Concordia University
Arts and Science
Department of Physics

CONCORDIA PHYSICS

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Why Does Concordia Physics Matter?

Science and Engineering are Electric!

Alexandre Champagne, Chair, Department of Physics

We know that the universe is governed by the fundamental forces of Nature. But there is one which is especially dominant in our lives (acts on human length scales), it is usually referred to as Electricity and Magnetism (E&M). This is the force which enables all modern electronics and optics, is at the heart of material science and engineering, and is the quintessential force in chemistry and biology. Our Department's teaching is largely focused on training students at all levels to understand quantitatively E&M. This training is crucial to support our cutting-edge research in nanoscale materials (graphene, nanowires, and many others), high-energy physics, physics education, and biophysical systems (human brains, photosynthetic complexes, and more).

As the Department of Physics participates in the ongoing University strategic planning, we are brainstorming bold ideas to further expand these research and teaching fronts in partnership with other Science and Engineering departments. While these other units have many applied skills we need to turn our ideas into practical applications, we can offer them a quantitative understanding of problems which is critical to speed up discovery and be competitive in today's multidisciplinary research. Over the coming years, we aim to offer our students more multidisciplinary programs and dual degrees, and continue helping them to secure research and job market experiences via one-on-one mentoring and programs such as Co-op.

Many career avenues are open to our Physics students. In this edition we feature the career advices and personal experience of one of our teachers: Dr. Mario D'Amico. Mario's career is vastly different than the one of most of our faculty members, and we encourage students interested in entrepreneurship to talk with him for career advice. Keep in mind that Concordia has a start-up incubator (District3) which can provide graduating students a platform to participate in a start-up or even launch their own business.

Also in this issue, you will learn about a hot research topic going on in our Department, two-dimensional materials and about an outreach program we conducted with Collège Ahuntsic to introduce CEGEP students to research. We take this opportunity to invite you all to attend the Physics Student Award Ceremony which will take place on February 15th, 12 pm in GE 110. Please RSVP to marie-anne.cheongyoune@concordia.ca.

2015 FAS Scholar Awards: Daniel Andrews (center), with Dr. Alexandre Champagne and Dean André Roy (left).

In This Issue:

Dr. Mario D'Amico

"What to do with a Physics degree?"

Undergraduate students have many reasons for pursuing a bachelor's degree in physics. Perhaps, like me, you are someone who is deeply curious about nature. Regardless of the reasons, you are probably wondering what you will do with a physics degree.

I will be honest. When I first had to decide between physics and engineering, I opted for (Computer) Engineering. Three years into the Engineering program, with my curiosity for nature gnawing at me, I decided to switch to a physics degree and never regretted it since. I admit however, that it was probably not the simplest career choice for job stability, at least in a traditional career sense. But it did offer several advantages over traditional career type jobs such as doctors, plumbers, accountants, or pilots.

If you decide on a bachelor's in physics and do not expect to continue towards graduate studies, you will be faced with the initial challenge of finding a job in a discipline not defined as a career. I remember going to a job search department. In my days, when you looked for work it was either through newspapers or at government agencies. When you walked into an agency, you would be presented with bulletin boards filled with cue cards organized under several categories. Needless to say, I never encountered a category for 'Physicists'. Despite this, I can testify that when I did enter the job market, I noticed two very important advantages of having a physics degree.

The first advantage was an intangible one. It seems that physicists have a reputation in the industry as being very capable. Capable at what, you might ask? I will answer this in the next paragraph. I remember reading a story in 'The New York Times' about the CEO of a large corporation (Oracle) who had pretended holding a B.S. in physics. The CEO lied to gain an advantage over his competition. This shows how prevalent this reputation is.

The second and more tangible consequence has to do with the skills physicists acquire as part of their academic studies. As students, potential physicists learn not only the models used to describe physical phenomena but the mindset and the clever techniques used by the founders of the models. This is why physicists have such a great reputation in industry – because they are seen as innovators. Throughout my career in industry, I could tackle any problem from any discipline. I would simply review the key topics of the discipline and then treat the problem as a physical system. I could do this with engineering topics, financial topics, or any socially related topic. This is the essential and unique skill of being a physicist and a skill that lends itself naturally to an entrepreneurial spirit – for those who hope to start a business. If you are not entrepreneurial, I would not worry. One great way of making yourself all the more marketable as a potential employee is to simply add value to your physics degree by learning additional skills or combining it with an already possessed skill – whatever that skills may be, whether computer programming, carpentry, music, sports, or other.

Dr. Mario D'Amico

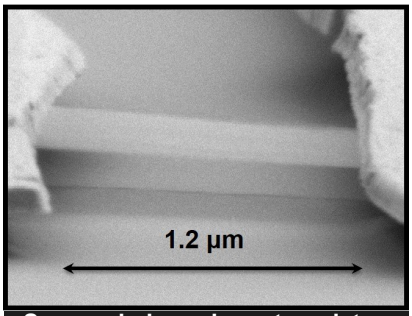
I have worked in industry both as a business owner and as a Director of Research. Throughout my career, I have travelled and visited many technology companies and always encountered physicists in various functions from technicians to executives. Everyone I have shared experiences with has expressed complete satisfaction for their choice of physics degree – a degree without limit.

Editor's note: Dr. D'Amico is a dedicated and resourceful teacher and mentor. Feel free to approach him for career advice!

Research Focus

Two-dimensional (2D) material research at Concordia

You have probably heard of graphene, a material which is a one-atom thick layer of graphite, and which was first discovered in 2004 (Nobel Prize in 2010). Graphene is an example of a two-dimensional (2D) material. What you may have missed is that since graphene's discovery, hundreds of other 2D materials have been discovered! These new materials have created an enormous activity in both the Sciences (Physics, Chemistry, Mathematics) and Engineering (Electrical, Mechanical, Chemical) over the last few years. What is so exciting about 2D materials? And what role is our Department playing in this research field?



Suspended graphene transistor

We live in a 3D (three-dimensional) world, and we have been studying the physical laws which govern this world. But can you imagine how physics (and thus chemistry, engineering, etc...) would change if we lived in a 2D world? In turns out that we can now explore this question using 2D materials. Many of the fundamental rules change in 2D, for example: the strength of interactions between electrons is stronger (affects whether they behave as single electrons or form groups), the geometry of space is different (changes the phases transitions, as in when and how a liquid of electrons turns into a solid of electrons). In many ways, the quantum physics in 2D materials is tightly connected with particle physics taking place in high-energy accelerators (relativistic particles).

The strange physics in 2D opens up new applications for 2D materials. A family of 2D materials, called topological insulators, are predicted under some conditions to carry electrical current without any lost of energy! Even at room temperature. Other 2D materials are exceptionally flexible and suited for wearable electronics (graphene), or behave as high quality semiconductors (MoS_2, phosphorene), or exceptional electro-optical devices (WSe_2). Perhaps most exciting, is that these 2D materials can easily be stacked one on top of another to make new materials which combine all of these exciting properties. These prospects are so tentalizing that the European Union has invested over 1 billion in fundamental 2D material research and similar investments have been made in many counrtries.

At Concordia, three faculty (Vasilopoulos, Champagne and Zazubovits) are engaged in 2D material research, as well as one postdoc (Tahir) and at least six graduate students. On the theoretical front Vasilopoulos and Tahir are using a combination of analytical and computational tools to explore a wide range of magnetic, electronic and optical properties in nanostructured 2D materials. For example they recently studied the optical properties of phosphorene (2D phosphorus) in the presence of a magnetic field. Champagne and Zazubovits focus on experimental studies of graphene. The graduate students in Champagne's lab measure the flow of electrons in ultra-low disorder devices where they can observe quantum interferences to understand how these electrons interact with their environment. In particular they are interested in studying devices where both the mechanics and electronics behave according to quantum physics. In the Zazubovits' lab, the focus is on exploring graphene as a simultaneously optical and electronic system (opto-electronics). By testing how energy is shuttled between photons, electrons and atoms (phonons), they aim to develop new types of photo-sensors.

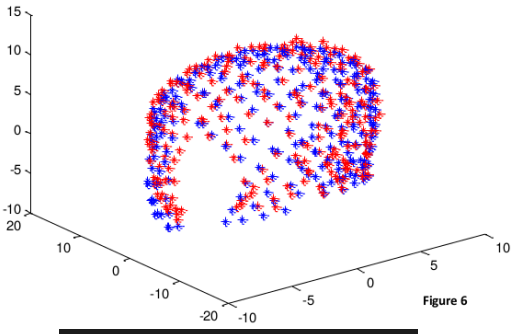
The prospects of this research field are rapidly expending as NSERC has recently identified 2D materials as a strategic direction and several local companies are investing heavily in this field (Grafoid, NanoXplore, Raymor, Photon etc., NanoCyl, GM Canada, and Ballard Power Systems).

Anastasia Kolokotronis, BSc student

Co-op summer 2015 internship experience

Anastasia Kolokotronis

Over the summer of 2015, I held a Co-op internship in the lab of Professor Christophe Grova. I was working at the new PERFORM centre across Sherbrooke Street. One of Dr. Grova's main projects is the evaluation of high-density Electro-Encephalography (EEG) acquisitions and source localizations from data acquired simultaneously with functional Magnetic Resonance Imaging (fMRI). Surface EEG provides a way to record electrical activity within the brain via measuring the differences in electrical potential on the scalp. Localization of the brain regions producing the measured EEG is crucial in many clinical applications as well as to understand brain functionality. Several factors affect the accuracy of source localization; one of them being the position of the electrodes. The distances between EEG sensors can be determined from photographs of the electrodes on the subject using photogrammetric methods. My role in this project was to understand and compare two photogrammetric methods to find out which one would offer the best accuracy for source localization.



Map of surface EEG sources

As a Biophysics student, my summer internship goal was to understand how both Physics and Biology interconnect and complement with each other. This work term and the findings of my experiments was a perfect example of how both these subjects come together. Over the summer, I learned more than I expected when starting out. During the first month, I read many documents and research papers to get a better understanding of the subject matter and the studies taking place. As the summer went on, I assisted in a few EEG acquisitions. I attended seminars where I received training on how to properly place an EEG cap on a patient. I learned how to properly position and interconnect the equipment and the instruments that were being used and much more. I helped in the preparation for the acquisitions, and I also had the opportunity to volunteer as a test subject! It was a great learning experience as I had the benefit of viewing both sides of the table.

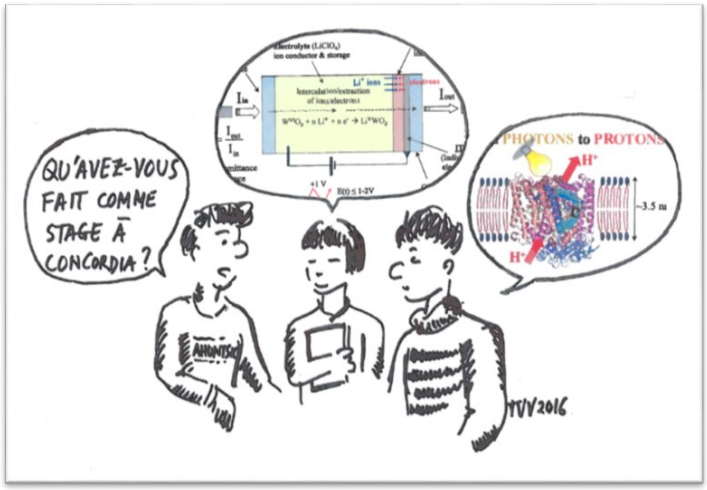
While working on this project segment, I realized that working as part of a team is one of the most important aspects in this field. Applying the knowledge I had to date in Biophysics in a technical setting, I could sharpen problem solving skills, resourcefulness, and attention to details. I also had the chance to practice my organizational skills, such as structuring complex tasks and to always work towards a well defined goal, whether it was short term or long term. However, I find that the most immediately useful skills I acquired during my internship were software skills. With the help of Dr. Grova's team, I was able to familiarize myself with MATLAB and start coding with it. It was a great challenge that I overcame and that will definitely serve as an advantage in my future.

My summer work term experience showed me another side of the application of Physics in the workplace and I am grateful to have partaken in an experience such as this. I look forward to unravelling some mysteries in this field in the near future, if only I am so fortunate.

Cegep Research Interns

Concordia Physics partnered with Collège Ahuntsic

Thanks to a grant from the Ministère de l'Éducation, du Loisir et du Sport (MELS), Concordia's Department of Physics has collaborated with Collège Ahuntsic in providing nanophysics and biophysics research internships to CEGEP students during three years, from 2013 to 2015. The aim was to initiate college students to laboratory work and research in a university environment. The work was usually organized for a one-semester attendance. Professors Pablo Bianucci, Laszlo Kalman, Valter Zazubovits and Truong Vo-Van welcomed students to their respective laboratories, offering a variety of research topics. The coordination from the Concordia side was done expertly by Dr. Simona Badilescu, working closely with Dr. Vo-Van who was the project director. The team on the Ahuntsic side was composed of Professors Lucie Brouillette and Gilles Picard. Overall, thirty five students have benefitted from this innovative program.



Asked to describe the work of some students in his lab, Prof. Kalman explained: "The focus of the research projects was the photosynthetic reaction center, a nanometer sized enzyme that is responsible for the conversion of light energy into chemical potential during photosynthesis. The students learned how to grow the photosynthetic bacteria, how to isolate and purify the enzyme, and how to characterize the individual steps of the energy conversion process itself. They were introduced to a software capable of displaying structural details of macromolecules at atomic resolution. They learned to perform a comprehensive analysis addressing structure-function relationship and thermodynamic principles."

Students working in Prof. Vo-Van's lab were introduced to topics such as plasmonics and carbon nanoparticles, smart nanostructured films and supercapacitors. Thanavady Phonemac was such a student involved in a work on electrochromic thin films that could change color with a small applied electric voltage. He confided: "Not only has this internship given me the opportunity to work in a research lab, it also confirmed my decision to become a researcher." At the end of the internship Phonemac even co-authored a paper with Prof. Vo-Van's group. He also had the chance to attend the ACFAS conference held in Montreal.

With Prof. Zazubovits' group, some students were involved in simulations of the effects of spectral hole burning in excitonically coupled multi-pigment systems. Non-photochemical hole burning is a phenomenon where optical excitation of a pigment embedded in amorphous solid triggers the conformational change in the amorphous solid resulting in a spectral shift of the pigment. Other students were involved in projects aimed at improving an optical setup to be used in measurements on graphene transistors. They designed and built a white light source to be incorporated into a home-built microscopy/spectroscopy setup. Prof. Bianucci's group was interested in photonic nano- and micro-devices. Participating students were introduced to applications of these devices and the optical properties of nanomaterials.

All interns showed a high degree of motivation and good participation. Despite a limited theoretical background and lab skills and the challenge of a busy schedule, they performed very well in their work. Some of the interns have indeed continued their studies at Concordia while others have chosen francophone universities. The project is indebted to graduate students who helped in mentoring the college students and the University Environment & Health Safety department.

Winter 2016 Physics Colloquiums*

***presentation titles are not final, but only indicative**

Room: L-CC 305, Mondays @ 3pm

Open to all

January 11: Visualization and Manipulation of Terahertz Light in the Near-Field, Francois Blanchard, École de Technologie Supérieure

January 18: Conformational Sculpting of Single Molecules via Nanofluidics, Walter Reisner, McGill University

January 25: Anatomy of Neutrinos, Chérif Hamzaoui, UQAM

February 1: MRI Characterization of the myelin microstructure in patients with multiple sclerosis, Nikola Stikov, École Polytechnique

February 8: Dongling Ma, INRS-EMT

February 15: TBA

February 22: Winter Break

February 29: Imaging tissues and biomaterials via Magnetic Resonance Elastography, Elijah Van Houten, Université de Sherbrooke

March 7: Application of Nuclear Magnetic Resonance spectroscopy to the study of protein and nucleic acid structures, Kalle Gehring, McGill University

March 14: Demonstration of Strong Near-Field Radiative Heat Transfer between Integrated Nanostructures, Raphael St-Gelais, Cornell University

March 21: Advanced magnetic resonance spectroscopy (MRS) techniques to measure metabolite concentrations in the human brain, Jamie Near, Douglas Mental Health University Institute

March 28: Easter Monday

April 4: Ultrafast nanostructure dynamics, laser material processing, and coherent imaging, James Fraser, Queen's University

April 11: Magnetoencephalography of brain activity, Stephan Grimault, PERFORM, Concordia University

New Research Grants and Lab

Even though the Fall semester is not the high grant season, our members received new funding this past Fall. We congratulate Drs. Claudine Gauthier (Drummond Foundation), Christophe Grova (Quebec Bioimagery Network) and Truong Vo-Van (NSERC-Engage Plus).

A new research laboratory space was added to our Department this semester. We thank the FAS for its financial support. This laboratory now hosts a biomedical image analysis computing facility (Gauthier and Grova groups).

Back Page Bulletin Board

The 2015-16 Physics Award Winners

Concordia Physics BSc Student Awards
(funded by faculty and staff)

1st year: **Amanda Di Nitto ($750) and Mariya Krasteva ($750)**

2nd year: **Daniel Andrews ($1500)**

3rd year: **Peter Collins ($1500)**

Mukerji Upreti Award (BSc Entrance Award)
Crystal Harmer ($1000)

Mustafa Showleh Physics TA Awards
Ash Arsenault ($500) and Tugba Ozturk ($500)

Lorraine Gosselin Graduate Award
Kathleen McGarvey-Lechable ($5000)

Interested in doing a project for PHYS 496/497 or simply curious about our research?

Please visit our department website to learn about faculty research interests and programs, and contact them for a lab visit or a discussion.

New Physics Scholarship for a Refugee Student

Faculty, staff, and friends of the Department together with the Advancement and Alumni Office have funded a 4-year scholarship which will cover tuition and fees for a refugee student entering a BSc in Physics. The Syrian Kids Foundation will be responsible to provide support for living expenses and find a suitable candidate. We are hoping to welcome this student as early as September 2016.

BSc Student Summer Research Opportunities

The deadline to apply for the NSERC Summer awards is February 1st, and for the Concordia Summer awards the deadline is Feb 16th, so please look into this right away. The details can be found at the links below.

https://www.concordia.ca/students/financial-support/scholarships-awards/internal/nserc-usra-program---summer-2016.html

http://www.concordia.ca/research/students-and-postdocs/undergraduate-opportunities/cusra.html

There are many other exciting opportunities for doing work in Physics this summer, some of them can be found at this link:
https://www.physics.utoronto.ca/students/undergraduate-program/undergraduate-opportunities/summer-research-opportunities

New physics course: Fall 2016—PHYS 498/679

Principles of Medical Imaging
Contact: Dr. Christophe Grova

The most beautiful thing we can experience is the mysterious. It is the source of all true art and science.

Albert Einstein