Physics Senior Research Oral Presentations

Michigan Technological University

Thursday, April 12, 2012
3:30 – 5:00pm
Room 139 in Fisher Hall

Boron-nitride Nanotube Fabrication

M. Perry Nerem
Advisor: Y.K. Yap

Abstract: Production of Boron Nitride Nanotubes (BNNTs) through Chemical Vapor Deposition (CVD) was modified in order to advance theoretical understanding of BNNT formation and increase the availability of BNNTs for future experiments and applications. Guided by nucleation theory, a series of CVD experiments was conducted in which the vapor pressure in the growth chamber and concentrations of reactants in the system was varied None of the variations displayed the desired increase in production yields but revealed the significance of the reactant vapor pressure which is not uniform inside the growth chamber. Shifting the position where the reactants interact controls the growth density of BNNTs and reveals transitions where the reactant vapor pressure allows other boron nitride nanomaterials to develop instead of BNNTs. Increasing BNNT yield does not scale with an increase in the reactant vapor pressure; optimizing the growth conditions, and improving understanding of the theory behind BNNT formation is necessary in order to improve production yield of BNNTs.

Computational Analysis of Gravitational Settling in Turbulent Flows

Benedict Malec
Advisor: R. Shaw

Abstract: Turbulence is a long unsolved problem, filled with difficulties due to the non-linear nature of the Navier-Stokes equations. It is well understood that turbulence rapidly scatters and mixes particles, and Batchelor and Richardson proposed theories on how particles should disperse within a fluid, but a transition between their two regimes has not been observed. I used a Direct Numerical Simulation (DNS) to simulate particles within a turbulent flow. I primarily focused on gravitational settling, which tended to overpower local variations in smaller scales of turbulence, as well as ensure a transition between the Batchelor and Richardson regimes.

Concentrating Ambient Aerosols via Acoustic Resonance

Arin Nelson
Advisor: C. Mazzoleni

Abstract: Aerosols play a significant role in atmospheric processes such as ice nucleation, but it is difficult to collect a significant number of these aerosols while in their natural environment to better examine these processes as well as properties of the aerosols themselves. It has been documented that a hollow piezoelectric cylinder can be used to create standing pressure waves in its interior air-filled cavity which can force aerosols into the low-potential nodes. However, this is the first known attempt made to quantify how ambient aerosols are concentrated in such a resonator as a function of time.

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Crystalloluminescence of Water
Nigel Anton
Advisor: W. Cantrell

Abstract: Crystalloluminescence is an emission of light due to crystallization. This phenomena has been documented in salt solutions and has been reported (by Henri Becquerel) in supercooled water. We made measurements of changes in light intensity as supercooled water droplets froze in a dark chamber; however no observable changes in light intensity were detected.

Limiting Energy-related Dispersion in the Universe with Gamma-ray Bursts
Ryan Connolly
Advisor: R. Nemiroff

Abstract: The dispersion of light over cosmological distances is predicted by some theories of dark energy as well as by some theories of quantum gravity. Distant gamma-ray bursts are an excellent source of high-energy photons which can provide limits on the strength of dispersion of light as a function of energy. Extremely energetic bursts detected by NASA's Fermi Gamma-ray Space Telescope were analyzed with the Norris gamma-ray burst pulse model, the characteristic width of which provides a maximum timescale at which dispersion could be present. Using pulses above 1 GeV within GRB 090510A, we limited dispersion to less than one second per Gpc per GeV.

First principles analysis of the elastic properties of $ReMg_xTi_{7-x}B_{16}$
Daniel Burrill
Advisor: R. Pandey

Abstract: The elastic constants of several systems of $ReMg_xTi_{7-x}B_{16}$ are calculated in an ab initio approach using density functional theory with the Becke three-parameter Lee-Yang-Par functional. Building upon a previous study, rhenium was substituted into an $Mg_xTi_{8-x}B_{16}$ alloy with the goal of improving its strength while decreasing density through the substitution of magnesium. Examination of the density as well as the bulk and shear moduli leads to the conclusion that the introduction of rhenium into the mixed alloy of $Mg_xTi_{8-x}B_{16}$ does not improve the strength-density ratio of the material comparable to TiB_2. Electron density plots are presented which show the bonding characteristics of a mixed system with rhenium compared to either the titanium or magnesium diboride systems to provide further explanation of this result.