Student Talks

Medical physics session – July 18

Alexandra Bourgouin - 10h00
Carleton University

Improving radiation dosimetry through an investigation of the mean energy required to create ionisation in dry air.

The ionisation potential of a solid, gas or liquids plays a crucial role in a range of physical phenomena and applications. In radiation physics, one of the most important quantities of this type is the energy required to create ionisation in air. This quantity, referred to as W_{air}, can be used to relate the electrical signal measured with an ionisation chamber (a high-accuracy instrument similar to a Geiger counter) to absorbed dose, which is the real quantity of interest in radiation therapy and radiation protection. W_{air} is considered to be energy independent above 10 keV, with a recently-recommended value of 33.97 ± 0.12 eV. However, an extreme interpretation of the available data would allow a variation of up to 2% in the clinical energy range, significantly larger than stated uncertainty. Any variation in W_{air} impacts the accuracy of radiation therapy treatment deliveries and therefore deserves further investigation. To address this, a graphite ionization chamber and calorimeter were irradiated with high energy electron beams to yield a value for W_{air}. Fourteen different configurations were used (varying incident radiation energy, material thickness, and irradiation time) to investigate a number of influence factors and test the robustness of the detectors used, with particular focus on the calorimeter response and analysis algorithm. Results show an average value 0.56 % lower than the consensus value, which is less than the worst-case analysis of literature data, but still not insignificant. The results to date indicate that the feasibility of the method but further work is required to reduce the uncertainties in the experiment, with particular focus on the evaluations of the specific heat capacity of the graphite used for the calorimeter and the mass of the air cavity in the ionization chamber.

Kristy Rieck - 10h15
University of Victoria

Gold Nanoparticle uptake in synchronized breast cancer cells and the effect on radiation therapy

Purpose: To overcome the challenge of delivering the prescribed dose to cancer cells while sparing normal tissue, preferential introduction of high Z material to tumour cells works as a method of radiation sensitization. Gold nanoparticles (GNPs) are very useful in this respect. It has been shown that the size, shape, and surface properties of GNPs affect their cellular uptake. Manipulation of the cell cycle to arrest cells at different stages offers a unique strategy to study the molecular and structural events as the cell cycle progresses. To optimize delivery of GNPs into tumour cells and enhance the effect of radiosensitization, we investigated nanoparticle uptake in synchronized populations of MDMBA231 breast cancer cells

Methods: Populations of MDAMB231 cells were arrested in S-phase. Synchronized cells were incubated with 5nm GNP, 15nm GNP, and two formulations of liposome encapsulated 5nm GNPs. Uptake of nanoparticles is visualized using hyperspectral imaging and quantified with ICP-MS (Inductively Coupled Plasma Mass Spectrometry). Following internalization of gold nanoparticles, cells were irradiated with 6MV photon beams from a linear accelerator, and the survival fraction and DNA damage were studied.

Results: Cell cycle analysis after a double-thymidine block shows the population is well synchronized. Uptake of nanoparticles is higher in synchronized cell population and is increased using liposome encapsulation delivery system. Ionizing radiation interacts with the GNPs inside of cells and produces secondary electrons that cause cellular damage. After a dose of 2Gy cell survival fraction is decreased following incubation with GNP indicating dose-enhancement.

Conclusion: After cell irradiation, clonogenic assays shows that when the uptake of GNPs is higher, there is a decrease in survival fraction and γ-H2AX immunofluorescent staining shows more DNA double strand breaks. Optimizing uptake of gold nanoparticles is important to fully take advantage of their radiosensitizer properties and the cell cycle is a factor to consider.

Astrophysics session – July 19

Marie-Lou Gendron-Marsolais - 9h00
Université de Montréal

A journey into the Perseus cluster of galaxies

Jets created from accretion onto supermassive black holes release relativistic particles on large distances. These strongly affect the intracluster medium when located in the center of a brightest cluster galaxy. On the other hand, the hierarchical merging of subclusters and groups, from which cluster originate, also generates perturbations into the intracluster medium through shocks and turbulence, constituting a potential source of reacceleration for these particles. In this talk, I will present state-of-the-art multi-wavelength observations of the Perseus cluster, a nearby and bright galaxy cluster. Its proximity allows us to study in detail the complex processes that are taking place in these systems. I will first present new deep low radio frequency (230-470 MHz) observations of the Perseus cluster from the Karl G. Jansky Very Large Array. Our observations have revealed a multitude of new structures associated with the central diffuse radio emission, extending to hundreds of kpc in size. Furthermore, I will analyze the interplay between these radio structures and the optical filaments of NGC 1275, the Perseus cluster's brightest galaxy, based on new observations with the optical imaging Fourier transform spectrometer SITELLE (CFHT). I will present the first detailed velocity map of this nebula in its entirety and tackle the question of its origin. I will thus show how these high-fidelity observations are improving our understanding of these environments.

Elizabeth Loggia - 9h15
University of British Colombia

Replacing dark matter with a slow force

Historically, dark matter emerged to explain inconsistencies in general relativity and galaxy rotation curves, and it has since had success through indirect observation. However, after several decades of searching, there have not been any direct detections, and the constraints on dark matter keep increasing. As such, it is important to explore alternatives. One such alternative idea is an entropic gravity theory where gravity is described as an entropic force, implying it is an emergent phenomenon rather than a fundamental interaction. This theory serves as motivation for the toy model presented here. Instead of dark matter, we consider an extra force. This force couples to baryonic matter and acts in much the same way that gravity does, but with an important distinction: speed. Where gravitational interactions propagate at the speed of light, the interactions from this new force propagate more slowly. The idea is to explore how this delayed gravity-like force affects the dynamics of baryonic matter that were originally explained via dark matter. Theories associated with dark matter have a rich phenomenology. As the parameter space in which dark matter could live continues to shrink with ongoing experiments, this study will provide important insight into the validity of theories alternative to dark matter.

Frédérique Baron - 9h30
Université de Montréal

Hunt for WEIRD giant planets with Wide-orbit Exoplanet search with InfraRed Direct imaging

The Wide-orbit Exoplanet search with InfraRed Direct imaging (WEIRD) survey was designed to search for Jupiter-like companions on very wide orbits (1000 to 5000 AU) around young stars (<120 Myr) that are known members of moving groups in the solar neighborhood (< 70 pc). Sharing the same age, distance, and metallicity as their host while being on large enough orbits to be studied as "isolated" objects make such companions prime targets for spectroscopic observations and valuable benchmark objects for exoplanet atmosphere models. The search strategy of WEIRD is based on deep imaging in multiple bands across the near-infrared domain. For all 177 stars of our sample, z', J, [3.6] and [4.5] images were obtained with CFHT/MegaCam and GEMINI/GMOS, CFHT/WIRCam and GEMINI/Flamingos-2, and Spitzer/IRAC. Using this set of 4 images per target, we searched for sources with red z'-J>2.2 mag and 0.1<[3.6]-[4.5]>2 mag colors, typically reaching sensitivity to 1MJup companions at separations of 1000-5000 AU. The search yielded 4 candidate companions that were all rejected through follow up observations. Our results constrain the occurrence of the planetary-mass companions, between 1 and 13 MJup, on orbits with a semi-major axis between 1000 and 5000 AU, to be less than 0.02, with a 95 % confidence level. This result strongly constraints the presence of these types of planets and shows that giant planets on wide orbits might form like a star or brown dwarf rather than like a planet.

Hope Boyce - 9h45

McGill University

Flaring at the Heart of the Milky Way: X-ray and Infrared Variability of Sgr A*

Emission from the supermassive black hole at the center of our galaxy, Sagittarius A* (Sgr A*), is variable at both X-ray and infrared (IR) wavelengths. The physical mechanism behind the variability is still unknown, but careful characterization of the emission using simultaneous multi-wavelength observations can constrain models of the accretion flow and the emission mechanism. Recently, simultaneous observations have observed X-ray flares are always accompanied by a rise in the IR activity, while the opposite is not always true (not all peaks in the IR have a corresponding X-ray flare). Using 100+ hours of overlapping data from a coordinated campaign between the Spitzer Space Telescope and the Chandra X-ray Observatory, I will present results of the longest simultaneous IR and X-ray observations of Sgr A* taken to date.

Lisa Dang - 10h00

McGill University

The Curious Westward Hotspot Offset on the Hot Giant Exoplanet CoRoT-2b

Over the past two decades, thousands of planets orbiting stars other than the Sun have been discovered. Perhaps one of the most surprising finding is that the majority of these planets have no analog in our solar system. Among the large pool of known extrasolar planets (exoplanets), many of them belong to an exotic class called hot Jupiters. These planets have a size and mass comparable Jupiter's metrics, but they reside extremely close to their host star. Hot Jupiters' rotation rates are expected to rapidly synchronize due to tidal interaction with their host stars. Blasted with stellar irradiation, they typically exhibit large temperature gradients between the dayside and nightside hemispheres which drives a broad equatorial eastward flowing jet, displacing the hottest region east of the substellar point. This eastward shift has been predicted by dynamical models, and all Spitzer phase observations to date are consistent with this offset. We present the first counter-example: the detection of a westward hotspot offset in the 4.5 μm phase curve of CoRoT-2b. With an inflated radius and a remarkably featureless spectrum, this target is not a typical hot Jupiter. Now, a westward offset can be added to the list of unusual characteristics and this may not be coincidental. During my talk, I will present the possible explanations for CoRoT-2b's abnormal hotspot location and the implications of this result beyond this work.

Annabelle Richard-Laferrière - 10h15
Université de Montréal

On the Relation between Active Galactic Nucleus (AGN) Feedback in Clusters of Galaxies

Mini-halos are diffuse radio emission sources found in galaxy clusters, arising from relativistic particles in a magnetic field. However, this radio emission is located too far from the relativistic particles source, the Active Galactic Nucleus (AGN), implying that the particles must be reaccelerated in situ. Unfortunately, this explanation is not completely accepted, therefore, their origin remains unknown. Also, only a few mini-halos have been discovered so far. I will report the discovery of two new mini-halos (PKS 0745-19 (z=0.1028) et MACS J1447.4+0827 (z=0.3755)), as well as a compilation from the literature of the 28 known mini-halos. This compilation allowed us to compare properties of mini-halos to those of their galaxies cluster and find new, previously unknown, correlations between the radio power of the mini-halo and of the dominant galaxy of the cluster (Brightest Cluster Galaxy - BCG), as well as between the radio power of the mini-halo and of the cavities created by the AGN. The implication of the discovered relations will be discussed.

Climate science session – July 19

Marie-Pier Labonté - 14h00
McGill University

Water cycle changes toward the inner edge of the habitable zone of a tidally-locked Earth-like exoplanet

In exoplanet research, tidally-locked planets - one side facing their star (dayside), the other permanently in the dark (nightside) - orbiting dim host stars have been shown to be good candidates for habitability. Indeed, those planets often show the potential to maintain an Earth-like climate with a complete hydrological cycle when orbiting within the habitable zone. In this study, we present the water cycle changes under a radiative forcing, as a planet moves closer to its star, and the main underlying mechanisms. Using a slowly-rotating tidally-locked Earth-like aquaplanet atmospheric model, we perturb a control climate simulation by increasing the stellar constant by 10%. The dayside shows the typical eyeball pattern, with heavy precipitation rate on the substellar region surrounded by a desert-like ring. Similarly to global warming simulations of Earth, we do observe the same ”wet regions get wetter, dry ones get drier” on the dayside; this is dominated by the thermodynamic changes due to direct surface temperature increase and specific humidity following Clausius-Clapeyron scaling. The transport of energy by advection from dayside to nightside is critical to nightside’s energy budget and is sensitive to the atmosphere’s vertical stability. Considering a moist adiabat maintained on dayside and a weak temperature gradient in upper troposphere, we show that nightside’s stability changes result from the variations in dayside’s specific humidity and the day-to-night surface temperature contrast. Therefore, the slight increase in nightside’s low precipitation rate is the result of the close cancellation between the increased day-to-night heat transport and the bigger atmospheric radiative cooling, as the inner edge of the habitable zone is approached.

Ellen Eckert - 14h15

University of Toronto

The Brewer-Dobson circulation is a global transport phenomenon, and changes in it can indicate changes in Earth's climate. While model predictions coherently show an increase in the speed of the Brewer-Dobson circulation, this could not be comprehensively shown through measurements. We use global long-lived trace gases, like chlorofluorocarbon, whose concentrations were measured by a satellite instrument called MIPAS (Michelson Interferometer for Passive Atmospheric Sounding). The novelty of this study's approach is that it is able to process the concentrations of several different trace gases at once. It uses inverse methods to derive information on month-to-month changes in velocities and two-way mixing that is consistent among all these atmospheric constituents. This work shows one of the first applications of this inversion tool and the benefits that come with the inclusion of additional trace gases.

Fatma Kerouh - 14h30

Université de Sherbrooke

The concept of the smart city raised several technological and scientific issues including light pollution. There are various negative impacts of light pollution on economy, ecology, and heath. This paper deals with the census of the color of light emitted by lamps used in a city. We propose the use of specific physics based image formation model for light source modelisation and a probabilistic reasoning for the estimation of the light color emitted by lamps. From acquired images overnight by a digital camera, the normalized color of light is considered as a directional data on sphere sampled from von Mises-Fisher probability density function (pdf). The illuminant is a parameter of the pdf estimated using empirical Bayesian reasoning over directional data. In addition to the novelty of the target application, five features distinguish the proposed method from the state of art: 1) the low computational complexity; 2) it is based on both physics of image formation and Bayes reasoning; 3) the derivation of a direct light based image formation; 4) the used transforms to derive other mean estimators than the usual arithmetic mean; 5) the illuminant estimator is local. Experimental results show the effectiveness of the proposed approach.

Keywords: Smart city, night vision, light pollution, light color, image formation model, Bayesian reasoning, directional data.

Material science session – July 19

Cristina Cordoba -14h45
Simon Fraser University

Built-in potential mapping of InP/GaInP NW tunnel diodes in thermal equilibrium

Keywords: Electron holographic tomography, tunnel junctions.

We have characterized the electrical abruptness of highly-doped nanowire (NW) p-n junctions using Electron Holographic Tomography (EHT). The NWs were grown via vapour-liquid-solid (VLS) Au catalysis using metal-organic vapour phase epitaxy (MOVPE), in two growth configurations: n/p/Au and p/n/Au with the aim of integration in tandem solar cells [1]. The n-type InP was doped using S or Sn-based precursors (H2S, TESn) while the p-type InGaP with diethyl-Zn. Current-Voltage (I-V) measurements show excellent tunnel diode characteristics in the latter configuration. However, in the former configuration, the peak voltage in the negative differential resistance region varies from 0.3 to 2 V among devices. To better understand the differences evidenced by the electrical measurements, we used EHT to reveal the morphology and map the built-in 3D potential gradients. EHT measured a depletion width of 24 nm and built-in potential of 1V for the p/n/An configuration. For the n/p/Au configuration, EHT showed that the n-dopant kept on doping the NW even after the dopant precursor gas was turned off, resulting in a shift of junction position. The measured built-in potential was 1V, while the depletion width was 20 nm. The compositional gradient due to the further n-doping was attributed as the mean effect that decreases the tunneling capacity of the diodes grown in this configuration.

Faezeh Mohammadbeigi - 15h00
University of British Colombia

High resolution photoluminescence spectroscopy and transport properties of Ga doped ZnO nanowires grown by metalorganic vapor phase epitaxy

We have used high-resolution low temperature photoluminescence (PL) coupled with transport measurements to demonstrate the controlled doping of Ga impurities in high crystalline quality ZnO NWs grown by MOVPE. PL spectra of nominally undoped ZnO NWs exhibited I7 (unknown origin) and I9 (In) transitions in the bound exciton region. Doping small amounts of Ga resulted in the appearance oftheI8transition at 3359.9 meV, which is 0.2 meV below the I7 transition, and a doublet of I8and I7can be clearly identified. The integrated PL intensity of I8increased monotonically with increasing Ga concentration. At higher doping, a tail appears in the low energy side of I8.We explain this asymmetric broadening with a model considering interaction of the bound excitons with Ga donors. Transport measurements on single ZnO nanowires with different doping concentrations confirm the incorporation of Ga and are consistent with the broadening model.

Student Posters

Azin Aghdaei
Université de Sherbrooke

Investigation of Nitrogen-Vacancy Defects in Aluminum Nitride films

During the last decades, Aluminum Nitride attracts considerable attention due to its novel properties such as strong piezoelectric effect, high thermal conductivity, excellent optical and dielectric properties, low dielectric constant and good mechanical strength. AlN is also a material of interest for the realization of novel optomechanical and photonic circuits. Recently, AlN has been proposed as a good candidate for hosting qubit centers. The search for stable point defects having a spin configuration S = 1, in a III-V semiconductor host matrix, is of great interest for the implementation of large-scale quantum technologies. Calculations based on density functional theory have recently reported that defects related to nitrogen-vacancy of the AlN wurtzite structure can acts as good spin qubits [1-2], however to our knowledge, this has never been demonstrated experimentally. The aim of this work is to investigate, experimentally, the characteristics of nitrogen-vacancy related defects in AlN films grown by different methods (chemical vapor deposition and sputtering) . Samples were characterized by Electron Spin Resonance (ESR), Photoluminescence (PL) and Cathodoluminescence (CL) spectroscopy.. Two specific results are shown in Fig.1 and Fig. 2, on one particular sample. The cathodoluminescence spectrum of Fig. 1 shows four main emission bands: the AlN band-to-band transition at ~6 eV and three defect-related bands at lower energy. The band centered at 3.2 eV can be assigned to the transition from the excited 3E spin triplet state related to the nitrogen-vacancy (see H.Seo et.al [1]). The ESR spectrum of Fig. 2 shows five typical differential absorption peaks that can be attributed to the hyperfine structure related to nitrogen vacancies in the AlN film. The hyperfine splitting results from the interaction of the nitrogen-vacancy electron spin with one particular surrounding Aluminum nuclei spin. Our results are in a good agreement with the theoretical papers [1,2].

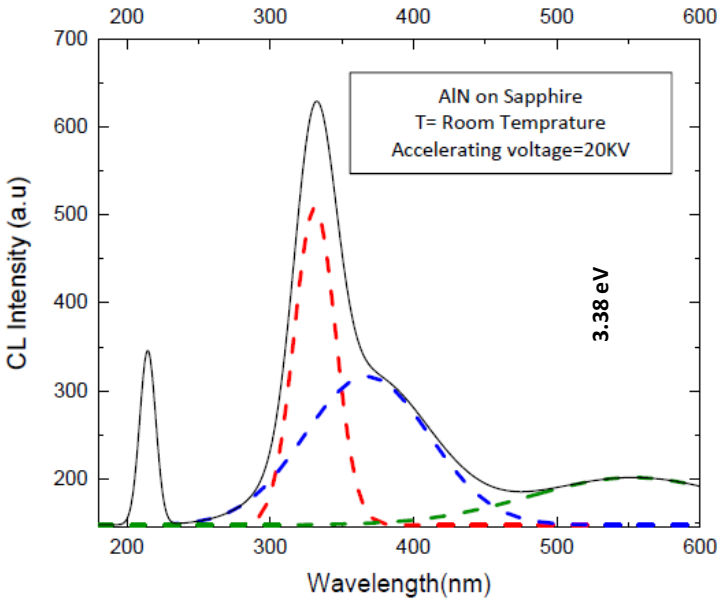

Fig.1 Cathodoluminescence (CL) spectrum of a 1 μm-thick AlN film grown on sapphire. Each colored dotted curve corresponds to a specific defect-related optical emission band.

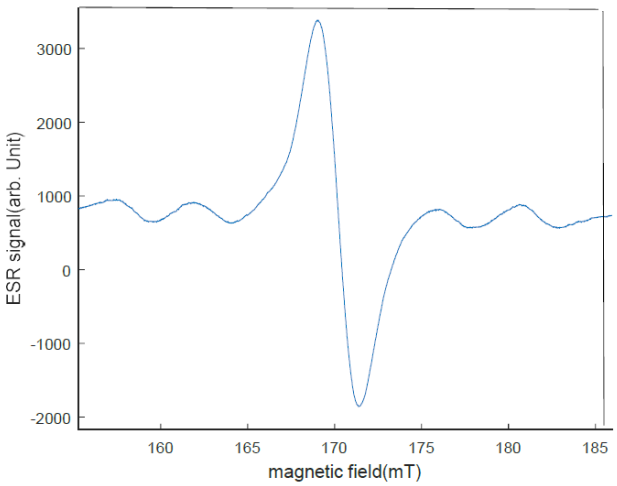

Fig.2 Room-temperature ESR spectrum of a 1μm thick AlN film grown on sapphire.

Gabrielle Beaudin
Université de Montréal

Emerging nematicity in EuB6 from magnetic polarons

One of the great successes of quantum theory of solids was that electrons largely behave as gas of free spin 1/2 particles due to the periodic arrangement of atoms in a crystal. Strong electron-electron interactions can change their behavior to that of a liquid. However, unlike in classical liquids, where a suspension of rod like molecules can lead to anisotropic interactions and the occurrence of nematic or liquid crystal phases, the point like nature of electrons seems at first sight not to lend itself to the formation of an electronic nematic. So it was quite a surprise, when experiments first in ultraclean quantum Hall system, and then in Sr3Ru2O7 indicated presence of an electronic nematic, which breaks symmetry of the system. Later these phases were also discovered in the high temperature superconductors as well as the iron arsenides, where the relation between the nematic order and superconductivity, and the close-by structural instability is hotly debated. Here we present evidence for the presence of an electronic nematic in EuB6 in which magnetic polarons break the cubic symmetry. As in EuB6 there are no structural instabilities nearby, this opens an interesting new system for studying electronic nematicity.

Patrick Bourgeois-Hope
Université de Sherbrooke

Origin of the upturn in resistivity in cuprates probed by thermal conductivity

We report low temperature thermal conductivity measurements in the cuprate superconductor LSCO for samples with a doping x between 0.125 and 0.15. In this doping range, spin-density-wave order coexisting with superconductivity can be induced by applying a magnetic field [1,2]. We study the impact of this order on the conduction of d-wave quasiparticles by measuring the residual thermal conductivity $\kappa 0/T$ in the $T \rightarrow 0$ limit, as a function of doping and magnetic field.

Éloise Chakour
McGill University

Signatures of Cosmic Strings Using 3D Ridgelet Statistics

The goal of this project is to construct an algorithm which would distinguish between data sets containing and not containing a cosmic string wake. We observe the presence of a cosmic string by observing the effect of its wake in the distribution of dark matter. Ultimately, the goal of this type of algorithm will be to obtain more precise information on how to detect cosmic strings. By applying this type of analysis to simulated data, we eventually hope to determine at what redshift, tension and scale could be observed in the real world. More precisely, the goals of this project are the construction of an algorithm, the development and implementation of a normalization scheme and the adaptation of existing 1D and 2D statistical methods to be used on 3D data sets. An algorithm was written, but has yielded only mixed results, most of which we believe to be false positives or false negatives. Significant successes are the implementation of the 3D ridgelet algorithm described in 3D Sparse Representations, which adapts 1D wavelet analysis for use on a 3D data set, the creation of a functional normalization scheme and the precision of the peak-detection portion of the algorithm. However, the runtime of the algorithm continues to be problematic and further work needs to be done in order to make the algorithm usable in a real-world research context.

Annabelle Richard-Laferrière
Université de Montréal

Hunting for the Most Massive Black Holes in the Universe using Hubble Space Telescope Data

Massive black holes play an important role in the formation of galaxies, likely modulating the growth of the stellar component. Indeed, there is an observed correlation between the mass of the central black hole (MBH) and the bulge stellar velocity dispersion (σ) in a galaxy. Our understanding of this fundamental relation is still incomplete, even if it is extensively used to support models of the linked formation of galaxies and black holes. Furthermore, there is a deviation from the relation at low-mass and a lack of experimental data at the high-mass end. Indeed, there are only four black holes with masses exceeding 1010 MΘ (solar masses) known so far. Moreover, studies based on the fundamental plane of black hole activity, an established relation between the mass, radio and X-ray luminosity of a black hole, indicate that there should also be a deviation from the relation at high-mass. Finding new black holes of more than 1010 MΘ is therefore the only way forward to understand the details of the MBH-σ relation and confirm or infirm the deviation at high-mass. We have identified an exceptional galaxy, PKS 0745-BCG

(z=0.1028), which should be at least 2.5 × 1010 Mʘ, but could be the first 1011 Mʘ black hole ever measured. Also, it has clear rotation of the gas within the central regions of the galaxy to enable modelling of the black hole mass. I will explain why we think this black hole could be the most massive one in the Universe and how we are finding its mass using new Hubble Space Telescope data.

Noémie Chagnon-Lessard
Université Laval

Geothermal power plants with maximized specific work output: Optimal design of the Organic Rankine Cycle

The energy sector and the environment protection are both major issues of our time. Binary geothermal power plants are one of the most environmentally friendly power generation modes and they can be used in regions with low-temperature reservoir. As a matter of fact, the liquid pumped from the reservoir (geofluid) never sees daylight as he only transfers its heat to a working fluid (the one producing power in the turbine) and is reinjected right after. The project is to optimize the Organic Rankine Cycle (ORC) of a hypothetical geothermal power plant to maximize its specific work output (a manner of representing power per unit of geofluid's mass flow rate). Two basic cycles are numerically modelled: a subcritical cycle (where all pressures are below the critical pressure) and a transcritical cycle (where the higher pressure is above the critical pressure). Both cycles are optimized and the one with the best specific work is selected. This optimization is done for a large range of geofluid's temperature (80 to 180°C) and for a large range of the temperature within the condenser (0.1 to 50°C). The latter temperature being directly linked to outdoor temperature, the generated charts can guide the design of the ORC according to uncontrollable regional characteristics. These charts offer choices of working fluids and controllable operating conditions (flow rates and pressures) leading to an optimized performance.

Amélie Dumont
Université Laval

Dwarf galaxies formation in gas rich mergers

Galaxies usually follow a mass-metallicity relation, where higher mass galaxies are typically more chemically enriched than the lower mass galaxies. Yet, tidal dwarf galaxies are outliers to this relation. These kinds of dwarves are formed in galactic mergers. Since their material come from the parent galaxies, they are typically more chemically enriched than regular dwarves. However, galaxies were far less enriched when the Universe was younger. One can ask if tidal dwarves who formed a long time ago could be chemically distinguish from regular dwarves? To answer this question, we simulate a gas-rich merger in which we identify around twenty dwarf galaxies. While the initial abundance in chemical element was low, the merger allows a rapid enrichment and nearly all dwarves end up with high abundances. We conclude that tidal dwarves should be outliers to the mass-metallicity relation, no matter the epoch of formation.

Jihane Ez Zaaf
Université de Sherbrooke

Engagement des femmes dans le projet QMSat

Le champ magnétique terrestre écrante, les effets des vents solaires et leurs rayonnements associés, susceptibles d'affecter les réseaux satellitaires associés aux télécommunications, et réseaux de lignes de haute tension. Afin de mieux prédire ces phénomènes, des missions spatiales utilisent des magnétomètres pour mesurer l'effet des tempêtes solaires.

Grâce à un projet de génie quantique de l'Institut quantique, un magnétomètre quantique à base de diamant a vu le jour. Base sur le défaut quantique nommé centres azotes-lacune, il possède plusieurs avantages par rapport aux magnétomètres conventionnels comme : une mesure du champ vectoriel absolue, une faible influence face à la variation de température, et une grande sensibilité, pouvant atteindre les picoteslas. Le prototype actuel de magnétomètre de dimensions 40 cm× 40 cm× 10 cm, sera miniaturisé à 10 cm× 10 cm× 3 cm pour convenir à un nanosatellite de type CubeSat de 2 unités. Il y a d'autres critères à respecter pour répondre aux requis des CubeSats, notamment la consommation limitée et la tolérance aux variations de températures. L'objectif est d'effectuer la première démonstration mondiale d'un magnétomètre quantique à base de diamant dans l'espace, mis en orbite en 2021.

Le satellite est conçu dans le cadre du projet QuantumMagnetoSatellite - QMSat gagnant de la bourse de l'Agence Spatiale Canadienne. Le projet encourage les femmes en leur attribuant des rôles importants. En termes de travaux techniques, le projet dispose de deux membres féminins, dont une future ingénieure à la tête de l'équipe de télécommunication. Cette équipe assurera le développement et la conception du système de télécommunication du satellite, ainsi que la conception d'une station terrestre à la faculté de génie de l'université de Sherbrooke. Des actions concrètes sont prévues pour maximiser le nombre de femmes participantes dans le projet, comme l'organisation d'activités scientifiques, et l'inclusion de jeunes filles d'école secondaire dans le développement technologique d'une partie du projet.

Chloé-Aminata Gauvin-Ndiaye
Université de Sherbrooke

Electronic and Magnetic Properties of the Candidate Magnetocaloric-Material Double Perovskites La2MnNiO6, La2MnCoO6 and La2MnFeO6

The search for room-temperature magnetocaloric materials for refrigeration has led to investigations of double perovskites. In particular, a puzzle has appeared in the La2MnNiO6, La2MnCoO6 and La2MnFeO6 family of compounds. They share the same crystal structure, but while La2MnNiO6 and La2MnCoO6 are ferromagnets below room temperature, La2MnFeO6, contrary to simple expectations, is a ferrimagnet. To solve this puzzle, we use density-functional theory calculations to investigate the electronic structure and magnetic exchange interactions of the ordered double perovskites. Our study reveals the critical role played by local electron-electron interaction in the Fe-d orbital to promote the Fe3+ valence state with half-filled d-shell over Fe2+ and to establish a ferrimagnetic ground state for La2MnFeO6. The importance of Hund's coupling and Jahn-Teller distortion on the Mn3+ ion is also pointed out. Exchange constants are extracted by comparing different magnetically ordered states. Mean-field and classical Monte-Carlo calculations on the resulting model give trends in TC that are in agreement with experiments on this family of materials.

Charlotte Ferworn
Ryerson University

On Ultrasound Microbubble Potentiated Therapy as a Modality to Enhance the Cytotoxicity of Pro-Apoptotic Drugs in Prostate Cancer Cells in vitro

Ultrasound and microbubble (USMB) therapy has been shown to enhance the cytotoxicity of various chemotherapeutic drugs in cancer models. Here, we investigated whether USMB can enhance the cytotoxic effects of pro-apoptotic drugs. It was hypothesized that combining the pro-apoptotic drug, Sabutoclax, with USMB therapy would increase cell death. Prostate cancer cells (PC3s) were treated with two different concentrations of drug, 10μM and 1μM, both alone and in combination with USMB therapy using a 1MHz transducer at 0.6MPa and in the presence of Definity microbubble at a concentration of 1.7% (v/v). The microbubble (MB) acoustic response was assessed using a passive cavitation detection system; a 2.5 MHz transducer was used to passively detected the echo from the MBs behaviour during the therapy and subsequently the integrated cavitation dose was quantified. The data supports the hypothesis that the application of USMB enhanced the cytotoxic effects of the proapoptotic drug Sabutoclax. This was demonstrated most significantly at the higher of the two drug concentrations, 10μM. The increased cytotoxic effect was linked to the disruption of MBs based on the increased integrated cavitation dose.

Evelyn Macdonald
McGill University

Mapping the Earth's Transit Spectrum

Transit spectroscopy is a technique used to study the atmospheres of transiting exoplanets, that is, those which pass between their star and an observer. The planet's radius can be deduced by measuring its transit depth, the fractional decrease in stellar flux due to obstruction by the planet. A planet's apparent radius varies as a function of wavelength due to absorption of light by molecules in its atmosphere. Each molecule has a distinctive absorption spectrum; therefore, higher transit depth in certain wavelength regions can be attributed to specific molecules. A planet's transit spectrum can thus be used to infer the composition of its atmosphere. In this project, the Earth's transit spectrum is mapped using data from the Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS) on the SCISAT satellite. This instrument measures the transmittance of the Earth's atmosphere as a function of wavenumber during solar occultations, when the atmosphere is between the Sun and the satellite. The Earth's transit spectrum is obtained from these data and then modified to account for refraction, differences in star size, and the specifications of future instruments to simulate future observations of exoplanet systems. The Earth spectra obtained in this project provide the ground truth, which will be used as a benchmark for models to interpret the transit spectra of potentially habitable exoplanets.

Layale Bazzi
University of Windsor

Women in Science: WinS for All

The underrepresentation of women in science is an ongoing issue in institutions of higher learning and industry alike. While the number of women in Canadian academia is increasing, there is still a large gender gap in Science, Technology, Engineering and Math (STEM) disciplines. The Faculty of Science has undertaken an initiative, spearheaded by three undergraduate students, to quantify and compare gender ratios in the various science programs and faculty rankings in an effort to bring attention to the underrepresentation of women in those fields and devise strategies to reduce gender gaps. Students were tasked with analyzing undergraduate and graduate enrolment data over the last ten years across all Science programs. The data revealed that although the overall gender gap in science graduate programs have decreases, it has remained unchanged at the undergraduate level, with female students least represented in computer science, physics and economic programs. Gender gaps also persist among faculty with the greatest discrepancy at the ranking of full professor. With this data, the Women in Science (WinS) initiative, which seeks to engage students, faculty and staff, raise awareness, and address challenges facing women in science, was created. Initial successes include a new public seminar series launched by guest speaker Dr. Imogen Coe, Dean of Ryerson University, outreach to regional high school students in collaboration with our community partner Build A Dream, and a service learning credit through WinS. Collectively, these efforts encourage young women to pursue education and careers in STEM, while engaging and supporting current science students, faculty and staff. It has also allowed these student researchers to practice civic responsibility and engage in faculty-staff partnerships that empowers them in leadership roles within the scientific community. This study also contributes to future recruitment strategies in the Faculty of Science to boost representation of women and foster diversity.

Morgan Maher
Ryerson University

Using high frequency ultrasound to assess the biophysical properties of blood clots

Blood circulation requires regulated clot formation and breakdown; however, disease or injury often causes derangements in this process. Such perturbations may result in excessive bleeding or thrombosis (the blockage of blood flow due to the lack of clot breakdown), which in turn can lead to morbidity or even mortality. Current strategies for monitoring clot formation and breakdown involve multiple time consuming blood tests each with associated costs and complexity [1]. Existing laboratory tests, such as platelet count and fibrinogen levels, as well as viscoelastic point of care tests are routinely used to aid diagnosis of deficiencies in the coagulation process but have limited to no ability to determine the quality or integrity of the clot [2]. Additionally, the design of the tests typically affects the temporal dynamics of the process and thus impacts results. In order to address this gap in quantitative coagulation assessment, high frequency ultrasound (HFUS) is being used to examine the biophysics of clot formation, breakdown, and quality.

In vitro plasma (acellular) clots are assessed by HFUS (SASAM acoustic/photoacoustic microscope - Kibero GmbH, Germany) with a central frequency of 80 MHz. Throughout the clot formation and breakdown, RF data is collected periodically and temporal dynamics associated with changes in the density and speed of sound of the clot are observed.

Preliminary results indicate that this technique is highly sensitive to changes in the sample and is effective at examining the kinetics of clot formation and breakdown. Additional experiments will be

performed to ensure reproducibility and further analysis will attempt to isolate factors affecting the ultrasound response. Modifications to the clot composition can then be used to assess the effects of drugs on clot quality. Future work will aim to incorporate the simultaneous use of photoacoustics and HFUS to acquire additional information about the contents of the clot.

Francia Ravalison Soloarivelo
Université de Trois-Rivière

Effet de l'hydrogène sur les propriétés tribologiques des revêtements sur l'acier 444

L'acier est abondamment utilisé dans les applications industrielles. Les problèmes de corrosion sur ce métal sont bien connus et étudiés. Cependant, la fragilisation causée par l'hydrogène est moins comprise. Pour certaines applications, l'hydrogène peut également modifier les propriétés tribologiques des aciers. Dans ce travail, nous allons investiguer l'effet de l'hydrogène sur les propriétés tribologiques des revêtements sur l'acier inoxydable ferritique, type 444; notamment la résistance à l'usure. Pour ce faire, une méthode électrochimique est utilisée. L'étude consiste à un chargement d'hydrogène des échantillons. Ensuite, quantifier l'hydrogène qui a été absorbé par le métal pour après, déterminer l'impact de la présence de l'hydrogène sur la résistance à l'usure des composantes dans des applications industrielles. La méthode électrochimique a été choisie car c'est l'environnement le plus proche du domaine d'application réel d'une part; d'autre part, c'est un moyen particulièrement commode pour générer de l'hydrogène susceptible d'être impliqué dans un phénomène de pénétration. Éventuellement, l'effet d'un revêtement sera aussi étudié. D'où, on pourra valider l'efficacité des revêtements sur l'acier inoxydable ferritique, type 444 et sa pérennité pour les applications industrielles.

Marc-Antoine Roux
Université de Sherbrooke

Use of a guard ring as an ESD protection component for tunnel junctions

Modern electronic fabrication processes allow to make nanoscale devices. However, the small size of those devices increases their sensitivity to electrostatic discharge (ESD) due to the bigger current density for the same applied voltage. In many cases, it becomes challenging to manipulate and characterize samples without damaging them especially when many preparation steps are required before the final experiment. Therefore, the use of a guard ring that shorts every connection on the samples can protect them when used with simple ESD precautions. Following sample fabrication, two guard ring removal processes, with diamond tip scribing and laser cutting, have been investigated. On Al/Co tunnel junctions isolated by a thin aluminum oxide layer, the diamond tip scribing lead to a 93% yield for junction integrity. However, removal of the guard ring with laser cutting doesn't remove the electrical conductivity between connections.

Maude Roy-Labbé
Université Laval

Multiple Target Tracking using LiDAR sensors with low angular resolution

Automation in vehicles is on the rise. Using detection technologies, the aim of our project is to create a real-time view of the vicinity of the road, facilitating drivers' maneuvers and reactions, thus improving road safety.

To assist drivers in their decisions, it is essential to be able to predict the movement of the objects encountered on the road, which requires adequate tracking and detection capabilities. The tracking process is complicated by the fact that several targets, each following their own trajectories, must be managed at the same time. This domain of research is referred to as MTT - Multiple Target Tracking.

Our project aims to find the most appropriate MTT method in a context of detection by several LiDAR sensors with low angular resolution each covering a distinct part of the road. We will report in this presentation on the results we have obtained in our research work.

During our initial experiments, simulation data representing multiple types of trajectories were generated. The ability of different algorithms to identify and track the objects represented by those simulations was subsequently evaluated. The use of a Kalman filter on the measured data allowed a gain of performance compared to a simple reference algorithm for linear trajectories.

Subsequently, a multiple hypothesis tracking (MHT) algorithm was implemented. This method enhances the performance of previous algorithms by deferring decision-making when confronted with uncertainty. To consider multiple scenarios, Murty's algorithm, which generate ranked solution to assignment problems, is used to produce several hypotheses. As additional information is received by the sensors, later detections allow us to confirm which hypothesis seems to be the correct one. An optimization of the parameters of the MHT was also carried out in order to obtain better results from our algorithms.

Édith Ducharme
Université Laval

Use of a double clad fiber for OCT suveillance of laser therapy using real-time speckle variance

Laser therapy have been used to perform both ablation and coagulation of diseased tissue. Such therapies, however, still lacks an accurate and cost-effective method to monitor the affected area and depth during treatment.

We present an integrated solution to provide both therapy delivery and monitoring based on an OCT system. Prior works have focused on the analysis of the signal a posteriori, lacking real-time feedback. In addition, the delineation of the therapy zone was performed on the complex-amplitude OCT signal, increasing the complexity of the analysis and necessitating a sufficiently phase stable system. Lastly, the thresholds used to delimit coagulated tissue determined rather arbitrarily to provide good results for the specific OCT system used and tissue types tested.

Here, we present a proof-of-concept experiment demonstrating a step forward into the practical implementation of real-time monitoring in an OCT. Firstly, a single fiber is used to deliver both the therapy laser and to perform OCT imaging, simplifying the endoscopic probe design. Secondly, the monitoring algorithm developed is significantly more efficient, uses only the intensity of the OCT

signal, and is designed to be run at the same time as the therapy providing the real-time monitoring of the tissue.

Ruth Mutala Kabeya
ASEAD

Experimental Study and Numerical Simulation of Ecological Steamer in "Yakam Matrix"

In this communication, we present the simple ecological steamer designed and manufactured in "Yakam Matrix" application. We concentrated the coupled problems in the development of three-monocylindrical compartments device of 300 mm diameter, namely: (i) an improved furnace whose combustion phenomena examined, (ii) the evaporator vessel and (iii) The steamer properly so called. This useful device responds to the news challenges: from food security to minimizing malnutrition with granular steaming, energy saving through better burning of the improved flames burner, to the fight against global warming challenge of the environment with Deforestation, and the service to the society by a simple technology accessible to all the exchange of modest cost.

The combustion phenomena, evaporation and pressure cooking at the flame/structure fluid interface are empirically demonstrated in this work. The simulation and modeling with the equipment during turbulent flow gas-solid/vapor of water for steaming show some various open questions in fundamental and applied research. The preliminary result is limited only onto the agreement of design, experimental, simulation and modelling in "Yakam Matrix". The steamer used in situ by women give some satisfaction and ASEAD receive the renewable command to others steamers.

Keys words: women, steamer, food technology, combustion, " Yakam matrix", simulation and modelling.

Dana Wegierak
Ryerson University

Acoustic-Based Photoacoustic Contrast Agents

Photoacoustic imaging, which relies on the generation of ultrasound waves following optical absorption, can have superior contrast compared to ultrasound imaging and greater imaging depth compared to optical imaging, making it an attractive biomedical imaging method. The number of photons exponentially decreases as a function of depth, which lowers the amplitude of the acoustic waves that are generated. Some of these waves might not be sensed by the transducer due to acoustic attenuation through the medium. Contrast agents in photoacoustic imaging attempt to address this problem by increasing optical absorption in the region of interest. In ultrasound imaging, microbubbles have been used as intravascular contrast agents to enhance the signal through the resonant excitation of the microbubbles by the incident ultrasound waves. In my work, the stimulation of microbubbles by a photoacoustic wave is investigated as a means to increase intravascular contrast in deep tissue. Experiments were designed to experimentally measure the excitation of microbubbles by photoacoustic waves. In the first set of experiments, a black glass bead absorber, 1mm in diameter, was embedded in a polyacrylamide phantom separated by up to 30 mm from three vessels (1mm in diameter) filled with activated microbubbles. Results show that signal is detected from regions corresponding to microbubble location. Next, two phantoms with three hollow vessels were made. In the second set of experiments, the phantoms are filled with blood and blood and bubbles respectively, and

photoacoustic images of both are compared. Results show that the introduction of microbubbles increases signal by as much as 6dB within vessel regions. Additionally, by thresholding the images to identify signal above the noise level, vessels with microbubbles show an increase of 13% in the area compared to vessels without bubbles. The results of these experiments are highly suggestive that microbubbles (which have negligible native optical absorption) can be used as photoacoustic contrast agents by their acoustic interactions with photoacoustic waves produced by other chromophores in their close vicinity.

Andy Bondo Ilunga
Institut Supérieur de Technologie de Kinshasa

Monitoring Model for management of technical data determining high-risk pregnancy factors for girls mother in developing countries, case of Democratic Republic of Congo in Sub-Saharan Africa

This communication develops a model of significant data on the program framework of young girls due to the determinants of high-risk pregnancies for female mothers aged 12 to 16 years. The statistical method used during three last years types, raise the complex multiparametric.

In the standardized [0, 1] topology, more than 73% of girls have sexual life under 17 and 21% at more than 12 years old. Those who become pregnant are traumatized to keep the secret during the first 6 months of their pregnancies, with adverse consequences. A simple Model A * U = f in [0, 1] predicts the crisis paradigm of regulatory policies for hospitals and health clinics services. The model codifies the ethics regulation, the rambling of clinics, the exchange of data for health centers, which can follow the dynamics of girls.

The work contains three points : (i) the state of the art face of the girl's education on sexuality and the management of technical data in reliable information (MTDRI) which is taboo in Africa; (ii) the model of support based on monitoring in multi-culturality and practice, (iii) the simulation of improvements in the "Worldview" context.

Thomas Baker
Université de Sherbrooke

Selecting initial states from Genetic Tempering for efficient Monte Carlo sampling

An alternative to Monte Carlo techniques requiring large sampling times is presented here. Ideas from a genetic algorithm are used to select the best initial states from many independent, parallel Metropolis-Hastings iterations that are run on a single graphics processing unit. This algorithm represents the idealized limit of the parallel tempering method and, if the threads are selected perfectly, this algorithm converges without any Monte Carlo iterations--although some are required in practice. Models tested here (Ising, anti-ferromagnetic Kagome, and random-bond Ising) are sampled quickly with a small uncertainty that is free from auto-correlation.

Funding for this project was provided solely by the postdoctoral fellowship from Institut quantique. This research was undertaken thanks in part to funding from the Canada First Research Excellence Fund (CFREF).