Physics Colloquium
Senior Research

Michigan Technological University

Thursday, April 16, 2015
3:00-5:00 pm
Room 139, Fisher Hall

Jeanine Chmielewski
Advisor: Dr. Aleksey Smirnov
Investigation of the Effect of the Verwey Transition on Remnant Magnetization in Magnetite

Cycling magnetite (Fe3O4) through its crystallographic transition at ~120K (the Verwey Transition) in a magnetic field results in the acquisition of a Low-Temperature Transitional Remnant Magnetization (LTTrRM). In nature, an LTTrRM may be acquired by meteorites when they enter the Earth's atmosphere. This magnetization can complicate the use of meteorites as recorders of planetary and interplanetary magnetic fields. The field-dependence of LTTrRM was investigated for magnetite samples with different grain sizes. Synthetic samples of magnetite were placed in liquid nitrogen to get to temperatures below the Verwey Transition temperature. A magnetic field was applied as they warmed up back through the transition point, simulating the meteorites entry into the atmosphere. The samples show a linear dependence on the applied magnetic field at the low field levels. Future investigations will include the relative stability of LTTrRM with respect to other types of remnant magnetization (such as thermal and isothermal remnant magnetizations).

Luke Schroeder
Advisor: Dr. Ramy El-Ganainy
Supersymmetric Single Mode Lasing Arrays

Laser arrays are devices that consist of several coupled optical cavities or waveguide structures. They are mainly used instead of traditional lasers to produce high power emission. However this comes at the expense of transverse multi-mode operation. Multi-mode operation can lead to chaotic temporal behavior as well as lower beam quality. In order to overcome these drawbacks, the higher order modes must be suppressed to allow only for the fundamental mode to lase. Here it can be shown that this single-mode operation can be achieved by utilizing the concept of SUperSYmmetry (SUSY). In particular, this numerical analysis demonstrates that by coupling the main array to an auxiliary SUSY array that exhibit frequency matching with all the modes of the main array except the fundamental one, single mode operation can be achieved through introducing extra loss into the SUSY structure.

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Raven Stone
Advisor: Dr. Claudio Mazzoleni

Quartz-Enhanced Photoacoustic Spectroscopy of Light Absorbing Aerosols

I am developing a Quartz-Enhanced Photoacoustic Spectroscopy (QEPAS) sensor to measure the light absorption coefficient of atmospheric aerosols. The goal of the QEPAS is to collect data about aerosols to improve current climate models to better predict the effect that aerosols have on the radiative balance of our planet. In fact, aerosols interact with solar radiation absorbing and scattering it and therefore warming or cooling the planet. This instrument development will be important to more accurately determine human influences on the environment, climate and air quality. The QEPAS functions with a laser that is incident upon the aerosol in an enclosed chamber, passes through the prongs of a quartz tuning fork, and pulses at the resonance frequency of the tuning fork. When absorbing aerosol is present the light absorbed is released in the form of heat generating acoustic waves. The acoustic wave excites the piezoelectric material that the tuning fork is made of generating an electrical signal. The resonance frequency of the tuning fork was obtained by directly striking the fork with a 532 nm and a 447 nm laser while sweeping through a range of frequencies and it was determined to be in the range of 32,560-32,610 Hz. The optimal position of the laser with respect to the tuning fork was explored by striking it with the laser at its resonance frequency and moving the fork at different positions. We are working towards testing the sensitivity of the QEPAS on NO2 and soot, which has an expected sensitivity around 3 Mm-1 for the 447 nm laser and 1.6 Mm-1 for the 532 nm laser where commercial PAS sensors are around 1 Mm-1.

Adam Laxo
Advisor: Dr. Raymond Shaw, Physics

Effect of Charge on Heterogeneous Ice Nucleation

Ice can be formed from supercooled water through heterogeneous nucleation. The possible role of electric charge in ice nucleation is investigated using a pyroelectric material, which induces charging when its temperature is changed. A high-speed camera is used to capture the freezing process, specifically whether there is any preference in the spatial location of the nucleation events. Freezing of supercooled water has been observed over a range of cooling rates and the corresponding rates of charging.

Michael Small
Advisor: Dr. Yoke Khin Yap
Towards the Fabrication and Construction of Quantum-dot Sensitized Nanowire-based Photovoltaic Devices

Previous work has shown the potential for constructing a quantum dot sensitized solar cell with a nanowire architecture. This design would yield higher efficiency while reducing the cost of materials. This project investigated the possibility of constructing a solar cell utilizing a layer-by-layer process using pulsed laser deposition and spin coating. From this research, a preliminary method for solar cell construction has been established. However, future work is necessary to avoid electrical shorting between the electron and hole collecting electrodes.

Eric Morris
Advisor: Dr. Sean J. Kirkpatrick (Biomedical Engineering)
Analysis of Reperfusion in a Hand Using Laser Speckle Contrast Imaging

A speckle pattern is the random interference caused from a coherent light source being scattered by a rough surface or by a scattering volume. The intensity within the speckle pattern is random, and its statistical properties depend on the motion of the object relative to the light source. If the illuminated object is in motion, the imaged speckle pattern will also display motion. Laser speckle contrast imaging (LSCI) is one approach for quantifying relative motion between different regions of the image. This imaging technique can be used to improve currently established medical tests, more specifically, the modified Allen's test that is used for estimating hand blood perfusion. In this project, LSCI was used for a quantitative analysis of post-occlusive reactive hyperaemia on the palmar surface of the hand.

Cody Bell
Advisor: Dr. L. B. King, MEEM
Construction of a Retarding Potential Analyzer (RPA) for an Ion Thruster

With the recent advancements in ion propulsion technology, various analyzing apparatuses must be used. For the testing of our electrospray beams, a RPA was designed which can be used with smaller emitters as well as in the smaller vacuum chambers. This design will utilize a two grid system instead of a four grid system which will be space efficient and reliable. Through the use of this instrument, various samples can be tested for the maximum ion current density; allowing for optimal performance from future ion thrusters.