QMI Professor Emeritus George Sawatzky.

"Under Andrea's leadership, QMI has become a research powerhouse, bringing together physicists, chemists, and engineers to collaborate on R&D projects advancing the field and training the future quantum workforce."

In 2015, Damascelli led UBC's effort, which resulted in a $66.5 million award from the Canada First Research Excellence Fund for Quantum Materials and Future Technologies. Under his leadership, Blusson QMI became UBC's first Global Research Excellence Institute (GREx) in 2016.

Damascelli is also a Tier I Canada Research Chair in the Electronic Structure of Quantum Materials and co-director of the Max Planck-UBC-UTokyo Centre for Quantum Materials.

"It's an honour to receive the Jacob Biely Research Prize from the UBC community. I extend my gratitude to UBC, the Office of the Vice-President Research and Innovation, Faculty of Science, Department of Physics & Astronomy, and the Blusson QMI community for supporting me and investing in this endeavour throughout the years," Damascelli said.

"I would also like to thank the students, postdocs, and senior scientists who have worked in my group, as well as our many collaborators at Blusson QMI, for their fantastic work and achievements. This award recognizes and celebrates our teamwork and shared success."

Damascelli 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, with emphasis on superconducting cuprates, ruthenates, and other correlated oxides.

Leveraging facilities established at QMI in the UBC-Moore Centre for Ultrafast Quantum Matter and the Quantum Materials Spectroscopy Centre at the Canadian Light Source, he pursues 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.

With more than 170 papers published, more than 19,000 citations, and an h-index of 59 (Google Scholar), Damascelli's work on quantum materials has gained global significance, positioning Canada as a leader in the field of photoelectron spectroscopy.

His work has been recognized with the prestigious Sloan, Killam, and NSERC's Steacie Memorial Fellowships, the Bessel Research Award from the Humboldt Foundation, and the Canadian Association of Physicists' DCMMP Brockhouse Medal.

Damascelli is a Fellow of the Royal Society of Canada, the American Physics Society, the Max Planck Graduate Centre for Quantum Materials, a Kavli Fellow of the US National Academy of Sciences, and a Senior Fellow of the CIFAR Quantum Materials Program.

FACULTY

ALANNAH HALLAS RECEIVES PRESTIGIOUS SLOAN FELLOWSHIP

Blusson QMI Investigator Alannah Hallas was named a Sloan Research Fellow in 2023. A Sloan Research Fellowship is one of the most prestigious awards available to young researchers providing winners with a two-year, US$75,000 fellowship to advance their research. Among the past Fellows are renowned physicists such as Richard Feynman and Donna Strickland.

Blusson QMI Scientific Director Andrea Damascelli congratulated Hallas, noting that the fellowship recognizes her contributions to the discovery of new quantum materials through high-pressure synthesis.

“Alannah is a visionary leader and an exceptional interdisciplinary scholar with expertise in Physics, Chemistry and Mathematics. Her research program and achievements are world-class, and she is on a global leadership trajectory in quantum materials,” said Damascelli.

As the head of the Quantum Material Design Lab, which is still in the development stage, Hallas has crafted an ambitious plan to develop high-pressure synthesis capabilities, including a high-pressure image furnace apparatus that will be the first of its kind in Canada.

Hallas, who joined UBC in 2019 to establish the Hallas Research Group and Blusson QMI’s *Quantum Materials Design Lab*, said it’s an honour to be selected as a 2023 Sloan Fellow.

“One of the amazing aspects of this award is that it comes with generous funding that can be used for any research purpose. We’re working towards having a very unique set of synthesis capabilities, which will allow us to explore quantum materials under extremely high pressures to discover materials that can’t be accessed in any other way, and those materials we hope will have very fascinating quantum properties,” Hallas said.

Hallas has been recognized with numerous major international awards, including: 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.

As a 2023 Sloan Fellow, Hallas joins former Sloan fellows from Blusson QMI, including:

- Andrew Potter, 2021
- Joshua Folk, 2010
- Robert Raussendorf, 2009
- Andrea Damascelli, 2007
- Mona Berciu, 2006
- Marcel Franz, 2002
- Douglas Bonn, 1996
- Ian Affleck, 1983

FACULTY

Killam Teaching Prize

In 2023, Hallas was also awarded UBC's Killam Prize for Excellence in Teaching. The prize from the National Killam Program is awarded annually to faculty nominated by students, colleagues and alumni in recognition of excellence in teaching. Hallas was recognized for her remarkable commitment to excellence in teaching, significant impact in mentoring students, and her ability to effectively communicate complex scientific concepts, which have inspired students and colleagues alike.

IUPAP Early Career Scientists in the Field of Magnetism

The International Union of Pure and Applied Physics (IUPAP) recognizes emerging leaders for their exceptional accomplishments in the field of magnetism. Hallas received this recognition in 2023 for "outstanding contributions to the discovery of magnetic quantum materials through advanced synthesis methods."

Canada Research Chair Tier 2 Renewal

The Canada Research Chairs program invests up to $311 million every year to attract and retain the world's most accomplished and promising minds. Blusson QMI Investigator Ziliang Ye was reappointed as the Canada Research Chair in Two-Dimensional Quantum Materials.

STUDENTS AND POSTDOCTORAL FELLOWS

Blusson QMI Postdoctoral Fellow receives Governor General's Gold Medal for Doctoral Dissertation

MengXing (Ketty) Na, Postdoctoral Fellow, Blusson QMI.

MengXing (Ketty) Na, a Postdoctoral Fellow supervised by Blusson QMI Investigators Andrea Damascelli and David Jones during her PhD studies, was awarded Governor General's Gold Medal for her PhD dissertation titled Electron-phonon coupling in the time domain: TR-ARPES studies by a cavity-based XUV laser.

Na said receiving the Governor General's Gold Medal is an immense honour and a humbling experience.

"I am filled with gratitude for this recognition of my work and the opportunity to contribute to the field of condensed matter physics. It serves as a testament to the dedication and support of the incredible team of mentors, colleagues, and collaborators who have played a pivotal role in my journey," said Na.

The Governor General's Academic Medals were created in 1873 to encourage academic excellence across Canada. Over the years, they have become the most prestigious award that students in Canadian schools can receive.

"I have learned that no breakthrough is achieved in isolation; rather, they are the result of collective effort and the synergy of diverse perspectives. I would like to express my heartfelt gratitude to my supervisors, Andrea Damascelli and David Jones, whose mentorship has been invaluable. Their support, encouragement, and belief in my abilities have helped me navigate through challenges and grow as a researcher," Na said.

"I am also indebted to my fellow colleagues and lab mates, who have greatly enriched my academic and personal life. Furthermore, I would like to extend my appreciation to the funding agencies, institutions, and research facilities that have provided the resources and infrastructure necessary for my research endeavors. I am truly grateful for the collective efforts that have led to this prestigious recognition."

The award was presented to Na at UBC Vancouver's Chan Centre during the graduation ceremonies on May 25, 2023.

STUDENTS AND POSTDOCTORAL FELLOWS

Matthew Mitchell, Postdoctoral Fellow at UBC Blusson QMI, Mitacs Award Ceremony in Ottawa, Ontario. Image supplied.

From lab to market: Matthew Mitchell honoured with Mitacs Award for Commercialization

UBC Blusson QMI Postdoctoral Fellow Matthew Mitchell has received the 2023 Mitacs Award for Commercialization for spearheading over a dozen innovative research and development projects in advanced optical package prototyping with Canadian and international commercial partners.

Mitchell joined Blusson QMI as a postdoctoral fellow in 2020. He began his Fellowship with Mitacs and the photonics technology company Dream Photonics in 2022. He now leads the Photonics Integration Team at Dream Photonics.

"The Mitacs Accelerate Fellowship has allowed me to focus on commercializing the research that I was doing at Blusson QMI and help companies around the world prototype their devices with access to state-of-the-art equipment at the institute," said Mitchell.

"The award means a lot to me — prior to starting my Mitacs program at Dream Photonics, I had no experience in commercializing my research or developing a business. Winning this award provides reassurance that I am on the right path and that the work we are doing will have an impact."

Mitacs Fellows are tasked with addressing complex challenges through a one or two-year research project with a partner organization and a professional development curriculum that prepares them for success as leaders in research and industry.

"Canada excels at undertaking innovative research and working in niche areas that add great value to the supply chain. The area I am focused on is advanced photonic packaging and integration, which I think is a good example of this," Mitchell said.

"Here, we take components that are manufactured by large foundries in the US and Asia and enhance their function by integrating exotic materials and components with those building block pieces. This is something that requires less capital investment compared to building a foundry, but does require highly qualified personnel — the training of which is something we excel at in Canada."

During his studies at Blusson QMI, Matthew gained expertise in using cutting-edge equipment at the institute's Advanced Nanofabrication Facility (ANF) — notably the photonic wire bonding tool, garnering global interest in solving optical packaging bottlenecks through innovative technologies (see page 24 for more on UBC's ANF).

"We now have clients around the world who are interested in demonstrating and testing photonic wire bonding as a solution for their optical packaging needs. This technology has the potential to solve photonic packaging challenges for the industry," Mitchell said.

"I would like to thank my mentors at UBC, including Lukas Chrostowski, Sudip Shekhar and Jeff Young. I would also like to thank Paul Barclay at the University of Calgary and my partner Emily and family for supporting me outside of work."

Ehsan Hamzehpoor (MacLachlan Group)
MengXing (Ketty) Na (Damascelli and Jones Groups)

NSERC Banting Postdoctoral Research Fellowships
The prestigious Banting Postdoctoral Fellowships program provides funding to the very best postdoctoral applicants, both nationally and internationally, who will positively contribute to the country's economic, social, and research-based growth. The goal of the Fellowships is to attract and retain top-tier postdoctoral talent (nationally and internationally), develop their leadership potential, and position them for success as research leaders of tomorrow.

MengXing (Ketty) Na at the UBC–Moore Centre for Ultrafast Quantum Matter

PRINCIPAL INVESTIGATORS

UBC Blusson QMI Investigator Doug Bonn, Staff Scientist and Research Associate Jisun Kim, Investigator Sarah Burke and Staff Scientist and Research Associate James Day.

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 Blusson 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
Dean UBC 2018 – 2023
Professor UBC 2018 – present

UNDERGRADUATE STUDENTS

Divya Chari, Satyam Priyadarshi

GRADUATE STUDENTS

Joern Bannies

POSTDOCTORAL FELLOWS

Xiyang Li

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 accelerate decarbonization.

CURRENT PROJECTS
- Reactive carbon capture
- Electrification of the chemicals industry
- Colder 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
Aloysio Campos Da Paz, Wesley Chan, Elija De Hoog, Bowen Ge, Derek Greenaway, Kyle Kochi, Joseph Koh, Aidan Madokoro, Aditya Menon, Nada Nasr, Enoch Rassachak, Lara Saber, Zoey Yang

GRADUATE STUDENTS
Chaitanya Donde, Oliver Horner, Andrew Jewlal, Tengxiao (Alec) Ji, Minhyo Kang, Cameron Kellett, Alessio Mezza, Thomas Morrissey, Douglas Pimlott, Alexandra Rousseau, Connor Rupnow, Jessica Sperryn, Mia Stankovic, Samuel Weiss, Aubry Williams

POSTDOCTORAL FELLOWS
Kuo-Yi (Glori) Chen, Yifu Chen, Kevan Dettelbach, Aref Eshkevar Vakili, Rana Faryad Ali, Marvin Frisch, Gaopeng Jiang, Yong Wook Kim, Xin Lu, Siwei Ma, Shaoxuan Ren, Li Shi, Arijit Singha Hazari, Abhishek Soni, Yunzhou Wen, Georgia Wood

SCIENTIFIC STAFF
Elija de Hoog, Kevan Dettelbach, Fatima Garcia, Sergey Issinski, Gaopeng Jiang, Daniel Lin, Mehrdad Mokhtari, Karry Ocean, Ryan Oldford, Chris Waizenegger

ADMINISTRATION TEAM
Amanda Brown, Anton Burdin, Emilija Ilic, Jannis Maiwald, 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 study high purity samples of metals and superconductors using a range of different spectroscopies. Microwave spectroscopy reveals the low frequency conductivity spectrum, and scanning tunnelling spectroscopy provides spectroscopic capabilities at low temperatures with atom-scale spatial resolution. The ultimate aim is to use this combination to understand charge carrier scattering in metals and exotic pairing states in superconductors.

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
Tim Branch, Dong Chen, Aaron Kraft

SCIENTIFIC STAFF
James Day, Jisun Kim, Mohamed Oudah

SELECTED PUBLICATIONS
D. Valentinis, G. Baker, D.A. Bonn, J. Schmalian. K*inetic theory of the non-local electrodynamic response in anisotropic metals: skin effect in 2D systems.* Phys. Rev. Research **5**, 013212 (2023).

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

UNDERGRADUATE STUDENTS

Luke Gallant, Nabiha Khan, Oliver Tong

GRADUATE STUDENTS

Jörn Bannies, Rysa Greenwood, Vanessa King, Alexandra Tully, 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, Masih Bahrani, Sheri Jahan Chowdhury, Omid Esmaeeli, Joshua Fabian, Daniel Francis Julien-Neitzert, Bobby Hang Zou, Philip Kirwin, Sean Lam, Becky Lin, Jake Osborne, Sayantani Podder, Jingxiang Song, Iman Taghavi, Alexander Tofini, Kithmin Wickremasinghe, Donald Witt, Xin Xin, Shangxuan Yu

POSTDOCTORAL FELLOWS

Samantha Grist, Ata Khorami, Zhongjin Lin, Matthew Mitchell

SCIENTIFIC STAFF

Jaspreet Jhoja

PROJECT MANAGERS

Serge Khorev

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, Josh Kraan, Peter Moen, Brian Pang, Cissy Suen (Joint PhD), Ching Au Yeung, Valentin Zimmermann (Joint PhD)

POSTDOCTORAL FELLOWS

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

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

UNDERGRADUATE STUDENTS

Emma Rayleigh-Smith

SCIENTIFIC STAFF

Miles Brodie, Hsiang-His (Sean) Kung

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 build quantum circuits, then investigate them at milliKelvin temperatures where sensitive electronic measurements allow us to probe fundamental characteristics of the underlying quantum state, often reflecting strong interactions or non-trivial topology. Careful design of the circuit and choice of materials allows us to address questions at the forefront of condensed matter physics, tuning each term in the Hamiltonian of interest in situ and watching the response. Materials used for these devices range from traditional semiconductors, such as GaAs, to van der Waals stacks of 2D materials such as graphene or dichalcogenides.

CURRENT PROJECTS

- van der Waals heterostructures
- Mesoscopic physics
- Thermodynamics in quantum devices

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 – 2021
Professor UBC 2021 – present

UNDERGRADUATE STUDENTS

Nick Phillips, Will Grant, Lily Watt, Emily Zhu, Anton Cecic, Diana Ryoo, Ray Su

GRADUATE STUDENTS

Johann Drayne, Zhenxiang Gao, Vahid Movahed, Elena Cornick

SCIENTIFIC STAFF

Silvia Lüscher

SELECTED PUBLICATIONS

R. Su, M. Kuiri, K. Watanabe, T. Taniguchi, J.A. Folk. *Superconductivity in Twisted Double Bilayer Graphene Stabilized by WSe_2.* Nat. Mater. **22**, 1332 (2023).

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)

T. Child, O. Sheekey, S. Luescher, S. Fallahi, G.C. Gardner, M. Manfra, A. Mitchell, E. Sela, Y. Kleeorin, Y. Meir, J.A. Folk. *Entropy measurement of a strongly coupled quantum dot.* Phys. Rev. Lett. **129**, 227702 (2022).

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 annealing
- 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

UNDERGRADUATE STUDENTS

Heung Tsz Fung

GRADUATE STUDENTS

Niclas Heinsdorf, Hrishikesh Patel, Vedangi Pathak, Tarun Tummuru

POSTDOCTORAL FELLOWS

Nitin Kaushal, Kyle Monkman, Tong Zhou

SCIENTIFIC STAFF

Alberto Nocera

SELECTED PUBLICATIONS

S.Y.F. Zhao, N. Poccia, X. Cui, P.A. Volkov, H. Yoo, R. Engelke, Y. Ronen, R. Zhong, G. Gu, S. Plugge, T. Tummuru, M. Franz, J.H. Pixley, P. Kim. *Emergent Interfacial Superconductivity between Twisted Cuprate Superconductors*. Science **382**, 1422 (2023).

B.T. Zhou, S. Egan, D. Kush, M. Franz. *Non-Abelian topological superconductivity in maximally twisted double-layer spin-triplet-valley-singlet superconductors.* Commun. Phys. **6**, 47 (2023).

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).

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
- Unusual transport regimes 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
IUPAP Early Career Scientist Prize 2023
Sloan Research Fellowship 2023

UNDERGRADUATE STUDENTS

Morgan Brand, Maxim Levi, Janna Machts, Valentina Mazzotti, Christine Trinh

GRADUATE STUDENTS

Mario Gonzalez-Rivas, Dhruv Kush, Abraham Mancilla, Megan Rutherford, Samikshya Sahu

POSTDOCTORAL FELLOWS

Solveig Stubmo Aamlid

SCIENTIFIC STAFF

Mohamed Oudah, Dongjoon Song

SELECTED PUBLICATIONS

S.S. Aamlid, M. Oudah M, J. Rottler, A.M. Hallas. *Understanding the role of entropy in high entropy oxides.* J. Am. Chem. Soc. **145**, 5991 (2023).

G.H.J. Johnstone, M.U. González-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**, 20590 (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).

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

Ebrahim Hussain

GRADUATE STUDENTS

Errol Bowman, Rysa Greenwood, Bradley Guislain, Mike Hemsworth, Alexandra Tully

POSTDOCTORAL FELLOWS

Christina Hofer, Philipp Sulzer

SCIENTIFIC STAFF

Arthur Mills, Sergey Zhdanovich

SELECTED PUBLICATIONS

M.X. Na, A.K. Mills, D.J Jones. *Advancing time- and angle-resolved photoemission spectroscopy: The role of ultrafast laser development*. Phys. Rep. **1035**, 1 (2023).

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**, ade3759 (2022).

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).

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 Center 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

Ethan Rajkumar, Cecilia Sorocco

GRADUATE STUDENTS

Philipp Elsaesser, Xuyang Guo, Jonas Jager, Pranav Kairon, Dawn Mao, Elham Torabian

POSTDOCTORAL FELLOWS

Dmytro Bondarenko

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 unstable nucleus, 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 correlated oxide thin films
- Spin relaxation in topological insulators
- Local properties of magnetic heterostructures
- Spin relaxation as a probe of Li^+ ionic mobility in solids and near interfaces
- Low dimensional Li^+ ionic mobility in crystalline hosts
- ^{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 – 2021
Professor UBC 2021-present

UNDERGRADUATE STUDENTS

Philip Macau, Signy Spencer

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

Stephanie Cao, Emma Gillman, Jared Lim, Christian Morris, Kosei Ogawa, Robert Plavan, Karl Tsang, Phoebe Wang, Michael Wong, Ashley Yeung

GRADUATE STUDENTS

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

POSTDOCTORAL FELLOWS

Kyoungil Cho, Ehsan Hamzehpoor, Yota Neagari, Soledad Roig

SCIENTIFIC STAFF

Miguel Angel Soto Munoz

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
- Electron and photon emission phenomena
- 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

Mike Chang, Mokter Mahmud Chowdhury, Titouan Gaborit, Amin Jalili

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

GRADUATE STUDENTS

Rui Wen, Sing Lam Wong

POSTDOCTORAL FELLOWS

Joseph Sullivan, Weicheng Ye

SELECTED PUBLICATIONS

R. Wen, A.C. Potter. *Bulk-boundary correspondence for intrinsically gapless symmetry-protected topological phases from group cohomology*. Phys. Rev. B **107**, 245127 (2023).

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).

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 Blusson QMI. .

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

Luna Liu, Aryan Tiwari

GRADUATE STUDENTS

Phillip Bement, Katherine Herperger, Daniel Korchinski, Jared Popowski

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 specific research expertise is in spin physics in quantum devices, with a growing interest in superconducting and optical 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
- Quantum transduction

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

Debojyoti Biswas, Nusair Islam, Nabiha Khan, Arjun Sen

GRADUATE STUDENTS

Anton Cecic, Ana Ciocoiu, Marcus Edwards, Daniel Francis Julien-Neitzert (co-supervised), Mohammad Khalifa, Phil Kirwin (co-supervised), Mukhlasur Rahman Tanvir

POSTDOCTORAL FELLOWS

Polina Feldman, 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

POSTDOCTORAL FELLOWS

Oliver Dicks

SCIENTIFIC STAFF

Ilya Elfimov, Kateryna Foyevstova, Fengmiao Li

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

Guyue Li, Tony Qiao, Jasnoor Singh

GRADUATE STUDENTS

Haodong Hu, Tianxiao Niu, Melisa Ozen, Yunhuan Xiao, Yuan Xie, Dongyang Yang

POSTDOCTORAL FELLOWS

Jing Liang

SCIENTIFIC STAFF

Jerry Dadap

SELECTED PUBLICATIONS

D. Yang, J. Liang, J. Wu, Y. Xiao, K. Watanabe, T. Taniguchi, J.I. Dadap, Z. Ye. *Non-volatile electrical polarization switching via domain wall release in 3R-MoS2 bilayer*. Nat. Commun., in press.

J. Liang, D. Yang, Y. Xiao, S. Chen, J.I. Dadap, J. Rottler, Z. Ye. *Shear Strain-Induced Two-Dimensional Slip Avalanches in Rhombohedral MoS2*. Nano Lett. **23**, 7228 (2023).

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

Felix Klose, Henry Mullock, Ruixin Qiu

GRADUATE STUDENTS

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

POSTDOCTORAL FELLOWS

Kirsty Gardner, Matthew Mitchell

SELECTED PUBLICATIONS

D. Witt, J. Young, L. Chrostowski. *Reinforcement Learning for Photonic Component Design.* APL Photonics **8**, 106101 (2023).

M. De Gregorio, S. Yu, D. Witt, B. Lin, M. Mitchell, L. Dusanowski, C. Schneider, L. Chrostowski, T. Huber-Loyola, S. Hofling, J.F. Young, A. Pfenning. *Plug-and-Play Fiber-Coupled Quantum Dot Single-Photon Source via Photonic Wire Bonding.* Adv. Quantum Technol. **7**, 2300227 (2023).

B. Lin, D. Witt, J.F. Young, L. Chrostowski. *Cryogenic Optical Packaging Using Photonic Wire Bonds.* App. Phys. Lett. Photonics **8**, 126109 (2023).

KE ZOU

RESEARCH FOCUS

Our research endeavors revolve around the intricate cultivation of complex oxide and chalcogenide films, each with an atomic thickness, employing the meticulous technique of molecular beam epitaxy. In our pursuit of scientific and technological breakthroughs, we aim to unravel the untapped potential inherent in novel materials, with a particular emphasis on crafting innovative functional devices. The core of our methodology integrates the synthesis prowess of molecular beam epitaxy with the finesse of nanostructure fabrication and characterization techniques, allowing us to intricately examine the physical and electronic structures of these materials. This concerted effort propels us into the unexplored realms of emergent properties, particularly in unconventional forms like two-dimensional thin films and heterostructures. Our ultimate goal is to comprehend and manipulate the unique characteristics of these materials, tailoring them for applications in diverse fields such as electronics, biology, and photonics devices.

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

Gor Nahapetyan, Joan Weng

GRADUATE STUDENTS

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

SCIENTIFIC STAFF

Bruce A. Davidson, Fengmiao Li

SELECTED PUBLICATIONS

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).

AFFILIATE INVESTIGATORS

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 SrFeO3 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)

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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.

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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.

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*Blusson QMI dogs
Hunter (left)
and Hobbes (right)*

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