

Physics Student Research Abstracts: Summer 2006

David Welch '08: NDMAP and the Battle for Magnetic Order

NDMAP is a well-known low-dimensional antiferromagnetic compound that has been the center of several studies in the last decade. Earlier this year, the similar $S=1$, 1-D antiferromagnet, NTENP, was found to have Tomonaga-Luttinger Liquid (TLL) behavior. This behavior was discovered through magnetic specific heat data taken in high magnetic fields. Some believe that TLL behavior also exists in NDMAP. To test this, specific heat data was taken for NDMAP over low temperatures and in external magnetic fields up to 20 T.

David Johnson '07: Assessment of Leukoencephalopathy using Quantitative Magnetic Resonance Imaging

Leukoencephalopathy is a common side effect of the drug methotrexate which is used to treat children with Acute Lymphoblastic Leukemia (ALL). We used a voxel-based analysis to determine common areas of white matter hyper intensities on T2 MR imaging among this patient cohort. Common areas of leukoencephalopathy were found in frontal lobe and parietal lobe white matter tracts.

Brad Taylor '09: Data Analysis of Jupiter's Magnetic Atmosphere

I spent my summer working under Dr. Gladstone of the Southwest Research Institute in San Antonio, TX. He helped head up the "New Horizons Mission" which launched last year. While working for him I worked on two main projects. My first project involved manipulating a computer program in the IDL computer language that took data from observations of the Jovian Aurora in 1999 and 2000. My work focused on improving reproducibility of the data crunching which would result in images of the aurora itself. From this data I obtained values for Jupiter's wind speed and frequency and wavelength of particles exiting its atmosphere. My second project was to test multi-layered shielding for devices used in the upcoming "Juno Mission." I used the MULASSIS program to run the tests and IDL to compile the data. I looked at different widths of Tantalum, Aluminum, and Polyethylene, and I looked at how those varying levels affected the amount of gamma and electron fluence.

Drew Scott '07: Effects of Biological Fluids on the Structure of Hip Joint Polymer

This study focuses on the polymer known as ultra-high molecular weight polyethylene (UHMWPE), the preferred polymer used as the articulating surface of total hip and knee replacement joints. Although this polymer is very resilient and nonreactive in the body, the wear it experiences in the joint results in the release of small UHMWPE wear particles. The exact microscopic mechanism by which these particles are produced is not yet fully understood. These sub-micron particles initiate defensive reactions from the body which lead to osteolysis (bone resorption) and ultimately failure of the implant. It is important to understand what factors in the biological environment affect the mechanical properties of the material, which are predictors for wear particle production. In this project, samples of UHMWPE are submersed in saline, cell media, and artificial synovial fluid. Fluid absorption is monitored for both loaded and unloaded samples (loaded to simulate the condition of an implant in the body). Changes in crystallinity and molecular structure are examined by microscopy, thermal analysis, and infrared spectroscopy to gain an understanding of the effect of biological fluid absorption at a molecular level.

Scott Barrows '07: Space: The Final Frontier; Captain's Log: Detection of Peaks in the Earth's Ring Current

At the Southwest Research Institute in San Antonio, TX, I worked as a research assistant in the Space Physics division. My project was to analyze data from the IMAGE spacecraft, which detected highly energetic neutral atoms emitted from the earth's magnetosphere. The images generated from the data allowed me to detect changes in the earth's ring current caused by fluctuations in the solar wind. I was able to identify peaks in the ring current, and link them to solar events.

Paul Sinclair '07: Calibration and Creation: My Summer Working for the Government

I am the recipient of the Department of Homeland Security scholarship, which required that I complete an internship at a DHS-funded location. I spent the first ten weeks of my summer working at the Transportation Security Laboratory, which leads the development, testing, and certification of Explosive Detection Systems used throughout the United States. My specific project was to help with the development of explosive simulants –compounds used for testing and training that appear real to baggage screening machines but will not actually explode. I worked daily with several X-ray baggage screening machines, first calibrating them for use in scientific work and then helping with the actual development and formulation of the simulants themselves.

Whitney Tidwell '07: Fractal Modeling of Cloud-to-Ground Lightning

It has been hypothesized that lightning, as a mover of charge within the thundercloud, is responsible for decreases in the total electrostatic energy of a thunderstorm. Therefore, understanding the mechanisms of lightning propagation can lead to a better understanding of the redistribution of charge within the thundercloud. Research suggests that gas discharges can be modeled using a probabilistic approach based on Mandelbrot's fractal theory. Several fractal models of lightning discharge have been developed. The results presented are obtained using the three-dimensional fractal model of lightning discharge discussed by Riouset. This model is based on the idea that lightning discharges are equipotential and overall neutral. We apply this model to investigate cloud-to-ground discharges and related cloud charge configurations leading to this type of discharge. Results are compared with measurements of actual lightning events, obtained using the Lightning Mapping Array observing lightning discharges over Langmuir Laboratory, New Mexico.

Hallie Graves '07: Determining the Pulsations of Subdwarfs and White Dwarfs

Nearly all main sequence stars collapse as their gravitational force overcomes the outward pressure at the end of their fuel-burning lives. White dwarfs and subdwarfs are two types of these incredibly dense non-burning remains. Some observed white dwarfs and subdwarfs have been found to change intensity over a regular period of time, and careful study of these pulsating stars can provide new information about the interiors of these stars, the existence of orbiting planets around these stars, and a serve as a stage for the observation and testing of extreme physical conditions. In this study, aperture photometry was used to examine the intensity of certain stars thought to be variable over a set exposure time. A 24" research grade telescope at the Paul and Jane Meyer Observatory was used to collect data, and Quilt 12 software was used to display results. Raw light curve data was reduced by taking comparison stars and sky background into account, and Fourier transforms were performed on the reduced data to determine if there were

any frequency peaks. Two potential pulsators, KBS 35 and KBS 44, are subdwarfs and were not found to pulsate. KBS 08 and KBS 107 are white dwarf pulsator candidates that also were not found to pulsate. A known white dwarf pulsator, G226-29, was observed for over 20 hours and analyzed to provide more information on the characteristics of the star's pulsations and more accurately define its period.

Kevin Andring '07, John Janeski '07, Desmond Campbell '06, Daniel Keedy '06, Sean Quinn '06: Orbital Dynamics of Electrically Charged Spheres

Coulomb's Law and orbital motion equations predict that the electrostatic force between two oppositely charged spheres will allow a small sphere to orbit a larger, stationary sphere. To our knowledge this has not been demonstrated macroscopically prior to our work. We tested an apparatus whereby a small graphite coated Styrofoam sphere (1.29cm radius), with a voltage of 20 kV, was set into orbit around a large, stationary metal sphere (radius = 7.5 cm) with a voltage of -25 kV. The orbital radius was approximately 0.2 m. The smaller sphere was charged and launched into orbit by a Teflon launcher and a hand controlled electrode. A microgravity environment was required for this experiment, and the entire experiment was carried out onboard NASA's C9b "Weightless Wonder" aircraft, flying out of Ellington Field, TX. Data was collected by three video cameras, one positioned above and perpendicular to the orbital plane and two positioned perpendicular to each other in the plane of the orbit. Collected data will be analyzed to find the orbital parameters of each successful orbit.

John Kirkham '08: Computer Simulation of Lipid Membranes

Cell membranes are extremely important because they control input and output to the cell. These cell membranes are bilayers of lipid molecules with a hydrophilic head group on the edge and a hydrophobic tail group on the inside. A component of understanding how cell membranes function is to understand how the head groups interact with one another. When some of these lipids are placed in vivo, they form a structure known as the hexagonal phase. By studying why this phase is formed, we attempt to understand the interaction of the head groups. During the summer I wrote a C++ program to simulate lipid head groups in the hexagonal phase and compared the results it to lipid head groups in the planar phase.