Physics Senior Research Oral Presentations

Michigan Technological University

Thursday, April 18, 2013

3:30 – 5:00pm

Room 139 in Fisher Hall

Effect of Surface Reflectance on Photovoltaic Performance

Mac Brennan

Advisor: Dr. Joshua M. Pearce, Department of Materials Science & Engineering

Abstract: To optimize the performance of a photovoltaic (PV) system for a specific application, it is necessary to understand the effects of surface reflectance. When reflected by a surface material, the incident spectrum is shifted away from the standard spectrum used to test and design PV devices. Due to the spectral response of PV materials, surface reflectance can have varying effects on PV performance depending on the PV material used. These effects were calculated for a combination of 22 natural and man-made surface materials, and 7 commercial PV materials. The results show the importance of both designing the surrounding environment of a PV array, and selecting PV materials based on specific locations and applications, in order to maximize solar electric output.

Studying Pulsar Wind Nebulae: Geminga and Boomerang

Abigail Dillon

Advisor: Dr. Petra Huentemeyer

Abstract: Using data gathered by the water Cherenkov detector Milagro, the energy spectrum of the Geminga and Boomerang pulsar wind nebulae are measured. The results obtained from Milagro data are compared to measurements from other gamma-ray detectors such as the MAGIC and VERITAS telescopes. The uncertainties on the spectrum parameters (i.e. the spectral index and flux normalization) resulting from the presented Milagro analysis are bigger than those from other experiments at slightly lower gamma-ray energies. Additional data will be collected with the more sensitive HAWC observatory, the successor to Milagro, which will provide more accurate measurements of gamma-ray energy spectra in the high TeV range. In my presentation, I will describe the physics of pulsar wind nebulae, discuss the Milagro data analysis procedure and show first results.

Computational Study of Droplet Formation from Micro-Pores

Jeremy Dobbs

Advisor: Dr. Kathleen Feigl, Department of Mathematical Sciences

Abstract: Emulsions are fluid systems in which droplets of one fluid are dispersed throughout the other, continuous fluid. The properties of an emulsion are dependent in large part on its microscopic structure (e.g., drop size distribution, number density), and a better understanding of how the dispersing process influences the microstructure will lead to more effective emulsions. In this study, droplet formation from micro-pores is numerically simulated for a fluid system with a high viscosity ratio. Conditions under which consistent drop formation occur in the dripping regime are found, and a relationship is determined between the size of the droplets formed and the shear rates imposed by the continuous fluid velocity. Specifically, the size of the droplets decreases as these shear rates increase, following a power law behavior. This decrease in drop size is due to the increased wall shear stresses imposed by the continuous phase at higher velocities, which cause droplets to detach with higher frequency. These results are consistent with experimental data and numerical simulations at lower viscosity ratios.

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Synthesis of Hexagonal Graphene Using Natural Graphite Crystals

Clarence King

Advisor: Dr. John Jaszczak

Abstract: Graphene is one of the newest topics to hit the research spotlight and has often been called a 'wonder material'. The number of amazing properties attributed to graphene is only exceeded by the number of different methods that can be used in its fabrication, as researchers race to find more effective techniques. Here, we use a standard mechanical exfoliation technique with high quality natural graphite crystals instead of the typical synthetic graphite used by most researchers. Initial results are similar to those previously published, however using crystals with natural formations known as 'Hillocks', it has been shown to be possible to synthesize hexagonally shaped graphite/graphene flakes about 10 micrometers in diameter. Results were verified using optical microscopy and laser Raman spectroscopy.

Investigations of the History Force on the Motion of Small Particles

Tyler Plamondon

Advisor: Dr. Raymond Shaw

Abstract: The motion of a particle through a viscous fluid is relatively simple if the particle is small and if the motion is steady, but even for small particles the description becomes more complicated if the particle accelerates. The relative acceleration between a particle and a fluid gives rise to a drag force dependent on the history of the particle's motion. With this history force, the equation of motion becomes an integro-differential equation with memory. Numerical simulations were used to determine the importance of this force on the trajectory of spherical particles and to show that this force is not as negligible as many hope. Fluid velocity fields such as solid-body rotation and a sinusoid as an elementary model of turbulence demonstrate the importance of the history term. These preliminary results give motivation for further study for cloud applications.

An Investigation into the Efficiencies of
ZnO Nanostructures used in Photovoltaic Cells

Derek Van Damme

Dr. Yoke Khin Yap

Abstract: Advances in nanoscale science have expanded the amount of materials feasible for use in solar cells. Semi-conductive ZnO nanostructures are still in their infancy, but hold promise in the field because their energy band gap lies in the visible spectrum, and their electron mobility is greater than that of some traditional solar cell materials, such as titanium oxide. Quantum dots are a source of excitement in the field as well because their tunable band gaps can be manipulated to more efficiently convert photons into current. In this study, results suggest that shorter sparse nanorods are more efficient than nanowires due to a reduction in electron transport length and shadow effects. The effect of the concentration of ZnS/CdSe core/shell quantum dots that decorated the ZnO nanostructures was investigated as well.