Physics Senior Research Oral Presentations

Michigan Technological University

Thursday, April 17, 2014

3:15 – 5:00pm

Room 139 in Fisher Hall

Formation of the Midcontinent Rift System: Fossil Magnetization of Intrusive Rocks

Darcy Jacobson

Advisor: Dr. Aleksey Smirnov

Abstract: The two main competing theories for the formation of the ~1.1 Ga Midcontinent rift system (MRS) around the Lake Superior region in North America are active rifting due to a mantle plume, and passive rifting. Two dyke swarms (lamprophyres and Abitibi dykes) with similar characteristics, coeval emplacement ages and their apparent fanning from a common center represent the first magmatic stage of MRS and may indicate the arrival of a mantle plume. In order to assess this hypothesis 25 lamprophyre dykes around the northeastern shore of Lake Superior, Canada were sampled for detailed paleomagnetic and rock magnetic analysis. The paleomagnetic directions obtained from these dykes were compared with the data from Abitibi dykes. The preliminary analyses indicate common origin for these two dyke swarms hence supporting the mantle plume hypothesis.

High-Speed Imaging of Freezing Drops: An Investigation of Contact Nucleation

Joseph Charnawskas

Advisor: Dr. Raymond Shaw

Abstract: Liquid water does not always freeze at 0 C, which is the melting point of ice. It can exist at supercooled temperatures, and the phase change in this supercooled state from liquid water to ice is initiated by ice nucleation. In our investigations high-speed imaging was employed in order to investigate contact nucleation, specifically, the preference for ice nucleation to occur at air-water interfaces. A high-speed camera was utilized to locate the nucleation site in a droplet of water, which was frozen inside of an isolated and temperature controlled chamber. In order to investigate the length scale at which line tension becomes significant, a 100 micron fiber optic cable with nanometer sized surface defects on its glass silica core was inserted through the droplet of water to determine the length scale preference for nucleation.

Synthesis of molybdenum disulfide for applications in van der Waal's heterostructures

By Emily Makoutz

Advisor: Dr. Yoke Khin Yap

Abstract: Van der Waal's heterostructures are formed from different types of two dimensional crystals that are held together by van der Waal's forces. With particular arrangements, it is possible for these heterostructures to exhibit a variable band gap and unprecedented optical and electrical properties (Humberto Terrones et al, 2013). Molybdenum disulfide (MoS2) is a semiconducting crystal with a recently realized direct band gap of 1.8 eV as a monolayer film (K. F. Mak et al, PRL 2010). In the nanotechnology lab we have worked towards achieving and improving the controlled synthesis processes of MoS2 using chemical vapor deposition for applications in heterostructured devices. Island growth of MoS2 crystals have been achieved and characterized using Raman spectroscopy, photoluminescence spectroscopy, and scanning electron microscopy (SEM) to evaluate the quality and uniformity of the growth. Acknowledgement: This work is performed with graduate student Mingxiao Ye under the supervision of Professor Yap.

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Preliminary Search for Exotic Events in the Pierre Auger Cosmic Ray Observatory Data

Greg Furlich

Advisor: Dr. Brian FIck

Abstract: A preliminary search for exotic events in the Pierre Auger Cosmic Ray Observatory surface detector data was conducted using Root and RooFit. The usual cosmic ray event creates a single bump longitudinal shower development profile that is parameterized by a Giasser-Hillas function. In contrast, an exotic event would create a double bump longitudinal shower development profile. The preliminary search found possible candidates for such exotic events, however further scrutinous examination of these candidates must be conducted for conclusive evidence.

Numerical Investigation of Water Vapor Effects in Rayleigh-Bénard Convection

Michael Adler

Advisor: Dr. Raymond Shaw

Abstract: The development of water vapor supersaturation and cloud formation are highly dependent on atmospheric convection patterns. To study this dependence, we explore the effects of including moisture within the Rayleigh-Bénard framework, where convection can be driven by gradients in temperature as well as water vapor concentration. Simulations of moist convection at small Rayleigh numbers are performed to demonstrate several non-intuitive results including non-thermal convection and the development of supersaturation in downwelling air parcels. Using a simple model for condensation and evaporation, we then explore the coupling that this phase change introduces to the system and the spatial patterns of cloud formation.

Synthesis and Characterization of Boron Nitride Nanosheets for Applications in Heat Dissipation

Sawyer Hopkins

Advisor: Yoke Khin Yap

Abstract: Faster and smaller devices have led to severe heat management issues in portable devices. Light weight Boron Nitride materials offer high heat conductivity and would be applicable for advanced heat management. Boron Nitride nanosheets (BNNSs) are synthesized and evaluated for this purpose. By altering the partial pressures of Boron Oxide and Ammonia gas during growth it was possible to tune these BNNSs to varying size and density. The effects of these BNNS samples were examined by comparing their heating and cooling profiles with that of a bare Si substrate. It was observed that samples grown with high Boron Oxide and low Ammonia gas pressure can double the cooling rate of hot Si chips.

Boson Sampling Using Optical Microcavaites.

Stephen Dipple

Advisor: Ramy El-Ganainy

Abstract: Quantum computation is an active field of research with promising potential in applications ranging from network security to computational chemistry and drug synthesis. It was recently shown that quantum effects can be used to calculate permanents of matrices. While for an n-size matrix, this calculations is known to be classically difficult; O(e^n), boson sampling can perform the same task without these restrictions. Boson sampling experiments use non-classical light propagating in waveguide networks to calculate these permanents. Here, we investigate the possibility of implementing this process using optical microcavaties. If successful, this will lead to boson sampling chips having a smaller footprint.