STUDENT TALKS: SCHEDULE

Time	Auditorium	Room 1416
1:00	Cissy Suen (McMaster) A Uniform, Modern Atlas and Tools for Globular Cluster Variable Stars	Sarah Hyatt (Dalhousie) Measuring and reducing parasitic heat flow in lithium-ion batteries to improve their lifetime
1:15	Jennifer Tang (McMaster) The Formation of Alzheimer's Plaques in Synthetic Membranes	Jacy Conrad (Dalhousie) Freeze-Cast Thin Films for Use in Dye-Sensitized Solar Cells
1:30	Marie Annie Saucier (Université Laval) A Computer model of neuron swelling and shrinkage under synaptic activity and osmotic stress	Jennifer Mauel (Queen's) Perylene as a Secondary Wavelength Shifter Candidate for SNO+ Liquid Scintillator
1:45	Hannah Stegen (Mount Allison) Hadron Polarizabilities Data Analysis	Emma McKay (Waterloo) Defining quantum chaos: random state production and eigenstate thermalization in the coupled kicked tops
2:00	Lina Rotermund (Dalhousie) Study of electrolyte additives “magic chemicals” in Li-ion cells	Maude Lizaire (Université de Montréal) Evolution of Fermi surface in Sr3Ru2O7
2:15	Alyson Spitzig (Dalhousie) MnSi thin film growth on SiC substrates in search of out-of-plane skyrmions	Jessie Dumont (Royal Military College of Canada) Learn Space by doing space

STUDENT TALKS: ABSTRACTS

Freeze-Cast Thin Films for Use in Dye-Sensitized Solar Cells **- Jacy Conrad** (Dalhousie University)

The potential use of freeze-casting to make titanium dioxide thin films with an ideal morphology for use in dye-sensitized solar cells is being investigated. In dye-sensitized solar cells, sunlight is harvested by dye molecules adsorbed onto the surface of a semiconductor, usually titanium dioxide. The cell efficiency could be improved by having structures with enhanced electron donor and acceptor interface surface area.

Freeze-casting is an environmentally friendly process that can be used to produce nanostructured ceramics. The technique consists of the solidification of a dispersion of ceramic particles in a solvent, followed by sublimation of the frozen solvent and sintering of the ceramic. The pores of the resulting ceramic are replicas of the fugitive solvent crystals, leading to the possibility of controlling the porosity by various chemical additives. Using this technique to make highly porous thin films of titanium dioxide can potentially lead to improved efficiency of dye-sensitized solar cells.

Titanium dioxide films with high porosity have been made via freeze-casting and characterized by surface profilometry and scanning electron microscopy. Preliminary dye-sensitized cells have been assembled and tested using these films as anodes.

Measuring and reducing parasitic heat flow in lithium-ion batteries to improve their lifetime - **Sarah Hyatt,** Laura Downie, and Dr Jeff Dahn (Dalhousie University)

We use lithium-ion batteries every day in our cell phones and computers. However, their lifetime and cycle life need to be increased. Unwanted parasitic reactions between the charged electrodes and electrolyte occur within batteries and limit their lifetime. Reducing or eliminating these reactions will improve battery lifetime. Isothermal microcalorimetry is used to accurately measure the heat flow produced by the parasitic reactions. I will show how special chemical additives to the electrolyte reduce the rate of parasitic reactions and also increase cell lifetime.

Evolution of Fermi surface in $Sr_3Ru_2O_7$ - **Maude Lizaire (Université de Montréal)**

Andy Mackenzie (University of St-Andrews), Andrew Huxley (University of Edinburgh), J. Ph. Reid (University of St-Andrews)

The material $Sr_3Ru_2O_7$ is known to possess a unique nematic phase which can only be revealed once the magnetic field is perfectly aligned relative to the crystal structure. It was believed that the origin of this nematic phase was the result of a spin texture of the Fermi surface which could explain the sensitive response to the magnetic field orientation. Very recently, a neutron scattering study revealed that

this nematic phase was the signature of a magnetic order called spin density wave. This new study has rekindled the debate around the true origin of this phase. Thermoelectricity is known to be extremely sensitive to any change of the Fermi surface. In fact, it is considered as an ideal method to probe any phase transitions such as Superconductivity and Magnetism. In this talk, I will be presenting thermoelectric measurements across the anomalous phase in order to study the impact of this SDW phase on the Fermi surface of $Sr_3Ru_2O_7$. After a thorough introduction of the experimental and theoretical aspects of this technique, I will show the design and conception of the probe we built for this experiment and I will expose the main challenges and constraints to complete such measurements. I will finish by explaining why $Sr_3Ru_2O_7$ is a material that worth further investigation and how this technique is ideal for that matter.

Perylene as a Secondary Wavelength Shifter Candidate for SNO+ Liquid Scintillator**- Jennifer Mauel** (Queen's University)

SNO+ is a kilo-tonne scale liquid scintillator experiment located 2km underground at the Sudbury Neutrino Observatory (SNOLAB). SNO+ will make use of SNOLAB's ideal low cosmogenic background levels to investigate various properties of the neutrino, in particular to search for neutrinoless double beta decay. The detector consists of a 12m diameter acrylic sphere which will be filled with a Tellurium-loaded linear alkyl-benzene (LAB) cocktail during the double beta phase. In order to maximize the optical properties of the scintillator cocktail, a primary and secondary wavelength-shifter will be included to absorb and shift light produced in the detector to an optimal range for photomultiplier (PMT) detection. The fluorescence emission and absorption spectra of perylene, a candidate wavelength shifter, has been measured and used in simulations for this purpose. Data collected on the optical properties of perylene has been used in simulations to determine the degree to which perylene can improve the sensitivity of the experiment.

Defining quantum chaos: random state production and eigenstate thermalization in the coupled kicked tops **- Emma McKay** (University of Waterloo), Joseph Emerson (Institute for Quantum Computing)

Classical properties of chaotic systems lead us to expect certain behaviour of quantum chaotic systems. In many instances our expectations are met, but not with enough frequency or rigour to even adequately define what a quantum chaotic system is. The random state conjecture postulates that quantum chaotic systems evolve dynamical states indistinguishable from random ones. The eigenstate thermalization hypothesis postulates that the eigenstates of a quantum chaotic system are thermal states. We test both of these ideas for the coupled kicked tops and draw conclusions about energy dependence of chaotic behaviour.

Study of electrolyte additives “magic chemicals” in Li-ion cells **- Lina Rotermund** Remi Petibon, Jeff Dahn (Dalhousie University)

Electrolyte additives, seemingly “magical chemicals” or “pixie dust”, are used in lithium ion batteries in small amounts (about 1%) to extend their lifetime. The earliest (since 1997), most famous and widely-used additive, vinylene carbonate (VC), increases the lifetime by a factor of about three. A “new kid on the block”, Prop-1-ene-1,3-sultone (PES), is similarly wonderful. However, there is still huge debate about how VC and PES work. More detailed knowledge of how additives function will help researchers discover even better ones.

Studies of the fate of VC and PES in Li-ion cells using gas chromatography/mass spectrometry are presented here: How much VC or PES remains in the cells as they are used? Is it important that any remains? What gases are formed from these additives when they react in the cell? These and other questions will be answered and discussed.

A Computer model of neuron swelling and shrinkage under synaptic activity and osmotic stress – **Marie Annie Saucier**, Nicolas Doyon (Université Laval)

Water fluxes through neuron membranes are essential in regulating homeostasis while osmolarity is challenged by heavy synaptic activity or high frequency spiking. The membrane displacement caused by the volume change in response to such activity may be only of a few tens of nanometres. The technique of holographic microscopy, a novel measurement method, enables us to assess these small volume changes using interferometry. However, indirect computations are necessary to infer magnitude and duration of synaptic current from the phase shift measured by holographic microscopy. In order to achieve such computations, we build a computer model to describe a neuron response to synaptic and spiking activity in terms of changes in volume and refractory index. The reverse use of our model allows computation of magnitude of synaptic events from phase shifts and refractory index. This model was used to study biomechanical properties of membrane under osmotic stress. The membrane was modeled as an elastomer. Our model pinpoints some inconsistencies in our current state of knowledge that could be due to unknown volume regulating mechanisms or to poorly describe biomechanical properties of membrane, suggesting further experimental investigation.

MnSi thin film growth on SiC substrates in search of out-of-plane skyrmions **- Alyson Spitzig** (Dalhousie University)

Skyrmions are locally stable magnetic knots, with the magnetic moments twisting around in a vortex. In MnSi this twisting is a consequence of a chiral interaction created by the B20 crystal structure.

Molecular beam epitaxy (MBE) and solid phase epitaxy (SPE) are used to grow MnSi on 6H-SiC(0001) substrates. X-ray reflectivity (XRR) and x-ray diffraction (XRD) are used to measure film thickness and plane spacings respectively. Plane spacing measurements are used to determine the phases present in the samples. It was

found that MnSi(111) can be grown on SiC(0001) with the proper procedure. A thin 0.1nm Si layer is annealed to 1200◦C to remove surface oxides, then an amorphous 0.22nm Si / 0.27nm Mn/ 0.4nm Si is grown and annealed to 460◦C , which produces the correct crystal structure to stabilize MnSi(111) when MnSi is codeposited.

Hadron Polarizabilities Data Analysis **- Hannah Stegen** (Mount Allison University)

The A2 Collabaration at the Intitute for Nuclear Physics in Mainz, Germany, is working towards solving the polarizabilites of hadrons through Compton scattering experiments. Raw data is taken in by the Crystal Ball detector, which detects photons after being scattered off a proton target. Specifically, my contribution to the collaboration includes working with the programs that analyze the data. The software package GoAT, or Generation of Analyzing Trees, is a program that can input simulated or real data and make specific cuts and organizes data into tree files is one of the main tools used in the collaboration. I have been working towards making a very general physics class, which will be useful to the whole institute. We plan to impliment this software so that it will be managable to both beginners and the more experienced. Solving the mysteries of Quantum Chromodynamics will be made easier and more effecient with this general program.

The Formation of Alzheimer's Plaques in Synthetic Membranes **- Jennifer Tang**, Matilda Backholm, Hannah Dies, Maikel C. Rheinstädter (McMaster University)

One of the hallmarks of Alzheimer’s disease is the formation of neurotoxic senile plaques, primarily consisting of amyloid-beta peptides. Despite their importance for the pathogenesis of the disease, little is known about the properties of these plaques and about the process by which they form. I developed a model system to study the formation and properties of Alzheimer’s plaques in vitro. I prepared synthetic anionic lipid membranes with brain-like composition and included different amounts of amyloid-beta(25-35), which comprises the transmembrane segment of the 42 amino acid long peptide. The systems were prepared as multi-lamellar membranes supported on silicon chips. We investigated size, density and molecular properties of these plaques using microscopy and X-ray diffraction. While at concentrations of 3mol%, the peptides were dispersed in the membranes, at 10 mol% and 20mol%, peptide aggregates were observed. Plaques with typical sizes of 12 to 13 micrometers were observed under the microscope. With increasing peptide concentration, the density of small plaques increased, however, their size stayed approximately constant. The aggregates were found to form inside the membranes and to coexist with the membrane structure. We used X-ray diffraction to determine the molecular structure of the membranes and detect the peptide signals to determine the amount of peptides in alpha-helical and beta-sheet structures. The preparation of synthetic Alzheimer’s tissue is a milestone for the in vitro testing of anti-Alzheimer’s drugs before they go into clinical studies. By preparing membranes

of different composition, such as saturated and unsaturated lipids, cholesterol and different length of amyloid-beta peptides, quantitative information about plaque formation will be obtained.

Learn Space by doing Space **- Jessie Tremblay** (Royal Military College of Canada)
It is well known that there are hundreds of artificial satellites orbiting Earth as you are reading this. To fulfill its mission, a satellite must be maintained on a reference orbit by focusing its instruments accurately: interventions are needed at regular intervals to correct the natural disturbances of the orbit generated by different sources. This is where space operators come in context. Those engineers/scientists are highly trained to be able to localise, to establish contact, to manoeuver and to collect data from the spacecraft(s) they are assigned to. This presentation will highlight my experience as a student operator, qualified space operator, and then trainer on one of the US Air Force Academy's cadet-built microsatellite: FalconSAT-3. Although this talk is not about search results, I believe it would be beneficial to all undergraduate women attending this conference, since I will present a quite different career path to which can lead a BA in physics.

A Uniform, Modern Atlas and Tools for Globular Cluster Variable Stars - **Cissy Suen** (McMaster University), Taylor Bell (University of Saskatchewan), Dr. Doug Welch (McMaster University), and Dr. Alison Sils (McMaster University)
Seventy years ago, Baade [Baade 1944] discovered that there are two classes of Cepheid variable stars (a famous type of star whose brightness fluctuates in a way such that the distance to the star can be determined). We have begun a project to establish the frequency of binarity among Type II Cepheids in globular clusters of the Milky Way. An immediate challenge we encountered was identifying variables from earlier published work. The inhomogenity of source positions and identification material led us to conclude that a set of modern, large-format CCD images needed to be taken to confirm identifications of variables and to establish coordinates and magnitudes on a standard system. New images were obtained using the 61cm Optical Craftsman telescope (Mt. John, New Zealand), the 61cm Table Mountain Observatory (New Mexico, USA), and the 50cm, wide-field Sonoita Research Observatory telescope (New Mexico, USA). Using IRAF, DAOPHOT/ALLSTAR/ALLFRAME photometry and astrometry.net astrometry we derived locations of variables and compared our results with literature, such as the Samus [Samus et al. 2009] catalogue and the Clements [Clements 2013] tables. We created scalable vector graphics of colour-magnitude diagrams and finder charts for each cluster using the dynamic Javascript library, D3 [Bostock, 2013]. This work will be compiled into an online public catalogue to be released as the work on a cluster is completed. Here, we present a platform in which users will have the ability to selectively label and cross-identify our results with available literature.

STUDENT POSTER: ABSTRACTS

Formation of RNA from mononucleotides in different environments **- Mindy Chapman** (McMaster University), Laura Toppozini (Origins Institute, McMaster University), David W. Deamer (University of California), and Maikel C. Rheinstädter (Origins Institute, McMaster University)

How nucleic acids first assembled and were then incorporated into the earliest forms of cellular life 4 billion years ago remains a fundamental question of biology. It is postulated that prior to today's DNA, RNA, and protein dominated world, RNA (ribonucleic acid) was used as genetic storage and a catalyst to chemical reactions[1]. RNA is a polymer chain of nucleotides bound together forming a ribose-phosphate backbone. The polymerization of nucleotides occurs in a condensation reaction in which phosphodiester bonds are formed[2]. In this study, we used X-ray scattering to investigate 5'-adenosine monophosphate (AMP) and uridine monophosphate (UMP) mono-nucleotides captured in different matrices, such as a multilamellar phospholipid matrix, nanoscopic films, ammonium chloride salt crystals and Montmorillonite clay to study the formation of RNA-like structures. Two contributions of the nucleotides were observed in all materials, one corresponding to a nearest neighbour distance of around 4.6 Å and a second at a smaller distance of 3.45 Å. While the 3.45 Å distance agrees well with the distance between base pairs in the RNA backbone, the 4.6 Å can be attributed to nucleotides that have not undergone polymerization. From the strength of the two contributions, the effectiveness of the different environment for producing RNA-like structures can be quantified for the first time. Montmorrilnite and the salt were found to be the most effective at producing RNA like structures. 87.6% of AMP, 84.2% of UMP, and 68.3% of the nucleotides in a mix of AMP and UMP were found to polymerize when in contact with clay. Organic molecules were less efficient: the lipid matrix lead to 24.8%, 20.4% and 38.9% of backbone structures. Confinement of the nucleotides in a nanoscopic film lead to 29.4% for AMP, 39.4% efficient for the UMP, and 37.2% mixed AMP and UMP molecules. This experiment is a direct demonstration that confinement of nucleotides in different matrices can, in fact, organize monomers and thereby promote polymerization into RNA-like polymers. This is strong evidence that first RNA may have formed in volcanic or hydrothermal vent environments. References [1] Deamer, David. Liquid crystalline nanostructures: organizing matrices for non-enzymatic nucleic acid polymerization. Chemical Society Reviews 41:5375-5379 (2012). [2] Toppozini, Laura, Hannah Dies, David W. Deamer, and Maikel C. Rheinstädter. Adenosine monophosphate forms ordered arrays in multilamellar lipid matrices: insights into assembly of nucleic acid for primitive life. PloS one 8:e62810 (2013).

Spectral Absorbance in Linear Alkyl Benzene - **Christopher Connors** (Laurentian University)

Liquid organic scintillators are a very attractive medium for particle physics detectors, especially if they come at low costs. Linear Alkyl Benzene (LAB) was first selected for the SNO+ experiment due to its chemical compatibility with acrylic and has since been considered by several others. Using Spectrophotometry techniques we can demonstrate the absorbance of LAB in different wavelengths in the visible and ultra violet spectrum. This study compares distilled LAB, contaminated LAB, LAB loaded with Neodymium and LAB loaded with Tellurium for absorption. This can aid material selection as well as optical studies for the experiments. Measurements will be explained and results shown.

Modeling fluctuations in the human heart rate - **Brittany Cook**, Dr. Rizwan Haq, Dr. Bruce Oddson (Laurentian University)

For a set of data of human heart rates, the aim of this study is to analyse the fluctuation by using statistical measures derived from random matrix theory. In particular, we will look at the effects of changing external parameters as well as indications of transition from regularity to chaos. The presentation will show the models and data available and describe the current status of the study.

The Search for Magnetic Monopoles at the ATLAS Detector (CERN) - **Jennifer Della Mora,** Dr. Wendy Taylor (York University)

The search for magnetic monopoles is a well-motivated effort for three main reasons: the existence of magnetic charge would reinforce the symmetry in the extended version of Maxwell's equations; by the Dirac condition, the quantization of electric charge would be explained; magnetic monopoles are predicted by many grand unified theories. In the ATLAS detector at CERN, the Transition Radiation Tracker (TRT) and the Liquid Argon Electromagnetic Calorimeter (LAr EM Cal) are of particular importance in this search effort. Magnetic monopoles are theorized to be highly-ionizing particles whose energy deposition (dE/dx) signature is uniquely characterized by high ionization in the TRT and large localized energy deposits in the LAr EM Cal. Monte Carlo simulations are used to propagate monopoles through the layers of the ATLAS detector to evaluate the performance of the online real-time monopole trigger.

Nucleon Polarizability Extraction via Compton Scattering - **Meg Morris** (Mount Allison University)

The A2 collaboration at the Institute for Nuclear Physics in Mainz, Germany, is experimentally determining the polarizabilities of nucleons in the grand pursuit of better understanding the strong interaction between quarks and gluons. Precise measurement of the neutron scalar polarizabilities has been a long-standing challenge due to the lack of a free-neutron target. Lead by the University of Glasgow and the Mount Allison University groups of the A2 collaboration, preparations have

begun to test a recent theoretical model with a high-pressure, active helium target with the hope of determining these elusive quantities with small statistical, systematic, and model-dependent errors. Apparatus testing, including the evaluation of new photomultiplier tubes and a study of the effect of nitrogen concentrations on detector response, and background-event simulations have been carried out with the full experiment projected to run in 2015. Once determined, these values can be applied to help understand quantum chromodynamics in the non-perturbative region.

New user-friendly scripts for the investigation of the colon using the compuGUT **- Kathleen Songin**, Hermann Eberl, Arun Moorthy (University of Guelph)

With the development of a new simulation model, the compuGUT, we are able to track quantities of interest (fibers, sugars, SCFAs and microbes) in the large intestine during digestion. The model at present is in beta testing, being used to confirm the model computes results as expected for known 'Test Scenarios'. For this reason, the model itself is highly inaccessible to researchers without significant experience with large C source code. To overcome these computational inconveniences, we've been able to create R scripts that are more user-accessible than the underlying compuGUT model, allowing us to use the compuGUT as a simulation platform for experimentation. An example simulation study is investigating the effect of dietary fiber on the microbial composition along the colon. The results provided percentage concentration amounts over a fixed amount of days, of different microbes that compose the gut microflora. The compuGUT continues to be re-worked and tested, thus all simulation results must be considered preliminary at this stage. However, with our user-accessible scripts, that are able to call the compuGUT model in an intuitive and convenient manner, we expect to aid the compuGUT evolution from a numerical integration program to a user-friendly research and learning tool; an in silico platform to study the basics of colon fermentation. In future prospects, development of a GUI will bridge that final gap between source code and accessible research tool.