QCAM
Quebec Centre for Advanced Materials

Newsletter

Summer 2022 5

2022 Student symposium

On Monday, May 9, 2022, the Quebec Centre for Advanced Materials (QCAM) organized the second edition of the student symposium at the MIL campus of the University of Montreal! The symposium was entirely organized by the QCAM student committee, and 120 participants attended the event, among them 80% of students, coming from the 11 member institutions from all over Quebec. This bilingual event encourages collaboration between QCAM members by increasing the visibility of research groups, disseminating student research work, and creating networking opportunities.

The program included 20 oral presentations and 31 poster presentations! The student presentations were given within the framework of the six QCAM research themes: three fundamental axes (science of polymers, self-assembly, and nanoscience) and three applied axes (applications in energy, green chemistry, and biomedical). A workshop on the theme of "the art of interviewing and negotiation at hiring", held by Gad Sabbatier, was an excellent opportunity for students to learn how to better prepare for professional interviews. In addition, students were also able to take part in mock interviews with our recruiters Julia Del Re, Gad Sabbatier, Bruno Gélinas, Matteo Duca and Cloé Bouchard-Aubin. The prizes for the best oral presentations were awarded to Ouardia Touag (University of Montreal) and Jun-Ray Macairan (McGill). The prizes for the best poster presentations were awarded to Tyler Brown (McGill) and Christophe Lachance-Brais (McGill). Our thanks go to Blue Solutions, Prima Quebec and Pharma in Silica for their generous sponsorship.

Article written by Yasmine Benabed (chair of the student committee)

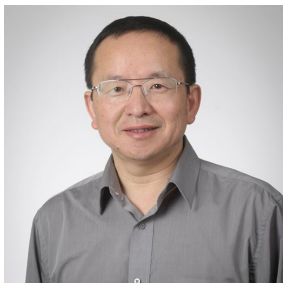
Quantum materials
Basic concepts (page 3)

Communication campaign #communautéFRQ
Available research internships CQMF-Bordeaux
Page 4

QCAM and technology transfer

Yue Zhao awarded an Axelys-MEI grant

Call for proposals : «For next-generation innovations »



Axelys, a non-profit organisation created by the gouvernement du Québec in 2021, aims to fast track the transfer of innovations resulting from publicly-funded research. This call for proposals intends to support the development of high-potential technical innovations (source). The funded projects will receive financial support from the ministère de l'Économie et de l'Innovation du Québec (MEI) within the framework of the "Programme de soutien aux organismes de recherche et d'innovation (PSO) volet 2D" (aiming to boost the technology maturation of a project). The MEI will contribute up to 80% of the project costs. You can find an abstract of the project below (kindly provided by prof. Zhao, translated by Matteo Duca)

Novel ultrafiltration membrane with a 20% higher performance

The aim of our project is to develop a new coating material for industrial ultrafiltration (UF) and nanofiltration (NF) membranes. Current commercial membranes rapidly become clogged and need cleaning with harsh, expensive chemicals that are hazardous to the equipment and the environment. The technology we have been developing is a surface modification of industrial UF membranes with a coating of stimuli-sensitive polymers. This increases the filtration efficiency of the membranes; in addition, it also reduces the amount of energy and of hazardous chemicals required for membrane cleaning.

Scientific entrepreneurship: initiatives

Scientific entrepreneurship support programme (FRQ). This programme aims to foster collaboration between academic researchers and companies already owning intellectual property. The aim of these collaborations will be to develop innovative solutions to aging and decarbonisation. Deadline: 2 August 2022

Quebec scientific entrepreneurship programme (QcES), an online training programme financed by FRQ and open to researchers who are completing or have completed a master's, Ph.D., or Postdoc in STEM fields in Quebec.

Jacopo Profili, co-founder of the Collective of scientific and innovative entrepreneurs of Quebec, gives an overview of CESIQc

CESIQc has created the first independent, non-profit strategic cluster in Quebec aiming to help entreprenenurs and to strenghten the links between them and public and private organisations. The ultimate goal is to foster success in the innovative scientific sector.

Since 2021, CESIQc members have conducted strategic talks with leaders of public and private Quebec organisations. To date, CESIQc regroups more than 40 entrepreneurs based in Quebec.

Among the initiatives already undertaken, the collective has :

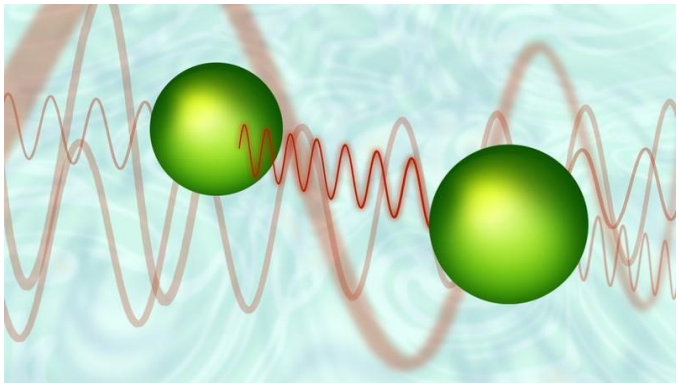
- Drawn up key documents containing strategic analyses and a series of recommendations aimed at improving government action to improve success of Quebec's scientific and innovative entrepreneurs :
  - Position paper for the Quebec research and innovation strategy 2022-2027 (June 2021).
  - Position paper for the Quebec action plan on entrepreneurship 2022-2025 (September 2021).
- Organised a strategic meeting with Quebec's chief innovator, Luc Sirois, to address issues concerning immigration, recruitement and access to material and intellectual resources abroad (February 2021).
- Started the preparation of informational documents aiming to help Quebec's scientific and innovative entrepreneurs (April 2021).
- Set up strategic collaborations with several institutes aiming to improve the activites and support offered to entepreneurs.

To join CESIQc or to become member, please write an e-mail to info@cesiqc.ca . Follow the Collective on LinkedIn!

Quantum materials

By Michaël Berteau-Rainville

The term "quantum" increasingly features in science news for broad audiences, sometimes incorrectly. For instance, the press talks about "quantum computing", "quantum supremacy", or yet again "quantum materials", which are the basis of all of these phenomena. Apart from the commercial potential of the term "quantum", quantum materials do show highly unusual properties that we can only explain thanks to quantum mechanics. Actually, quantum materials are specifically designed to demonstrate these baffling effects, or to exploit them with an eye to given applications. To understand quantum materials, we first need to understand what makes quantum mechanics special.



Michaël Berteau-Rainville won the first prize of the 1st QCAM science writing competition – French category. Click on the image above and read the winning entry published on the QCAM blog.

A short guide to quantum mechanics

First of all, energy transfers, which can take any value in our everyday life (we can give a little more or less energy to a system), can only be equal to well-defined amounts when the energies being transferred are very small, as is the case at the microscopic level for atomic or molecular systems. Thus, these systems will simply ignore any energy transfer incompatible with the allowed amounts. This is what gives all materials their particular colour: they only absorb light at given energies. A transparent material, in turn, can be flooded with light without absorbing any of it. For this material, the available energy simply does not exist. One should also note that a system cannot, in general, accept a given amount of energy twice to achieve twice as much energy; neither can a system accept half that amount to achieve half as much energy. The only way to transfer energy is to provide the exact value straightaway. If we look again at the scale at which typical quantum effects occur, particles display a wave-like behaviour instead of being like hard spheres. This brings about all sorts of counterintuitive phenomena: for instance, it enables quantum teleportation and gives rise to the uncertainty principle, two fundamental elements of quantum mechanics.

Quantum materials and quasiparticles

These central aspects of quantum mechanics are the defining features of quantum materials. These include, among the most well known, superconductors. In the simplest case, materials become superconducting at low temperature, at which electrons can interact with one another and move in a coherent fashion. At low temperatures, the energy of the surroundings is not sufficient to break this coherence (this energy is proportional to the temperature), which leads to the emergence of superconductivity. We should also stress that it is not possible, as explained above, to absorb the available energy repeatedly to achieve a higher energy level – one must raise the temperature of the surroundings to transfer more energy.

(Continued on page 4)

(Continued from page 3)

In the case of superconducting materials, it is then no longer possible to consider electrons as independent and we can rationalise the effects of coherent electron interactions by means of new equations. Since each particle has its own equations, we can say that new particles have taken shape! Although we cannot speak of fundamentally new particles, it is often useful to treat them as such from a mathematical point of view, and we will then call them quasiparticles. On the other hand, the interactions between the particles and their surroundings impose certain constraints on the particles themselves and their equations. Consequently, different materials will tend to lead to the emergence of different types of nanoparticles.

For many other materials, quantum effects appear thanks to their reduced dimensionality. We can for instance think about graphene or transition metal dichalcogenides, which exist in 2D – they are like a sheet that is one atom, or one molecule, thick (we are at the nanoscale). We can also think about carbon nanotubes, mono-dimensional, or again quantum dots, which are essentially zero-dimensional. These materials feature spectacular quantum effects under varying conditions, in particular by combining several 2D layers to obtain so-called van der Waals heterostructures. Once more, new quasiparticles often help in rationalising the unusual behavior of these materials, a behaviour that we can tune by changing the topology of the materials. The range of quasiparticles is very broad and new ones may join the list as research unveils new phenomena.

Towards quantum computing

The common feature of all quantum materials is indeed that they show quantum effect often translating into the emergence of new quasiparticles. This leads to groundbreaking technological achievements, the most striking of which is possibly quantum computing, a fast-growing field. The recent advances stem from our ability to engineer systems demonstrating quantum effects and to make these effects robust enough to be exploited for computational purposes. Perhaps, such applications represent the most remarkable example of the potential of quantum materials: quantum computing will therefore benefit from incremental progress in the understanding of quantum materials.

If quasiparticles and quantum materials have attracted your attention, go a step further and read the articles below. And do not wait for your first quantum computer!

Michaël Berteau-Rainville is a PhD student in Emanuele Orgiu's group. This group aims to design electronic devices based on a range of materials: 2D quantum materials (graphene, transition metal dichalchogenides), organic semiconductors, and organic-inorganic hybrids for van der Waals heterostructures and for perovskites.

Further reading

Geim, A., Novoselov, K. *The rise of graphene*. Nat. Mater. 6, 183–191 (2007).

Keimer, B., Moore, J. *The physics of quantum materials.* Nat. Phys. 13, 1045–1055 (2017).

Portugal, R. Basic quantum algorithms, arXiv:2201.10574 [quant-ph]

Translated by Matteo Duca

Bulletin board

#communautéFRQ

Building the future, one atom at a time: FRQNT's support is instrumental in allowing QCAM members to design innovative materials for energy, environmental and biomedical applications. Our members proudly belong to #communautéFRQ. Together towards the future!

QCAM enthusiastically joins in the FRQ's campaign *Propulsons ensemble la recherche*. Please find out more about this initiative on the dedicated website.

IN THE MEDIA

Let's talk about wood: do you know the difference between varnishes and impregnation treatment? Ici Radio-Canada visits the laboratory of our member Véronic Landry! Listen again to this radio report (in French), broadcast on the programme *Les années lumière,* highlighting the research carried out by PhD students Solène Pellerin and Marie Soula

Radiology for health and safety at work in a hospital setting: Marc-André Fortin sheds light on virus migration through a protective glove. Watch it again on the *Savoir-Media* website (in French).

The effect of defects: let's discover the polymer-electrolyte battery developed by the Claverie group in collaboration with Hydro-Québec researchers. Thanks to statistical copolymerization, the battery can work at room temperature: a major breakthrough paving the way for the widespread adoption of this disruptive technology in electric vehicles.

Read the article published in *Communications Materials*, which was also featured in the press (*Radio-Canada*, *leDroit*, *la-Tribune*). This work was also shortlisted for the 2021 *Quebec Science* Discovery of the year competition.

QCAM– A successful mid-term evaluation!

The meeting between QCAM and the FRQNT evaluation committee took place on 31 August 2021. The committee's review is very positive. The evaluation report was sent by e-mail to the members on 1 November 2021.

Here are some highlights of QCAM at mid-term

Publications by QCAM members (2018-2020):

17 % co-authored by at least 2 members

16 % published in high-impact journals (IF > 10)

Collaborative projects: impact

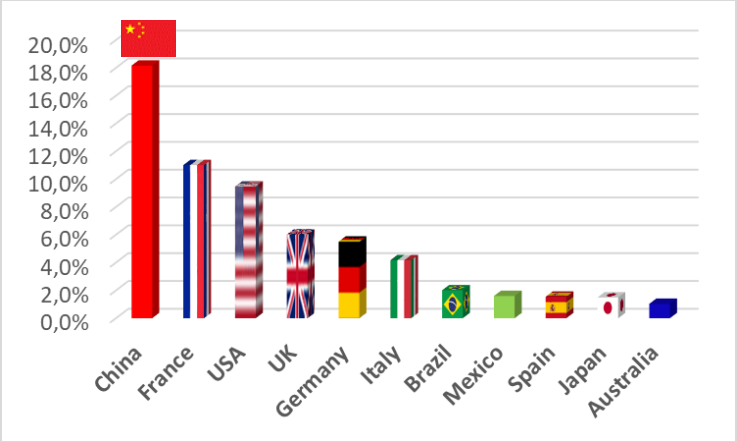
Out of 20 completed projects, **14** led to deliverables, of which 6 grants, 6 papers directly related to the project and 1 patent!

Collaborative research (2017-2021)

with **125** international and Quebec-based companies

International reach

% of articles by QCAM members with at least a co-author from:



Now: full speed ahead towards the grant renewal application (second half of 2023)!

Available research internships, QCAM-Bordeaux

New page "International internships" on the QCAM website: a list of research internships offered at QCAM (for students of University of Bordeaux) or at Bordeaux (for QCAM students). Would you like to host internship students from Bordeaux in your group? Please send the project description to Matteo Duca for online posting.