Physics Department

Professor Mary C. Wintersgill
Chair

Physics Department faculty and students were actively engaged in research and scholarship during the 2005-2006 academic year. Their efforts helped them keep current in their various areas of specialization, allowed them to expand the use of research-based teaching techniques in our classrooms and laboratories, and provided opportunities for midshipmen to develop as individual scholars.

The reports that follow describe studies in such traditional areas of physics research as acoustics, astronomy and astrophysics, atomic physics, condensed matter physics, nonlinear optics, nuclear structure physics, and planetary physics. They also relate work in a variety of interdisciplinary fields, including cognitive science, materials science, optical communications and photonics. Additionally, they describe important efforts to understand how students learn physics and how to teach it more effectively.

External research sponsors included the National Science Foundation (NSF), the Office of Naval Research (ONR), the Army Research Office (ARO), the Research Corporation (RC), the Naval Research Laboratory (NRL), the Naval Surface Warfare Center (NSWC), the National Atmospheric and Space Administration (NASA), and the National Center for Physical Acoustics (NCPA). Internal sponsorship came from the Naval Academy Research Council (NARC).

Our faculty shared the results of their efforts by publishing scholarly articles and making presentations at conferences. This year, physics faculty and students published 16 articles in refereed journals, 11 articles in conference proceedings, and one letter and one book chapter. In addition, they issued five faculty technical reports and one Trident Scholar report. Finally, faculty, midshipmen, and their collaborators made 50 presentations at scientific conferences and other meetings, including some at international meetings in France, England, Germany, Denmark, and Samoa.

As always, the scholarly bond between our faculty and students was close and productive. A Trident Scholar used data from the University of Arizona's Spacewatch Project, obtained at Kitt Peak National Observatory, to search for evidence of an unknown 10th planet. Three midshipmen developed successful new Trident Scholar proposals, which they will carry out during the next academic year. Over the course of the year, a total of twenty midshipmen participated in research projects in astronomy, acoustics, optics, materials, and nuclear physics.

Sponsored Research

Modeling, Synthesis and Testing of New, High-Performance Polycarbonates for Transparent Armor Applications

Researcher: Professor John T. Bendler
Sponsor: Army Research Office (ARO), Chemical and Physical Sciences Division, Polymer Chemistry Program

This project used molecular modeling, synthesis, physico-chemical and small-scale mechanical testing of several new aromatic polycarbonate molecules to assess their potential for application in various U.S. Army personnel protection systems such as transparent armor for face shields, goggles, vehicle vision blocks, windshields, blast shields and aircraft canopies. The results of a previous National Science Foundation project included the successful design (using ab initio and force-field molecular computer modeling methods) and synthesis of several new monomers for polycarbonate polymerizations using the Suzuki coupling methodology and readily-available starting materials. This project included new thermoplastic polymer analogues based on bisaryl monomers such as

trifluoromethylated, siloxane, formal, and *geminal*-dimethyl analogues of bis(biarylphenols). The objective in this new work was to evaluate and test these novel polymer systems for enhanced high-impact mechanical properties, oxidative stability, UV resistance, flame resistance, laser light sensitivity, environmental and chemical stability, as well as improved aging and embrittlement resistance.

The project included the successful fabrication and ballistic testing of a 4" x 4" plaque of tetraaryl bisphenol-A polycarbonate at Aberdeen Proving Grounds in September 2005. The plaque was made at General Electric Global Research in Schenectady, N.Y. and was tested by the U.S. Army at the Army Research Laboratory (ARL). The plaque showed impact toughness equal to or better than BPA-PC, the current material used by the Army in Humvee windows and face shields. This success prompted the scale-up to 20 pounds of material targeted for the project. This was a 50-fold scale increase in synthesis effort, and will require extensive procedural modifications as well as new equipment.

Synthesis, Modeling and Testing of Polymer Nanocomposites for Impact Protection

Researcher: Professor John T. Bendler
Sponsor: Army Research Laboratory (ARL), Weapons and Materials Research Directorate

The scientific goal of this project was to provide improved, fundamental understanding of the role of molecular entanglements, nanoparticle-matrix interactions, and molecular motions on filler percolation thresholds, high strain rate impact performance, heat resistance and mechanical deformation mechanisms in nanoreinforced polymer resins. The approach was to use synthetic chemistry along with molecular theory and simulations to fabricate, model and test new reinforced polymers for soldier protection systems.

The experimental and theoretical effort focused on polycarbonate molecules which are extensively used by the U.S. Army for ballistic impact protection. Novel polycarbonates designed and synthesized by the PIs are utilized and filled with carbon nanotubes, mineral sheets, and silica particles, coated and uncoated.

Sample preparation and modeling began two summers ago and testing has taken place at the Rodman Materials Center at the Army Research Laboratory in Aberdeen, MD and was also occurring at GE Global Research. General Electric has supplied novel high molecular weight BPA-PC for fabrication of electrospun composites.

Properties of Capacitor Materials

Researchers: Associate Professor Charles A. Edmondson,
Professor John J. Fontanella and Professor John T. Bendler
Sponsor: Office of Naval Research (ONR)

The long-term objective of the project was to provide basic studies of the structure, properties and dynamics of capacitor materials and to link these to performance. The primary objective was to elucidate the electrical properties of the materials. This includes dielectric constant, loss and breakdown. Complementary properties that will help understand the electrical properties will also be studied. This includes x-ray, thermal, optical and magnetic measurements. The capacitor materials being developed at USNA include Ultem®- and polycarbonate-based materials. Studies of materials supplied by other groups funded by ONR will also be carried out. The approach was to carry out state-of-the-art dielectric spectroscopy and breakdown, differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA). Positron annihilation lifetime spectroscopy (PALS), dynamical mechanical analysis (DMA), thermomechanical analysis (TMA), electron spin resonance (ESR), viscosity and infrared or visible spectroscopic studies were also carried out. The complex dielectric constant, dielectric spectroscopy, dielectric breakdown and PALS measurements were carried out at high pressures. The results have been compared with the temperature variation of related quantities such as viscosity and electrical relaxation time. The high-pressure results have been compared both with theory and other experimental results.

Fiber Optic Transmission Links for RF Signals

Researchers: Professor Nicholas J. Frigo and Dr. Frank Bucholtz (Naval Research Laboratory)
Sponsor: Naval Research Laboratory (NRL), Optical Sciences Division

The low-loss and extremely high bandwidth of fiber optic transmission has made this technology extremely attractive for the transport of high bandwidth signals. Illustratively, radar signals have a very large bandwidth and their information must be carried with great fidelity from remote antennae to a central location for processing and evaluation. Historically, transport of these signals was limited due to high losses associated with high frequency losses in metallic media. Fiber optics suffers no such loss mechanisms, but introduces other potential impairments. This research is an investigation of fundamental and technological limitations to the performance of these links.

The initial research has been to investigate the power and performance penalties associated with the fact that both the fiber optic transmission link and a high performance discriminator (a QPSK demodulator) treat different optical frequencies differently: in effect, there is a difference in the transfer function over the bandwidth of realizable signals. The demodulation performance, therefore, would have a random, time-varying, component. Most of the work to date has been theoretical, validating existing models and analyses, and casting the problem in terms that simplify experimental and theoretical investigations.

System Performance of Cascaded CWDM Links using Semiconductor Amplifiers

Researchers: Professor Nicholas J. Frigo, Dr. Patrick Iannone, Dr. Kenneth Reichmann (AT&T Labs),
Dr. Neo Antoniades (CUNY), and Dr. Ioannis Roudas (U. Patras, Greece)
Sponsors: American Telephone & Telegraph (AT&T), City University of New York (CUNY) and University Patras

An impediment to the development of a high capacity telecommunications infrastructure has been the high infrastructure costs in local networks. High fixed-cost solutions, which can amortized easily in high-volume core networks, are inappropriate for local and Inter-Office Facility (IOF) metropolitan networks. Carriers, faced with increasing traffic volumes but constrained by cost pressures, feel an economic pressure to slow the introduction of more capable communications services. As a country, this would slow our potential GDP growth.

The advent of dense wavelength-division multiplexing (DWDM) in the long-haul network seemed to portend its introduction in the shorter IOFs. However, its high fixed costs have not scaled in price. A much more inexpensive "coarse" WDM (CWDM) technology, with reduced optical tolerances and more robust transmission characteristics makes it attractive for IOFs, but its wide spectral coverage (70 nm) precludes using DWDM amplifiers. This research program investigates the practicality and advisability of using semiconductor optical amplifiers (SOAs) to increase the reach of this potential technology.

The research focused on the evaluation of conventional impairments (spontaneous emission noise, saturation intensity, polarization-dependent gain) in making cascades of amplifier blocks. The utility of a technological solution such as this is its ability to obey simple and practical "engineering design rules" so that technicians with modest technical expertise could install, maintain, diagnose, and replace them with as close to "black box" functionality as possible.

Polarization Mode Dispersion (PMD) in Long-haul Networks

Researchers: Professor Nicholas J. Frigo, Dr. Mikhail Brodsky (AT&T), and Dr. Andrei Sirenko (NJIT)
Sponsors: U. S. Naval Academy, American Telephone & Telegraph (AT&T),
New Jersey Institute of Technology, (NJIT)

An experimental investigation of the long-term stability of telecom links due to PMD has begun as an outgrowth of noticing a remarkable spectral persistence of the PMD magnitude over a wide range of external environmental histories, once performance is conditioned on the external temperature of the area which contains the links. This implies that methods to exploit this characteristic might exist. Such methods would tighten the system margin requirements for long haul networks, and would trade the cost of infrastructure equipment for the cost of rearranging spectral locations of WDM channels in optical networks. Thus, instead of engineering *each* channel to be resistant to all possible PMD variations, only a small fraction of channels could be deemed unusable.

High-Spin States in ^{169,171}Ta

Researcher: Assistant Professor Daryl J. Hartley

Sponsor: National Science Foundation (NSF), Division of Physics, Heavy Ion Nuclear Science Program

An experiment at the international user Gammasphere facility was performed to search for wobbling sequences based on the proton $i_{13/2}$ sequence observed in ^{171}Ta. Such sequences are unique to the rarely observed "triaxial-shaped" nuclei. The reaction ^{51}V + ^{124}Sn was used to populate high-spin states in ^{171}Ta after four neutrons were emitted from the compound nucleus. Unfortunately, no evidence for wobbling was observed; however, the level scheme was greatly extended with the addition of over 200 new transitions. These results were recently published in *Physical Review C*. In addition to the excited states in ^{171}Ta, the high-spin states in ^{169}Ta (resulting from the emission of six neutrons) were also strongly populated. Indeed, over 170 new gamma rays were placed in the level scheme, which included four new rotational bands, and all of the sequences have been linked together. The latter achievement allows for the determination of the relative excitation energies of each band, which was not possible before this experiment. Band-head energies may now be compared systematically with theoretical predictions in the light tantalum nuclei. The unique proton $i_{13/2}$ sequence was also identified for the first time in ^{169}Ta and was found to lie at a higher excitation energy than in ^{171}Ta. A wobbling sequence was also searched for but was not observed. The lower statistics of ^{169}Ta, as compared with ^{171}Ta, may be the reason for not seeing a wobbling structure, thus a new experiment designed specifically for ^{169}Ta may occur in the future.

Ion Beam Optical Spectroscopy

Researcher: Associate Professor James R. Huddle

Sponsors: Lawrence Livermore National Laboratory (LLNL) and Naval Academy Research Council (NARC)

Ion beams have been used to study the structure of matter for nearly one hundred years. In the paradigmatic experiment, a beam of ions is directed onto a target. As the ions suffer collisions with atoms and molecules in the target, particles and electromagnetic radiation are emitted. Measurements of the intensities of scattered particles, x rays and gamma rays as a function of energy can yield information about the structure of the ions in the beam and of the atoms and molecules in the target. The availability of sensitive, high-resolution visible light spectrometers may open a new channel for ion beam studies of matter. In this exploratory study, an Avantes miniature fiber optic spectrometer is used to measure visible light emitted in collisions between protons and atoms in samples of various minerals and determined that those emissions can be useful for identifying minerals.

Nonlinear Acoustic Experiments Involving Landmine Detection: Connections with Mesoscopic Elasticity and Slow Dynamics in Geomaterials

Researchers: Professor Murray S. Korman

and Dr. James M. Sabatier (National Center for Physical Acoustics, University of Mississippi)

Sponsors: National Center for Physical Acoustics

and the U. S. Army Communications-Electronics Command RDEC, NVESD

In nonlinear acoustic detection, airborne sound at two primary tones, f_1, f_2, (chosen several Hz apart from resonance) insonifies the soil surface over a buried landmine, and due to soil wave interactions with the landmine, a scattered surface profile can be measured by an LDV. Profiles at f_1, f_2, f_1-(f_2-f_1) and f_2+(f_2-f_1) exhibit a single peak while profiles at $2f_1$-(f_2-f_1), f_1+f_2 and $2f_2$+(f_2-f_1) are attributed to higher order mode shapes. The lowest resonant frequency for a VS 1.6 plastic, inert, anti-tank landmine, buried at 3.6 cm deep is ~125 Hz. The "on target" to "off target" contrast ratio, for some of the nonlinearly generated combination tones, is roughly 15 - 20 dB higher compared to either primary component. Near resonance, the bending (softening) of a family of increasing amplitude tuning curves, involving the surface vibration over the landmine, exhibits a linear relationship between the peak particle velocity and corresponding frequency. The tuning curves exhibit hysteresis effects. Landmine-soil vibrations exhibit similar characteristics to nonlinear mesoscopic/nanoscale effects that are observed in geomaterials like rocks or granular materials. Nonlinear mechanisms of soil, and the soil interacting with the top-plate of the mine case are compared.

Spacewatch Survey of the Solar System

Researchers: Assistant Professor Jeffrey A. Larsen and Dr. Robert S. McMillan (University of Arizona)
Sponsor: National Atmospheric and Space Administration (NASA), Planetary Astronomy

Spacewatch is an asteroid survey concerned with statistical properties of all types of asteroids, particularly the Near-Earth Asteroids. This ongoing project is part of the operations of Spacewatch pertaining to scientific studies of asteroids in the Solar System. The project has been to refine a positional linking package. The results of this linking package are short arc orbits for 20,000 asteroids which will help to study the distribution of smaller (fainter) asteroids in several populations of current research interest. In addition, an attempt has been made to detect a large planet hypothesized to exist in the outer solar system.

Spacewatch Survey and Study of Hazardous Asteroids and Comets

Researchers: Assistant Professor Jeffrey A. Larsen and Dr. Robert S. McMillan (University of Arizona)
Sponsor: National Atmospheric and Space Administration (NASA), Near Earth Object Observation

Spacewatch is an active contributor to the Near Earth Asteroid hazard study both in terms of discoveries and orbit refinement observations. The project involved performing several astrometry (positional) and photometry (brightness) calibrations for the two telescopes Spacewatch operates, and tuning and testing the automated motion detection routines.

Undergraduate Collaborative Research to Map the Asymmetric Thick Disk

Researchers: Assistant Professor Jeffrey A. Larsen and Dr. Roberta M. Humphreys (University of Minnesota)
Sponsor: National Science Foundation (NSF)

In the Galaxy's first quadrant there is a 25% excess in the number of thick disk stars on one side of the galaxy compared to complimentary fields taken on the opposite side at relatively high galactic latitudes. The region of the asymmetry covers several hundred square degrees and is therefore a major substructure in the Galaxy due to more than small scale variations. A kinematic signature in these stars has also been detected, the side showing the excess has a much slower rate of rotation about the center of the galaxy on average than stars about the other side. Possible explanations for this spatial and kinematic asymmetry include the fossil remnant of a dwarf galaxy absorbed by the Galaxy, a triaxial thick disk or gravitational interactions with the stellar bar in the disk. This project involves acquiring additional photometric and spectroscopic observations to map the size and extent of the asymmetry and extend the search into regions not yet studied. Previous results from this project have included detection of significant kinematic and spatial asymmetries in the distribution of thick disk stars in the inner part of the galaxy.

1000 Asteroid Light Curve Survey

Researchers: Assistant Professor Jeffrey A. Larsen and Dr. Robert Jedicke (University of Hawaii)
Sponsor: National Atmospheric and Space Administration (NASA) Planetary Astronomy, via University of Hawaii

The multi-institution collaboration attempted to use a large format imager to measure the light curves and thereby contain rotation periods for ~1000 asteroids in a well-controlled survey program designed to correct for observational selection effects. The rotation periods are important to a variety of important properties about asteroids including limits on the asteroid bulk strength, the frequency and effect of asteroid collisions in the main belt and the effects of thermal radiation on asteroid spin frequencies and orbits. The observations occurred using the wide field (~1 square degree) fast-readout MegaCam imaging system on Mauna Kea's CFH Telescope to obtain a coordinated series of images covering ~12 square degrees.

A prototype image processing pipeline is being employed in the analysis of a set of data useful for testing the viability of the 1000 Asteroid Light Curve Survey. The massive image analysis required for this survey is accomplished on parallel CPU systems located at the Institute for Astronomy and at the U.S. Naval Academy. Astrometric and photometric reduction of the images has been performed using software developed at the Institute for Astronomy. The final data can only be properly interpreted once it has been corrected for observational selection effects.

Nonlinear Optical Limiting in Organic Dyes

Researcher: Associate Professor Steve Montgomery
Sponsor: Naval Research Laboratory (NRL), Optical Physics Branch (Code 5613)

The optical nonlinear absorption of large complex organic dye molecules holds promise as an optical limiter to protect eyes and other sensitive optical detectors over a wide range of wavelengths. Solutions containing dye molecules are placed in capillary tubes and subjected to high energy laser pulses applied to one end of a capillary with a 10 micron inside diameter. If the solution has a higher index of refraction than the glass capillary, the light stays trapped in the core of the capillary by successive total internal reflections providing a long region of interaction between the light pulse and the organic dye molecules. Focusing by a lens in a solution without the capillary waveguide would provide only a short interaction region, called the Rayleigh range, between the high intensity radiation and the dye. Transmission through the capillary is measured relative to the input as a function of wavelength and input pulse energy. Nonlinear optical energy absorption measurements are used by molecular designers to develop new molecules with improved absorption characteristics. Problems addressed in the course of this work include, but are not limited to, finding appropriate solvents, loading solvents into capillaries, building sample systems, stabilizing the laser pulse sources, aligning optical beams to the capillary input, filtering impurities, matching detectors to the wavelength used, data acquisition and analysis.

Radiation-Balanced Power Scaling of Infrared Solid-State Lasers

Researcher: Assistant Professor Carl E. Mungan
Sponsor: Naval Research Laboratory (NRL)

A radiation-balanced laser operates with minimal internal heating of the medium. Specifically, an ytterbium-doped crystal is pumped with a mutually incoherent set of semiconductor diode lasers. These diode lasers simultaneously pump the 1-micron stimulated emission, which is tuned using an external cavity, and drive optical cooling via spontaneous fluorescence. By careful choice of the laser pump and emission wavelengths and polarizations, both the rates and powers of the Stokes heating and anti-Stokes cooling can be made to balance one another. In this way, the laser can be scaled to high powers for Navy applications such as jamming heat seekers, circumventing the usual thermal limitations of solid-state lasers.

Long and short samples of low-concentration ytterbium-doped YAG laser rods were optically characterized for application to a high-power radiation-balanced laser system. The absorption spectra were measured as a function of temperature near ambient, and calibrated against 1047-nm Fresnel-corrected laser transmission measurements. A hydroxyl spectral peak at 3 microns which arises from hydrogen diffusion through the surfaces was identified and quantified in many different samples. Fluorescence lifetimes and spectra were measured both for small bulk slivers and for powdered samples dispersed in an optical epoxy. Calorimetric measurements of the fluorescent heating and cooling in various samples were performed using a 1032-nm fiber laser and an infrared thermal camera. About a degree of laser cooling per watt of absorbed power was measured in air for 1-gram bulk samples. The theoretical equations describing this cooling were reviewed.

Solid-State Laser Cooling of Organic Dyes in Modified Polymers

Researcher: Assistant Professor Carl E. Mungan
Sponsor: Research Corporation

Fundamental thermodynamic principles for laser cooling and other applications were analyzed. A detailed statistical mechanics approach to optical refrigeration and lasing was undertaken. Significant errors in previously published work on this subject were uncovered while developing a consistent treatment of the entropy and temperature of radiation. This is significant because non-thermal radiative energy transfers are central to the operation of both luminescent coolers and optically pumped lasers. The next part of the project is to build a 3-cubic-centimeter antenna-coupled high-temperature-superconducting bolometer operating in the terahertz regime that is laser cooled to 90 K.

Characterization of Polymeric and Ceramic Foams and Their Adhesion to Metal Structures

Researcher: Commander Edward J. Tucholski, USN
Sponsor: National Atmospheric and Space Administration (NASA) Langley Research Center

Polymeric and ceramic foams and composites are bonded to metallic structures in spacecraft in order to protect the metals from structural degradation during reentry through the earth's atmosphere. A nondestructive field test to evaluate the bond between these materials is necessary to certify the spacecraft ready to fly. Using foam samples provided by NASA, several methods including acoustic resonance, microwave imaging, and x-ray backscatter will be evaluated to determine their viability to accomplish this task. The most promising methods will be studied to optimize their performance at detecting the smallest possible disbonds.

Gamma-ray Lineshapes in the $^{18}O(^{3}He,n\gamma)$ Reaction

Researcher: Professor Jeffrey R Vanhoy
Sponsor: National Science Foundation (NSF)

A new class of nuclear spectroscopy measurements is under development at the University of Kentucky Nuclear Structure Laboratory utilizing the (^{3}He,n) reaction. Information sought includes cross sections, branching ratios, spins and parities, and level lifetimes. This project develops procedures for extracting nuclear lifetimes from the shape of gamma ray peaks in the detector spectrum.

Independent Research

Compositional Analysis of Metal Fittings from 18th Century Wooden Ships

Researcher: Professor Francis D. Correll

The goal of this ongoing project is to provide new information about 18th-century naval production methods and metallurgy using Particle Induced X-Ray Emission (PIXE), an ion-beam analysis technique. HMB *DeBraak* was a 16-gun brig-sloop that sank in a squall on May 25 1798, off Cape Henlopen Delaware. The hull became covered with silt shortly after it sank, largely preserving it and its contents from decay. *DeBraak* was finally found and salvaged in 1984. Among the items recovered from the hull are copper-alloy bolts and fasteners as well as copper sheathing and sheathing nails. One of the bolts is stamped with the word FORBES, presumably referring to William Forbes, an 18th-Century English industrialist who pioneered the use of mechanically hardened copper bolts. Techniques for cleaning the bolts were developed, and it was determined which x-ray absorbers could be used to efficiently obtain useful and reliable spectra. Spectra for all 45 bolts were recorded and the data best fit to standard emission profiles to determine their compositions. The bolts were found to be nearly pure copper (98.37% on average), with most containing additional small amounts of iron (0.88%), nickel (0.04%), arsenic (0.42%), silver (0.08%), lead (0.18%) and bismuth (0.11%). Some also contain a little tin (0.05%), but few show evidence of zinc above the detection limits. The compositions of these bolts are similar to those reported for 18th-Century English copper, but are quite different from those of several copper alloys that are often claimed to have been used for hull bolts, including bronze (with 4-5% tin), alpha brass (30-38% zinc), beta brass (46-49% zinc), Muntz metal (40% zinc) or Kier metal (21% zinc and 5% iron). The conclusion is that by the time *DeBraak* was last fitted, the Admiralty had adopted Forbes's mechanically hardened "pure" copper bolts.

Synthesis and Characterizations of Sulfonated Polymers in Mesoporous Silica as Potential Electrochemical Separator Materials

Researchers: Associate Professor Charles A. Edmondson,
Associate Professor Joseph F. Lomax (Chemistry Department) and
Midshipman 1/C Jon Stockton, USN (Bowman Scholar)

Ordered mesoporous silica with enlarged pore sizes (2-15 nm) can now be made reliably in large amounts through a nonionic assembly pathway under acidic conditions. Uniform polymer coatings can be made inside these materials by radical polymerization. In this same article, they took the Organic – Inorganic composite nanoporous

material and reacted with sulfuric acid to make a sulfonated compound. This material has been made and its conductivity has been measured which, though modest (3×10^{-6} S/cm at room temperature), gives indications of further interest. Characterization of this material by TGA/MS has not only helped to devise a mechanism of decomposition, it has acted as a proof of utility of this instrument. In an expansion of this project, the mesoporous silica and the sulfonated Organic – Inorganic composite nanoporous material have been used as fillers for Nafion. The goal of the project is to use this filler to improve the overall conductive properties so that the Nafion would be useful in a wider temperature and humidity range.

Proton Conduction in Manganese Oxide Ambigel

Researchers: Associate Professor Charles A. Edmondson, and
Michael S. Doescher, Jeremy Pietron, Brett M. Dening, Jeffrey W. Long, Christopher P. Rhode
and Debra R. Rolison (all of the Naval Research Laboratory, Surface Chemistry Branch)

Ambigels and Aerogels hold the promise of providing high power density batteries and fuel cells as well as efficient sensors and electrocatalysts. The focus of the project was to understand the transport of protons through surface water layers adhered to the manganese oxide ambigel. Details of the transport path in monolithic and dense powders formed from macroscopic particles of the ambigel have been studied using complex impedance techniques in variable humidity environments.

Medical Geology Investigation: Effects of Chronic Toxicity from Geologic Sources on a South Pacific Island's Indigenous Population

Researcher: Professor Douglas W. Edsall

The project focused on the evaluation of trace elements and their bioavailability, movement and alteration in space and time in order to establish baseline data on levels of potentially harmful trace elements in water, soil, air, plants, animals and humans. Two study populations (inhabitants of Fiji and Nauru) were selected. Discussions are in the preliminary stages with USGS and The Johns Hopkins University Bloomberg School of Public Health participants and with South Pacific Island researchers selected by SOPAC and located at the University of the South Pacific and the Fiji School of Medicine.

OSL Dating of Diatoms

Researcher: Professor Douglas W. Edsall

Reports of Optically Stimulate Luminescence (OSL) dates for two species of diatoms were first presented in 2004. The multi-year effort will address the dating of diatoms which are an abundant component of planktonic-life in Antarctic waters and a major contributor to the sedimentary blanket. To date, diatoms have not been amenable to absolute age dating and the ages determined with this method will assist in solving many problems related to paleo-environment and paleo-climatology research.

Refinement of Global Planetary Magnetosphere Models

Researcher: Professor Irene M. Engle

The objective of this project is to incorporate a more realistic magnetotail model into the full range of global magnetospheric models of the Saturnian magnetosphere, in preparation for the Cassini spacecraft entry into polar orbits about Saturn. The problem of incorporating a modified magnetotail model based upon two of the incident solar-wind direction versions of the Saturnian magnetosphere model was solved. The next step was to modify the magnetotail models in such a way that their outer boundaries would meld with the boundaries computed from applying the magnetohydrodynamic principle of balancing the incident solar wind pressure on the boundary with the combined internal magnetic field pressure (plus some plasma pressure) inside the boundary. Many postulated modifications have been mathematically modeled and the resulting magnetospheric characteristics studied, and subsequently rejected. Consultation with the Cassini mission experimenters regarding the incorporation of these results into the working model for the encounter will also take place.

Developing a Temporal Model for the Dynamics of Multiply Connected One-Dimensional Systems

Researchers: Associate Professor John P. Ertel and Dr. Joseph W. Dickey (The Johns Hopkins University)

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Connected one-dimensional systems can be used to model a variety of complex dynamic systems; for example layered media, macroscopic and microscopic structural networks, and any canonical object in which the wave equation is separable. The temporal model being developed here would describe the reverberation of transients in these systems. Temporal descriptions are generally derived from frequency domain models via Fourier transform, which requires the structure to be stationary in time. In contrast to this, the current model is derived entirely in the time domain and can therefore incorporate boundary conditions that change in time.

The study of connected one-dimensional systems provides insight into the points of maximum amplitude due to time/spatial focusing in resonant systems and thereby a forecast of probable points of failure.

This technique also allows the time reversed calculation which allows the observer to calculate the most probable source point from the transient response at a point in the system. For this reason, the study of transient response in connected one-dimensional systems is of great significance to all of our Armed Forces.

Auralization of the Ultrasonic Response of Soft Tissue Masses

Researchers: Associate Professor John P. Ertel and Dr. Joseph W. Dickey (The Johns Hopkins University)

The latest work on this project tries to improve user interaction with acoustical sensing by acoustical analog of false-color imagery. The process has been named "auralization" and seeks to allow the trained listener to detect small soft tissue masses by heterodyning the ultrasonic signal down to the humanly audible range.

Experiments for Students during a Total Solar Eclipse

Researcher: Associate Professor James R. Huddle

A total solar eclipse presents an exciting opportunity to teach science to young people. A suite of experiments for this purpose has been under development since the 26 February 1998 eclipse in Aruba. One theme is experiments that help us see how the Sun interacts with the Earth's atmosphere. In the past year, Dallas Semiconductor introduced the Hygrochron, a device that may be useful in the study of eclipse meteorology. The device is about the size of a stack of six dimes, and contains sensors for temperature and for relative humidity, a microprocessor to collect data from the sensors, and enough memory to hold 2048 temperature and humidity readings. It is powered by an internal battery, and can be connected to a computer for programming and for data retrieval. Since the Hygrochron can be programmed weeks before a data run is to begin, it is not necessary to carry a computer into the field; this feature makes the Hygrochron very attractive for eclipse meteorology experiments, which often take researchers into remote locations that are accessible only with difficulty. After evaluating the Hygrochron's performance, they were used to monitor temperature and humidity at a point near the central line of the path of the total solar eclipse of 29 March 2006. Graphs of temperature and humidity versus time were collected and are under analysis.

Long Wavelength VLA Survey of Bright Sources

Researcher: Associate Professor Debora M. Katz

Observations of 20 resolved radio galaxies and supernova remnants were made at 74 and 330 MHz using the Very Large Array (VLA). Most of the objects range from a few tens to a few hundreds of Janskys integrated flux density, demonstrating the improved sensitivity and uv-coverage of the 27-antenna VLA 74 MHz system compared to an initial 8-antenna system. They also demonstrate that simple, angle-invariant self-calibration and now commonly available radio frequency interference excision and wide-field imaging techniques are sufficient for making good images of these relatively bright, isolated objects. After demonstrating that the gain stability of the 74 MHz VLA system is accurate to 5%, these new data are combined with those collected by Kuhr and Laing & Peacock. Finally new low-frequency spectra of all the sources in the sample were calculated.

Physics for Scientists and Engineers: Foundations and Connections

Researcher: Associate Professor Debora M. Katz

Physics education research (PER) is a relatively new field of study. There are two primary goals of PER: 1) to discover how students learn physics and 2) to develop new pedagogy to help instructors. Most calculus-based textbooks used in universities are several decades old, and very few textbooks have been updated to incorporate the findings of PER. *Physics for Scientists and Engineers: Foundations and Connections* (PSEFC) is a completely new textbook. The primary objective of this new book is to use the findings of PER to make physics more tractable for a greater number of students. PER has taught three major lessons: 1) Students have preconceived notions of the physical world. Moreover, students do not see how the concepts they learn in a physics class are related to the physical phenomena they see and experience daily. 2) They cannot sort out general principles from specific examples and phenomena. 3) They have trouble connecting mathematical formalism with physics concepts. These students see physics as a series of unrelated facts, concepts and equations which have little or no bearing on the world of their everyday lives. Part of the objective of PSEFC is to address these major issues through a variety of means.

AdS/QCD and Tensor Mesons

Researchers: Assistant Professor Adam Lewandowski,
Emanuel Katz (Boston University) and Matthew D. Schwartz (Lawrence Berkeley National Laboratory)

Tensor mesons in AdS/QCD were explored focusing on f2(1270), the lightest spin-two resonance in QCD. It was found that the f2 mass and the partial width (f2 →2 photons) are in very good agreement with data. In fact, the dimensionless ratio of these two quantities comes out within the current experimental bound. The result for this ratio depends only on Nc and Nf , and the quark and glueball content of the operator responsible for the f2; more importantly, it does not depend on chiral symmetry breaking and so is both independent of much of the arbitrariness of AdS/QCD and completely out of reach of chiral perturbation theory. For comparison, the decay (f2 →pi pi) was explored, which because of its sensitivity to the UV corrections has much more uncertainty. The masses of the higher spin resonances on the Regge trajectory of the f2 were also calculated. They compare favorably with experiment.

Demonstration of Nonlinear Effects in Acoustic Landmine Experiments using a Clamped-plate Soil Oscillator

Researchers: Professor Murray S. Korman and Amelia Bond

Current nonlinear experiments involving the detection of plastic landmines using acoustic-to-seismic coupling have developed from Sabatier's (linear) and Donskoy's (nonlinear) earlier methods. A laboratory apparatus called the soil-plate oscillator has been developed at the National Center for Physical Acoustics, and later at the U.S. Naval Academy, to model acoustic mine detection. The apparatus consists of a thick-walled cylinder filled with sifted homogenous soil resting on a thin elastic plate that is clamped to the bottom of the column. It represents a good simplified physical model for VS 1.6 and VS 2.2 inert anti-tank plastic buried landmines. Using a loudspeaker (located over the soil) that is driven by a swept sinusoid, tuning curve experiments are performed. The vibration amplitude as a function of frequency is measured on a swept spectrum analyzer using an accelerometer located on the soil-air interface or under the plate. The backbone curve shows a linear decrease in peak frequency with increasing amplitude. A two-tone test experiment is performed using two loudspeakers generating acoustic frequencies (closely spaced on either side of resonance, typically ~ 100 Hz). A rich vibration spectrum of combination frequency tones (along with the primaries) is observed which is characteristic of actual nonlinear detection schemes.

Unified Field Theory of Ferromagnetic Hysteresis

Researcher: Professor Carl S. Schneider

The project focused on research into the effects of field, shape, stress, conductivity and temperature on ferromagnetic hysteresis. The dependence of the differential susceptibility on magnetic state leaves the applied effective field due to these five sources separate and linear so that they can be superimposed. New data on

orthogonal vector fields and temperature dependence and viscosity were collected after samples were designed and fabricated. The data confirms the accuracy and breadth of application of the theory.

Oil Debris Monitoring

Researcher: Professor Lawrence L. Tankersley

The project is in its engineering development phase with current efforts directed toward a field deployable Portable Fluid Analyzer for application to the new marine amphibious assault vehicle. Electrical modifications to achieve compatibility and inoperability of the analysis subsystems have just been completed, and the effort is shifting to fine tuning the software. Preliminary data has suggested a new precursor that may identify a lubricant health problem allowing it to be addressed before significant system damage occurs.

Andes, An Intelligent Tutor for Basic Physics

Researchers: Professor Donald J. Treacy and Professor Mary C. Wintersgill

ANDES is an intelligent tutor for Basic Physics. It is designed to tutor midshipmen through their assigned Physics homework. This has 3 purposes: 1) remove "Physics frustration", 2) give "just in time help" to the midshipmen doing the assignments, 3) raise the level of classroom interaction because there is no need to discuss how to solve Physics problems assigned for homework. The tutor will immediately give the students feedback as to whether the action they took toward solving an assigned problem was correct of incorrect. If the action was incorrect the student may ask the tutor "What's wrong" and receive an answer to point them in the direction of a correct solution. If a student is at an impasse the student can ask the tutor to "Give me a hint". These features combine to make a type of mastery tutor that will allow a student to obtain a correct solution for every problem assigned. The results of using this tutor show that the students do substantially better on problem solving tests and somewhat better on multiple choice tests. As far as ONR is concerned the project is complete. ANDES is still being developed both at the USNA and the University of Pittsburgh and has been placed on a server at the "Open Learning Initiative" (OLI) at Carnegie Mellon University. The work with CMU has been an improvement for the research. Students regularly go to the server at CMU to download and complete their homework assignments. These assignments are then saved at CMU for later review by both the students and the instructor. This seems to have circumvented copying of solutions from other students or from an instruction manual.

Learn Lab

Researcher: Professor Donald J. Treacy

The purpose of "Learn Lab" is to try various strategies to improve student learning. This is a series of mini projects that a good teacher would use in the course to motivate and improve student learning. The important aspect is that the experiments are driven by previous cognitive research on how students learn. These experiments use an extension of Andes, giving it more power in generating hints for students. When a particular strategy is successful it is implemented. Three experiments were performed during this academic year. The first of these was so successful that it will be reported at the American Association of Physics Teachers meeting this summer. The other two experiments were performed during the spring semester and are being analyzed. This is an ongoing experiment. This research is being conducted in conjunction with the Learning Research and Development Center at the University of Pittsburgh.

Trident Scholar Project

The Search for the 10th Planet: Testing Inferences from the Kuiper Cliff

Researcher: Midshipman 1 /C Eric A. Roe, USN
Advisers: Assistant Professor Jeffrey A. Larsen and Professor C. Elise Albert
Sponsor: Office of Naval Research (ONR)

This project involved an extensive search of a sizeable archive of astronomical CCD imagery to test the validity of arguments regarding the existence of a hypothetical "Planet X". This object was proposed by Brunini and Melita (2002) to be a low inclination Mars-sized body residing in the Kuiper Belt between 55 and 75

astronomical units (AU) from the Sun. Resonances with this hypothetical planet form a convenient explanation of the "Edgeworth-Kuiper Cliff": the observation that no low eccentricity Kuiper Belt objects are found more than 47 AU from the Sun despite numerous searches. Although relatively bright, the distance to this object indicates that it could easily have been mistaken for a stationary object in previous searches. In particular, image archives of the University of Arizona's Spacewatch Project, a near-Earth asteroid survey based at Kitt Peak National Observatory, between May of 2003 and April of 2006, were reviewed in detail. To obtain multiple night orbits on its detected asteroids, the survey re-imaged the same sky area every 2 – 3 days, allowing for rate sensitivity to the proposed planet.

The results also included a search of over 12,000 square degrees of sky within 20 degrees of the ecliptic. This survey discovered the current tenth largest Kuiper Belt asteroid, 2003 MW12, as well as redetections of many already known Kuiper Belt objects and Centaur asteroids. Follow-up observations of 2003MW12 were via the Spacewatch Project's 1.8 meter telescope at Kitt Peak National Observatory.

Midshipman Research Course Projects

A Quest of Exploration: The Analysis of Exoplanet Behavior to Lead to the Eventual Discovery of Earth-type Planets

Researcher: Midshipman 1 /C John R. Pepin, USN
Advisers: Professor C. Elise Albert and CDR Paul Shankland, USN (U.S. Naval Observatory)
Sponsor: Bowman Scholar Program

Exoplanet research is a new area in astronomical research; it is a precise field that requires good observation technique and persistence. The goal of this project was to observe two exoplanet candidates, Gliese 876 and HD 102195, looking for potential transits of exoplanets around their parent star. Additionally, 44 Iota Bootis, an eclipsing binary system, was observed to collect more data on the transit phenomenon for reduction and analysis purposes. The data were inconclusive for exoplanet transits. The eclipsing binary data show variation, but do not correlate precisely to known curves for 44 Iota Bootis.

Analysis of Hull Bolts from HMB *de Braak*

Researcher: Midshipman 1/C Charles J. Slater, USN
Advisers: Professor Francis D. Correll and Professor Jeffrey R. Vanhoy
Sponsor: Delaware State Museums

The elemental compositions of 45 metal hull bolts from HMB *de Braak*, were measured. HMB *de Braak* was a 16-gun English warship that sank off the coast of Delaware in 1798. The Proton Induced X-ray Emission (PIXE) technique was used to gather data on the elemental makeup of the bolts and elemental concentrations were extracted with the program GUPIX. It was found that all of the bolts are nearly pure copper with very small amounts of iron, nickel, arsenic, silver, indium, tin, antimony, lead, and bismuth. None of these impurities seem likely to be the result of intentional alloying, but may be the natural constituents of English copper. The exception is iron, which may have been introduced accidentally during the fabrication of some bolts. The compositions seem consistent with those of bolts pioneered by William Forbes, an English copper industrialist.

Dielectric Studies of Polyproplyene

Researcher: Midshipman 2 /C Andrew J. Turo, USN
Adviser: Associate Professor Charles A. Edmondson
Sponsor: Office of Naval Research (ONR)

The ability to find a dielectric material with a high energy density is of fundamental interest. There are two ways to manipulate a dielectric in order to achieve the desired result. First, the dielectric constant can be increased, which in turn raises the capacitance. Second, the dielectric strength, which is a measure of the largest electric field that a material may with stand without sustaining dielectric break down, can be increased. Existing facilities were used to measure the complex dielectric constant of polypropylene over a wide range of frequencies

and temperatures in an effort to gain an understanding of its dielectric properties. The dielectric loss peak that corresponds to the glass transition was observed as well as previously unreported loss peaks. The initial stages of developing techniques to measure dielectric strength were undertaken and successfully applied to polypropylene.

Electromagnetic Railgun Analysis

Researchers: Midshipman 1 /C Levi LaRoche, USN and Midshipman 1/C Jonathan Zasadny, USN
Adviser: Associate Professor Charles A. Edmondson

The goal of this project was to develop a tabletop railgun suitable for studying the physical parameters that affect railgun performance. Starting with a preliminary design, students estimated the resistance and inductance as a function of projectile position. Treating the system as a damped RLC oscillator, they then estimated the exit muzzle velocity assuming 100% efficiency. The students spent two months building and modifying the portotype until an actual working railgun was developed. The students studied the effect of several parameters including projectile mass and initial capacitor potential, on muzzle velocity using a time-of-flight (TOF) apparatus. The TOF apparatus was constructed by the students using Helium-Neon lasers and detectors. The time over a fixed distance was measured using the detectors and a commercial data acquisition system.

Polarization Measurements with Gammasphere?

Researcher: Midshipman 1/C William H. Mohr, USN
Adviser: Assistant Professor Daryl J. Hartley
Sponsor: National Science Foundation (NSF)

For this research project, Midshipman Mohr investigated the possibility of determining the polarization of gamma rays detected by Gammasphere. Gamma rays remove energy and angular momentum from the nuclear system. The amount of energy removed is equal to the energy of the gamma ray and the angular momentum removed may be determined by an angular correlation measurement. However, a parity change may occur between the two states that any gamma ray connects. Whether a parity change occurred is determined by the electromagnetic nature of the gamma ray. Gamma rays are either electric or magnetic in nature, and thus they preferentially scatter in different directions when they Compton scatter off an electron in a gamma ray detector. The Gammasphere detectors are segmented in half, therefore, there is some sensitivity to this kind of polarization. Midshipman Mohr concentrated on editing a sorting routine that would indicate whether a gamma ray preferred to scatter parallel or perpendicular to the reaction plane. Midshipman Mohr became much more proficient in programming through this project. Great progress was made, however, the results were inconclusive.

High-spin States in ^{160}Tm

Researcher: Midshipman 1/C Timothy Fitzgerald, USN
Adviser: Assistant Professor Daryl J. Hartley
Sponsor: National Science Foundation (NSF)

Currently, triaxial deformation (where the nuclear mass is distributed non-uniformly about the three body-fixed axes) has only been observed in odd-mass lutetium (Lu) nuclei. These nuclei possess rotational structures called "wobbling bands" that result from the nucleus precessing and wobbling like an asymmetric top when rotated. An experiment was performed at Gammasphere to search for the first wobbling band outside the Lu nuclei. The primary nucleus of interest was ^{161}Tm, which was made following the emission of four neutrons from the reaction ^{37}Cl +^{128}Te. These data will be analyzed by collaborators at Florida State University. However, significant data were obtained on ^{160}Tm, which was populated after five neutrons were emitted. Midshipman Fitzgerald was responsible for sorting the 60 GB data set into a coincident cube such that an improved level scheme of ^{160}Tm could be created. Detector calibrations, efficiencies, and Doppler corrections were performed with the data before it was ready to be inspected. The coincidence events were then utilized to extend the previously known bands from spin ~25ħ to over 40ħ. In addition, Midshipman Fitzgerald discovered two new sequences in ^{160}Tm, as well as briefly investigating ^{161}Tm.

Characterizing Rotational Bands in ^{160}Tm

Researcher: Midshipman 1 /C Timothy Fitzgerald, USN
Adviser: Assistant Professor Daryl J. Hartley
Sponsor: National Science Foundation (NSF)

Building upon the work performed in the previous semester, Midn Fitzgerald concentrated on determining the configurations of the two strongest rotational bands in ^{160}Tm. Nucleons like to pair together, however, if there are an odd number of particles in the nucleus, valence nucleons will be present. In particular, for ^{160}Tm (which is an odd-odd nucleus), there will be a valence proton and a valence neutron. Similar to valence electrons determining properties in the atom, these valence nucleons govern the behavior of the rotational bands that are based on them. The particles can come from several different shells, therefore many combinations are possible. In order to determine which combination forms the observed bands, characteristic properties, such as aligned angular momentum and B(M1)/B(E2) ratios, were investigated. Aligned angular momentum (or alignment) is the amount of angular momentum from the valence particles projected onto the rotation axis. These values were calculated for the odd proton (^{159}Tm) and odd neutron (^{159}Er) nuclei for several different shells. The configurations in ^{160}Tm are likely a combination of an odd proton from ^{159}Tm and odd neutron from ^{159}Er. Thus, the sum of these individual alignments should be equal to the amount of alignment observed in a band of ^{160}Tm. This allowed for a good first guess. The B(M1)/B(E2) analysis, which is related to whether a state prefers to decay via an M1 or E2 transitions, is governed by which nucleons are involved. Therefore, comparing experimental values with theoretical values allowed for the determination of the proton $h_{11/2}$, neutron $i_{13/2}$ configuration for the strongest band, and the proton $h_{11/2}$, neutron $h_{9/2}$ configuration in the second strongest sequence.

High-spin States in ^{159}Tm

Researcher: Midshipman 2/C Albert J. Storrs, USN
Adviser: Assistant Professor Daryl J. Hartley
Sponsor: National Science Foundation (NSF)

In an experiment designed to investigate high-spin states of ^{161}Tm with Gammasphere, there was a possibility that new information could be obtained on the ^{159}Tm nucleus. Therefore, Midn Storrs was responsible for finding evidence of this nucleus in the coincidence data that was taken in the previous summer for this one hour research course. After many weeks of searching, ^{159}Tm was indeed found and could be extended up to what was previously known. Unfortunately, none of the bands could be extended beyond this point. Midn Storrs then learned how rotational bands are identified with particular nuclear shell model states. An understanding of the Nilsson deformed shell model was required and analysis of the aligned angular momentum (alignment) of the bands was performed. Following this analysis, it was concluded that the two primary structures that were observed were based on the odd proton occupying the $h_{11/2}$ and $g_{7/2}$ states.

Ion Beam- and Photon-Induced Optical Spectroscopy of Minerals

Researchers: Midshipman 1/C Alexander Ludington, USN and Midshipman 1/C Robert Foster, USN
Adviser: Associate Professor James R. Huddle

In a continuation of work begun at Lawrence Livermore National Laboratory last summer, spectra emitted by minerals that had been excited by red (650 nm) and green (532 nm) lasers were collected and analyzed. It was found that a few minerals (e.g., ruby, alexandrite and YAG) did emit spectra when excited with the red laser. More minerals luminesced when excited with the green laser, and alexandrite and YAG emitted more spectral lines than with the red laser. It was concluded that if a suitable database of spectra were to be developed, photon-induced luminescence could be a valuable technique for identifying minerals. A violet LED flashlight was used to induce luminescence in these same minerals, and some others. This source emitted a spectrum dominated by a single peak at 405 nm, about 10 nm wide. The emission spectra observed using this method were similar over the long-wavelength part of the spectrum to those collected with the lasers, but some minerals produced more lines of shorter wavelength.

It was also possible to collect a proton-induced spectrum from YAG. We noticed that the proton-induced emission spectrum exhibits lines that are absent from the photon-induced spectra; some of these emission lines have wavelengths longer than the wavelengths used for photon excitation. These lines could be the result of transitions

excited by one or both of the following mechanisms: They could be cascade transitions following inner-shell ionization events, or they could be transitions following direct excitation of the upper states. If the upper states are created directly, then they must be excited in violation of the electric dipole selection rules, and so they may be metastable. If they are metastable, then ion excitation may provide a new scheme for pumping a laser.

Nonlinear Acoustic Landmine Detection: Comparison of Off-target Soil Background and On-target Soil-mine Nonlinear Effects

Researchers: Midshipman 2/C Kathleen E. Pauls, USN and Midshipman 2/C Sean A. Genis, USN
Adviser: Professor Murray S. Korman

When airborne sound at two primary tones, f_1, f_2 (closely spaced near a resonance) excites the soil surface over a buried landmine, soil wave motion interacts with the landmine generating a scattered surface profile which can be measured over the "target." Profiles at the primaries f_1, f_2, and nonlinearly generated combination frequencies f_1-(f_2-f_1) and f_2+(f_2-f_1) , 2f_1-(f_2-f_1), f_1+f_2 and 2f_2+(f_2-f_1) (among others) have been measured for a VS 2.2 plastic, inert, anti-tank landmine, buried at 3.6 cm in sifted loess soil and in a gravel road bed. It is observed that the "on target" to "off target" contrast ratio for the sum frequency component can be ~20 dB higher than for either primary. The vibration interaction between the top-plate interface of a buried plastic landmine and the soil above it appears to exhibit many characteristics of the mesoscopic/nanoscale nonlinear effects that are observed in geomaterials like sandstone. Near resonance, the bending (softening) of a family of increasing amplitude tuning curves, involving the vibration over the landmine, exhibits a linear relationship between the peak particle velocity and corresponding frequency. Tuning curve experiments are performed both on and off the mine in an effort to understand the nonlinearities in each case.

Binary Systems and the Clarke Telescope

Researcher: Midshipman 2 /C Andrew McDonald, USN
Adviser: Assistant Professor Jeffrey A. Larsen

The purpose of this project was to use an SBIG CCD on the Naval Academy's Clarke Telescope at the Class of 1941 Observatory to take light curves on faint binary star systems. The first part of this project concerned the nature of binary stars, the observables to acquire and the peculiarities of the detection system. Two faint stars were selected as candidates and observations were attempted. The project found several complications in pointing the Clarke at faint stars and switched its focus to quantifying the difficulty.

Color Images and the Clarke Telescope

Researcher: Midshipman 3/C Jeffrey Jaglowicz, USN
Adviser: Assistant Professor Jeffrey A. Larsen

The purpose of this project was to use an SBIG CCD on the Naval Academy's Clarke Telescope at the Class of 1941 Observatory to take filtered images and combine them into color images. The first part of this project concerned the nature color image representation, the observables to acquire and the peculiarities of the detection system. Jupiter was selected as a candidate and observations were attempted. The project was successful at combining multiple bandpass data into a color picture.

Smooth AdS Solutions to Einstein's Equations

Researcher: Midshipman 2/C Jordan Kehrer, USN
Advisers: Assistant Professor Adam Lewandowski and Assistant Professor Paul T. Mikulski

This project was an investigation of the theory of General Relativity following the text of S. Weinberg, *Gravitation*. This was supplemented with investigations into tensor analysis using A.J. McConnell, *Applications of Tensor Analysis*. Einstein's equations in anti-de Sitter (AdS) space were investigated, as well as some aspects of the Randall-Sundrum model.

Theoretical Physics Survey

Researcher: Midshipman 1/C John Ciccocioppi, USN
Adviser: Assistant Professor Adam Lewandowski

In this research project in theoretical physics, Midn Chiccociopi investigated the properties of string-like solitons, the Nielsen-Olesen strings. This included an investigation into field theories and their equations of motion. Some properties of the two dimensional Ising model and the renormalization group, as well as the properties of systems having fractal properties, were investigated.

Physics and Epistemology

Researchers: Midshipman 3/C Bryan Fishman, USN,
Midshipman 3/C Mathew Herbaugh, USN, and Midshipman 3/C Courtnie Paschall, USN
Adviser: Assistant Professor Adam Lewandowski

The project investigated the nature of truth and meaning as it applies to physical phenomenon. Readings included those of Feynman, Kant and Jung. The nature of conscious intention and morality as it applies to empirical investigation was investigated. Also included was an investigation into introductory elements of quantum mechanics and special relativity.

Computational Study of the Friction of Self-Assembled Monolayers

Researcher: Midshipman 1/C Lawrence A. Herman, USN
Advisers: Assistant Professor Paul T. Mikulski and Professor Judith A. Harrison (USNA Chemistry Department)

The overall goal of this research is to use molecular dynamics simulations to study atomic-scale systems in sliding contact in an effort to better understand the physics of atomic-scale friction. An empirical classical hydrocarbon potential is used to model both chemical reactions (the breaking and forming of bonds) as well as long-range non-bonded interactions. Computationally feasible systems are typically composed of tens of thousands of atoms simulated over hundreds of picoseconds. Focus has been on simulations of an amorphous carbon tip sliding across self-assembled monolayers composed of linear hydrocarbon chains. Monolayers composed of chains with an even number of carbon atoms in chain backbones, $13(CH_2)CH_3$, are compared to monolayers composed of chains with an odd number, $12(CH_2)CH_3$. This is an on-going project. The current focus is on investigating finite domain SAMs.

Publications

Journal (Refereed) Manuscripts

BENDLER, John T., Professor, Filipova, T.S., and Boyles, D.A., "Novel Aromatic Polycarbonate Blends Using High Aspect Ratio Polycarbonates," *Polymer Preprints*, Vol. 46(2), pp. 955-956, 2005.

> The cost, properties and processability of polymer blends are major considerations. Polycarbonate blends have been developed exhibiting high mechanical strength, excellent ductility and thermal resistance, along with ease of processing. Polycarbonate is often blended with styrenics such as acylonitrile-butadiene-styrene (ABS) or acrylonitrile-styrene-acrylate (ASA) or with polyesters such as polyethylene terephthalate (PET) or polybutylene terephthalate (PBT). The majority of polymer pairs in many systems are immiscible and dispersion of one phase into the other leads to phase separation or otherwise tends to produce materials lacking useful properties. A limited number of polymer pairs are partially or fully miscible and the resulting blends may be homogeneous with useful properties, suggesting that polymer–polymer interactions on a molecular level do occur and are related to the chemical structure of the repeat unit. We have synthesized numerous high-aspect ratio polycarbonate materials as both homopolymers and copolymers and it was with interest that we wished to examine how the incorporation of high-aspect ratio bisphenols therein would affect the ability of the former to form blends with commercial polycarbonate as well as with themselves.

In this paper we examined the miscibility by either solution blending or melt blending of each of two high-aspect ratio polycarbonates with commercial polycarbonate and with each other in regard to the transparency and the glass transition temperatures of the final blends.

BENDLER, John T., Professor, FONTANELLA, John J., Professor, and Shlesinger, M. F., "The Defect Diffusion Model and the Properties of Glasses and Liquids", *Journal of Non-Crystalline Solids*, in press.

Several previously unexplained relaxation phenomena are interpreted quantitatively in terms of the defect diffusion model (DDM). That includes widely different pre-exponentials, exponents and consequently fragility. In addition, the DDM is used to give a qualitative explanation of many properties that glasses and liquids exhibit. This includes interpretations of the glass transition (T_g), the liquid-liquid transition (T_B), the crystalline melting temperature (T_m), and the different values of the characteristic temperature, T_C, that some materials exhibit for different types of physical measurements. Next, qualitative explanations of the origin of secondary relaxations such as the excess wing and the *beta* relaxation are given. In addition, the boson peak is discussed in terms of the DDM. Finally, it is pointed out that in the DDM, universality is embodied in the defects i.e. free volume.

BOOHER, Kevin R., First Lieutenant, USMC, Passerini S., EDMONDSON, Charles A., Associate Professor and FONTANELLA, John J., Professor, "Super-pressed and Super-cooled(?) P(EO)20LiBETI" *Solid State Ionics*, in press.

High pressure conductivity measurements have been carried out on P(EO)20LiBETI from 295 K to 368 K. The decrease of electrical conductivity with pressure is larger in the partially crystalline phase (low temperature and low pressure or high temperature and high pressure) than in the fully amorphous phase (high temperature and low pressure). It is found that if the phase transition is approached from the crystalline phase (decreasing pressure), the pressure of the phase transition varies from 0 to 0.23 GPa as the temperature increases from 336 K to 358 K. The shift of the phase transition temperature with pressure is approximately the same as the shift of the glass transition temperature with pressure for pure PEO. This can be understood in terms of the defect diffusion model. If the material is above 336 K and is in the fully amorphous phase, after pressure is increased above the critical pressure, the material remains in the amorphous phase for extended periods of time before transforming. This is reminiscent of a super-pressed state but may be an indication of slow crystallization kinetics.

EDMONDSON, Charles A., Associate Professor (co-author), "Using an Oxide Nanoarchitecture To Make or Break a Proton Wire", *Analytical Chemistry,* 2005, 77(24), pp.7924-7932.

Long-range proton diffusion (>0.3 mm) is generated in monolithic ultraporous manganese oxide nanoarchitectures upon exposure to gas-phase water. The sol-gel-derived ambigel nanoarchitectures, with bicontinuous networks of covalently bonded nanoscale solid and through-connected mesopores, exhibit conductometric sensitivity to humidity as established by impedance spectroscopy. The spectra contain a Warburg feature from which the concentration and diffusion length of the protonic charge carriers are determined. Water adsorbs conformally onto the architecture's continuous solid network in equilibrium with atmospheric humidity to create a continuous water sheath that acts as a 3-D proton wire. As a result, monolithic manganese oxide ambigels exhibit an equilibrium conductometric response to humidity that is 14 times greater than that of previous reports for electrolytic manganese oxide. A packed bed of 1-10-μm ambigel particulates in physical contact with one another, each with the same nanoscale morphology as the monolithic nanoarchitecture, also support longrange proton diffusion; however, the sensitivity to humidity is four times lower than the monolithic form due to restricted proton transport between adjacent particulates. Films composed of 0.3-12-μm ambigel particulates supported on interdigitated array electrodes with 20-μm electrode spacing express finite-diffusion behavior due to the short distance between the contact electrodes and have a conductometric sensitivity to humidity comparable to electrolytic MnO2 and 17 times lower than the monolithic ambigel. These results suggest that controlling the nature of the porous and solid phases in a nanoarchitecture provides a mechanism to limit interference from condensed water in conductometric gas-phase sensors. In addition, continuous monolithic architectures should

improve electrochemical performance in devices where efficient long-range transport of protons or other ions is critical.

The paper received a National Research Council / American Association of Electrical Engineers Postdoctoral Research Publication Award.

FONTANELLA, J. J., Professor (co-author), "Positron Annihilation Lifetime Response and Relaxation Dynamics in Glycerol," *Journal of Non-Crystalline Solids*, Vol. 351, No. 33-36, pp. 2599-2604, 2005.

Positron annihilation lifetime data on glycerol are related to the results of broadband dielectric studies from the literature. Specifically, the temperature variation of the ortho-positronium (o-Ps) lifetime, τ_3, and of the relative intensity, I_3, from 100K up to 300K have been compared with the spectral features of the α and β relaxation from the decomposed dielectric loss spectra. First, it is found that in the τ_3 vs. T plot, in addition to the universal characteristic PALS temperatures T_g^{PALS} and $T_{b2}^{L} = 1.53T_g^{PALS}$ where large discontinuities in slope are observed and which are associated with the glass-liquid transition and the onset to a quasi-plateau level, respectively, a discontinuity in the slope occurs at $T_{b1}^{L} = 1.28T_g^{PALS}$. Further, it is found that τ_3 at T_{b1}^{L} is approximately the same as the mean secondary β relaxation time, $\tau_3 (T_{b1}^{L}) \approx \tau_\beta(T_{b1}^{L})$. Next, it is suggested that the decrease in the I_3 vs. T plot as temperature increases above T_g^{PALS} can be related to the β and α relaxation qualitatively. These findings are consistent with the notion about free volume redistribution in the liquid glycerol due to the local β as well as the high-frequency part of cooperative α process causing a partial elimination of smaller holes from the PALS spectrum as temperature increases.

FRIGO, Nicholas J., Professor (co-author), "240-km CWDM transmission using cascaded SOA Raman hybrid amplifiers with 70-nm bandwidth," *IEEE Photonics Technology Letters,* Vol. 18, No. 2, pp. 328-330, 2006.

We demonstrate the cascading of broad-band semiconductor optical amplifier-Raman hybrid amplifiers which provide nearly flat gain over 70 nm. A coarse-wavelength-division multiplexingtransmission system consisting of three spans of 80 km shows uniform performance and 1-dB power penalty.

FRIGO, Nicholas J., Professor (co-author), "Comparison of System Penalties from First- and Multiorder Polarization Mode Dispersion," *IEEE Photonics Technology Letters,* Vol. 17, No. 8, pp. 1650-1652, 2006.

We experimentally investigate the polarization-mode dispersion (PMD)-induced system penalty arising from first-order and all-orderPMD.We use a measurable quantity, "string" length, to parameterize the penalty, find a deterministic correction to the accepted first-order PMD-induced system penalty approximation, and discuss the implications for system outages. Further, we show that higher orders of PMD introduce an additional penalty scatter that is nearly independent of "string" length, and correlated to the magnitude of the second-order PMD vector.

HARTLEY, Daryl J., Assistant Professor (co-author), "Systematics of Isomeric Configurations in N = 77 odd-Z Isotones near the Proton Drip Line," *Physical Review C,* Vol. 73, pp. 024316-1 – 17, 2006.

The systematics of the $\pi h_{11/2}\nu h_{11/2}$ and $\pi h_{11/2}\nu s_{1/2}$ isomeric configurations was studied for the odd-Z N=77 isotones near the proton drip line. The isomeric decays in ^{140}Eu, ^{142}Tb, ^{144}Ho, and ^{146}Tm were measured by means of x-ray, γ-ray, and charged particle spectroscopy at the Recoil Mass Spectrometer at the Holifield Radioactive Ion Beam Facility (ORNL). The spin and parity of $I^{\pi}=8^+$ and 5^- were deduced for the isomers in ^{140}Eu and ^{142}Tb. New decay schemes were established, and the half-lives of the 8^+ isomers were measured to be 302(4) ns for ^{140m2}Eu and 25(1) μs for ^{142m2}Tb. No evidence for the expected 1^+ ground-state was found in the ^{144}Ho decay data. The proton-emission from ^{146}Tm was restudied. Five proton transitions were assigned to two proton-emitting states. The half-lives of 198(3) ms and 68(3) ms and the spin and parity values of $I^{\pi}=10^+$ and 5^- were established for ^{146m}Tm and ^{146gs}Tm, respectively. For the first time for an odd-odd nucleus, the interpretation of the observed decay properties and structure of the proton-emitting states was made by accounting for deformation and proton and neutron coupling to the core excitations. A complex wave-function structure was obtained, with dominating components of $\pi h_{11/2}\nu h_{11/2}$ for the 10^+ isomer and $\pi h_{11/2}\nu s_{1/2}$ for the 5^- ground state.

HARTLEY, Daryl J., Assistant Professor, MOHR, W.H., Midshipman 1/C, USN, and VANHOY, Jeffrey R., Professor, (co-authors), "Detailed High-spin Spectroscopy and the Search for the Wobbling Mode in ^{171}Ta," *Physical Review C,* Vol. 72, pp. 064325-1 – 16, 2005.

> High-spin states in ^{171}Ta were populated in the ^{124}Sn(^{51}V,4*n*) reaction at 228 MeV to search for evidence of stable triaxial deformation. Identification of a wobbling sequence based on the previously known $\pi i_{13/2}$ structure would provide a unique signature for this rarely observed shape. No such sequence was identified in these data, which suggests that the island of triaxial strongly deformed bands may be smaller than once thought. However, over 200 new transitions and two new bands were placed in the level scheme and the sequence based on the $\pi i_{13/2}$ orbital could be observed up to spin and parity I^{π}=(101/2^{+}). The relative excitations of all the sequences were determined and the ground state of ^{171}Ta was found to have 5/2^{+} quantum numbers, contrary to previous reports. All of the previously known structures were extended to much higher spin and their high-frequency band crossings are interpreted within the framework of the cranked shell model.

HARTLEY, Daryl J., Assistant Professor (co-author), "Structural Behavior of $^{157,\ 158,\ 159}$Dy in the I=30-50 ħ Spin Regime," *Physical Review C,* Vol. 72, pp. 06307-1 – 11, 2005.

> Significant extensions to the high-spin excitation spectrum of the *N*=91, 92, 93 isotopes ^{157,158,159}Dy have been achieved using the high-efficiency γ-ray spectrometers Euroball and Gammasphere. These nuclei were populated via weak 3*n* or αxn exit channels in fusion evaporation reactions. In ^{157}Dy, the yrast band has been extended to I^{π}=101/2^{+} (tentatively to 105/2^{+}) with four sideband structures (two of which are new) observed in the 35–50ħ spin range. In ^{158}Dy, three bands have been extended to 42^{+}(44^{+}),40^{-}, and 41^{-}(43^{-}), whereas in ^{159}Dy the yrast band is observed to 81/2^{+}(85/2^{+}). The high-spin behavior and band crossing systematics of the Dy isotopes and of the neighboring *N* = 91, 92, and 93 isotones are discussed in terms of rotational alignments and shape transitions. Cranked Nilsson-Strutinsky calculations without pairing have been performed for detailed comparisons with the very high-spin states observed in ^{157}Dy.

HARTLEY, Daryl J., Assistant Professor (co-author), "New Isomeric State in ^{116}Ag," *Physical Review C,* Vol. 72, pp. 044306-1 – 6, 2005.

> A new isomer in ^{116}Ag with a half-life of 20(1) s has been discovered through the use of conversion electron, β, and γspectroscopy of on-line mass-separated radioactivities at the Holifield Radioactive Ion Beam Facility at ORNL. The observed electron peaks at 22.5, 44.42, and 47.33 keV were interpreted as the *K*,*L*, and *M* conversion electron lines resulting from a 47.9-keV *E*3 transition associated with the decay of a second isomeric level in ^{116}Ag. A new level structure of ^{116}Ag is proposed, with the levels identified as the 0^{-} ground-state and isomers at 47.9 and 128.8 keV having spin/parities of 3^{+} and 6^{-} respectively.

MIKULSKI, Paul T., Assistant Professor, HERMAN, Lawrence A., Midshipman 1/C, USN, and HARRISON, Judith A., Professor (Chemistry Department), "Odd and Even Model Self-Assembled Monolayers: Links between Friction and Structure," *Langmuir,* Vol. 21 (26), pp.12197 -12206, 2005.

> The friction between an amorphous carbon tip and two *n*-alkane monolayers has been examined using classical molecular dynamics simulations. The two monolayers have the same packing density, but the chains comprising each monolayer differ in length by one -CH_2- unit. The simulations show that the monolayers composed of C_{13} chains have higher friction than those composed of C_{14} chains when sliding in the direction of chain cant; the difference in friction becomes more pronounced as the load is increased. Examination of the contact forces between the chains and the tip, along with conformational differences between the two chain types, lends insight into the friction differences.

MUNGAN, Carl E., Assistant Professor, "Accelerating Around an Unbanked Curve," *Physics Teacher*, Vol. 44, pp. 99–100, February 2006.

> The December 2004 issue of *Physics Teacher* presents a problem concerning how a car should accelerate around an unbanked curve of constant radius r starting from rest if it is to avoid skidding. Interestingly enough, two solutions were proffered by readers. The purpose of this note is to compare and contrast the two approaches. Further experimental investigation of various turning strategies using a remote-controlled car and overhead video analysis could make for an interesting student project.

MUNGAN, Carl E., Assistant Professor, "Atwood's Machine Without Hanging Masses," *Journal of the Washington Academy of Sciences*, Vol. 91, pp. 15–24, Winter 2005.

> Atwood's machine is presented in introductory physics courses as an exercise in the simultaneous solution of Newton's second law for translational and rotational motions, assuming the pulley has non-negligible mass. Occasionally it is also used as a lecture demonstration or for quantitative laboratory measurements of a system undergoing constant acceleration. As discussed in this paper, one can progressively simplify the apparatus while maintaining these pedagogical goals, to end up with an easy way to measure the value of the freefall acceleration, g, by counting to ten.

MUNGAN, Carl E., Assistant Professor, "A Classic Chase Problem Solved from a Physics Perspective," *European Journal of Physics*, Vol. 26, pp. 985–990, November 2005.

> The trajectory, travel time, and relative approach velocity of a pursuer tracking a prey along a simple curve of pursuit are deduced using basic principles of two-dimensional kinematics. While such curves are well known in the mathematics literature, little attention has been paid to this problem by the physics educational community, despite the fact that it has abundant physical applications. It also makes an interesting alternative to the traditional problems of introductory kinematics.

SCHULZE, Kay G., Professor (USNA Computer Science Department), SHELBY, Robert N., Professor Emeritus, TREACY, Donald J., Professor, and WINTERSGILL, Mary C., Professor, (co-authors), "The Andes Physics Tutoring System: Lessons Learned," *International Journal of Artificial Intelligence and Education*, Vol. 15, No. 3, 2005, pp.678-685.

> The Andes system demonstrates that student learning can be significantly increased by upgrading only their homework problem-solving support. Although Andes is called an intelligent tutoring system, it actually replaces only the students' pencil and paper as they do problem-solving homework. Students do the same problems as before, study the same textbook, and attend the same lectures, labs and recitations. Five years of experimentation at the United States Naval Academy indicates that Andes significantly improves student learning. Andes' key feature appears to be the grain-size of interaction. Whereas most tutoring systems have students enter only the answer to a problem, Andes has students enter a whole derivation, which may consist of many steps, such as drawing vectors, drawing coordinate systems, defining variables and writing equations. Andes gives feedback after each step. When the student asks for help in the middle of problem-solving, Andes gives hints on what's wrong with an incorrect step or on what kind of step to do next. Thus, the grain size of Andes' interaction is a single step in solving the problem, whereas the grain size of a typical tutoring system's interaction is the answer to the problem. This report is a comprehensive description of Andes. It describes Andes' pedagogical principles and features, the system design and implementation, the evaluations of pedagogical effectiveness, and our plans for dissemination.

Conference Proceedings

BENDLER, John T., Professor (co-author), "Design and Synthesis of Polycarbonates for Transparent Armor Military Applications", *Proceedings of the Society for the Advancement of Material and Process Engineering (SAMPE),* in press.

> Bisphenol A polycarbonate (BPA-PC) is a unique engineering material of great versatility which enjoys a global production of more than two million tons annually. Its properties find applications in optical recording media, sports equipment, architectural applications, unbreakable materials, and automotive interiors and exteriors. The objective of this work is the design and synthesis of new polycarbonate monomers which have high-aspect ratios, and their polymerization, molding, and mechanical testing specifically for ballistic impact properties and transparent armor for high performance military uses. After synthesizing a variety of monomer and polymer candidates, a particular copolymer was selected for scale up synthesis and used to mold a ballistic plaque. The ballistic properties of this material were tested at the Army Research Laboratory in Aberdeen, Maryland and compared with those of commercial polycarbonate (Lexan®) bisphenol A homopolycarbonate. The methods and results of this investigation will be described. The properties of the new material showed little if any mechanical degradation, making it as good as commercial material, even though it was used in only 50 percent as the copolymer. This is in marked contrast to previous investigations indicating that copolymers evidence considerable decrease in notched Izod impact strength the greater the percentage of comonomer incorporation.

BENDLER, John T., Professor (co-author), "Aromatic Copolycarbonates of Bisphenol A and Triptycene-1,4-hydroquinone", *Polymer Preprints*, in press.

> Bisphenol A polycarbonate (BPA-PC) is a widely-used engineering thermoplastic having remarkable properties including ductility, toughness, and optical clarity, which have been well-reviewed. Because of our interest in bisphenol monomer development for new polycarbonate applications, we thought it would be worthwhile to explore how incorporation of triptycene might affect the properties of new polymers.
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> Einhorn is credited with the synthesis of aromatic polycarbonates of hydroquinone and catechol as early as 1898. These materials lacked the unique properties of bisphenol A polycarbonate (BPA-PC) which have made the latter commercially successful in a variety of niche markets estimated at a production level of 2.7 million tons globally per year. Polycarbonates of bisphenol A copolymerized with hydroquinone tend not to exhibit the ductility of BPA-PC and are relatively brittle materials. Owing in part to its relative ease of synthesis, 1,4-dihydroxytriptycene has received recent attention as a bisphenolic monomer for a variety of polymeric materials. The incorporation of 21 wt % 1,4-dihydroxytriptycene into an aliphatic polyester was reported to appreciably enhance modulus, strength, and strain to failure of the copolymer compared to the properties of the homologous polyester material without triptycene. The presence of the rigid, relatively low aspect ratio triptycene moiety in the polymer was indicated to enhance aliphatic polymer lateral chain interactions particularly during deformation and to lead to enhanced properties. The triptycene cleft was considered instrumental to both the threading and interlocking of polymer chains comprised of comonomers including a highly flexible, C-10 aliphatic chain. On the other hand, the dihydroxytriptycene monomer has also been cited to prevent polymer reorganization, aggregation, or □-stacking owing to its large interior free volume relative to the chain backbone.
>
> Although nominally 1,4-dihydroxytriptycene may be regarded as a triptycene derivative, the eccentric positioning of the two hydroxyl groups breaks the symmetry of the triptycene parent molecule, and 1,4-dihydroxytriptycene may therefore be regarded as a small aspect-ratio, ring-fused hydroquinone having a bulky side group. In previous work we hypothesized that small packing length polycarbonates synthesized from high aspect ratio monomer will display improved ductility and toughness over commercial bisphenol A polycarbonate owing to increased entanglement density and decreasing entanglement molecular weight in comparison with bisphenol A polycarbonate. Comparisons among an isomeric series of high aspect ratio tetraarylbisphenol A monomers experimentally demonstrated that the copolymer formed from the *para*- and *meta*-monomers of greatest aspect ratio indeed formed strong, tough copolymers, unlike the *ortho*-monomer.

It was of interest to copolymerize 1,4-dihydroxytriptycene with bisphenol A to polycarbonate in order to (1) ascertain whether the monomer 1,4-hydroxytriptycene, would, like hydroquinone, confer brittle characteristics when copolymerized with BPA-PC, (2) investigate whether the exceptional property enhancements conferred by 1,4-dihydroxytriptycene on aliphatic polyesters would similarly translate to property enhancements in aromatic polycarbonate systems or lead to degradation of the unique properties of BPA PC.

Triptycene was synthesized over a decade ago and it is the part of a large and synthetically challenging class of compounds based on one triptycene unit. Triptycene quinone has a unique structure in which three benzene rings are three-dimensionally arranged.

The synthesis of the triptycene monomer and polymerization to the corresponding homopolycarbonate (Tr PC) and copolymers with BPA, and properties including glass transition temperature (T_g), molecular weights, and Young's modulus, tensile strength, and elongation at break were presented.

BENDLER, J. T., Professor, FONTANELLA, J. J., Professor, and Shlesinger, M. F., "Random Processes Underlying Stretched Times and Divergent Time Scales near the Glass Transition," *Proceedings of the SPIE – The International Society for Optical Engineering*, Vol. 5845, pp. 238-244, 2004.

A model of relaxation in glassy materials, involving anomalous slow diffusion of defects, is reviewed. The movement of the defects causes a stretched exponential relaxation. If there is an attractive force between defects then as the temperature is lowered, or the pressure increased, the number of mobile defects will decrease. This loss of mobile defects produces a Vogel type law for the singular behavior of the relaxation time scale at a critical temperature.

FRIGO, Nicholas J., Professor (co-author), "Polarization Dynamics in Installed Fiberoptic Systems", *Proceedings of the LEOS 18th Annual Meeting, 23-27 October 2005,* pp. 414-415.

We report analyses of the SOP fluctuations in two operating lightwave systems, one urban and one suburban. We observed several fast (<50μs) polarization changes, and multiple slower polarization rotations. The most interesting feature of the observed fast polarization effects was that they are all "elastic", that is the SOP returned to its original state once the fast variations died out.

FRIGO, Nicholas J., Professor (co-author), "Dispersion Compensation Module as a Polarization Hinge," *Proc. ECOC 31st Annual European Conference on Optical Communication,* 25-29 Sept 2005, Vol. 3, pp. 335-336.

We study polarization rotations by a Dispersion Compensation Module responding to quasi-periodic room temperature oscillations. The rotations seem to have aa functional temperature dependence on short time scales interrupted by rather abrupt shifts occurring, on average, every month.

HARTLEY, Daryl J., Assistant Professor (co-author), "Beyond Band Termination in ^{157}Er and the Search for Wobbling Excitations in Strongly Deformed ^{174}Hf," *Journal of Physics (London) G*, Vol. 31, pp. S1735-S1740, 2005.

High-spin terminating bands in heavy nuclei were first identified in nuclei around $^{158}Er_{90}$. While examples of special terminating states have been identified in a number of erbium isotopes, almost nothing is known about the states lying beyond band termination. In the present work the high-spin structure of ^{157}Er has been studied using the Gammasphere spectrometer.

The subject of triaxial superdeformation and 'wobbling' modes in Lu nuclei has rightly attracted a great deal of attention. Very recently, four strongly or superdeformed (SD) sequences have been observed in ^{174}Hf and ultimate cranker calculations predict such structures may have significant triaxial deformation. We have performed two experiments in an attempt to verify the possible triaxial nature of these bands. A lifetime measurement was performed to confirm the large (and similar) deformation of the bands. In addition, a high-statistics, thin-target experiment was run to search for linking transitions between the SD bands and possible wobbling modes.

HARTLEY, Daryl J., Assistant Professor (co-author), "Quadrupole Moment Measurements of TSD1 and TSD2 Bands in ^{167}Lu", *Journal of Physics (London) G,* Vol. 31, pp. S1873-S1876, 2005.

The triaxial strongly deformed (TSD) bands in ^{167}Lu were populated by the ^{123}Sb(^{48}Ca, 4*n*) reaction with a beam energy of 203 MeV. Gamma rays, requiring five fold or more in prompt coincidence, were detected with the Gammasphere spectrometer. Of particular interests are TSD bands 1 and 2 which have previously been interpreted as zero phonon and one phonon wobbling bands, respectively. Using the Doppler shift attenuation method (DSAM), a preliminary transition quadrupole moment of $6.9^{+0.3}_{-0.3}$ eb was extracted for the TSD1 band. Data analysis continues for TSD2 which is considerably more weakly populated.

HARTLEY, Daryl J., Assistant Professor (co-author), "Study of the N = 77 odd-Z Isotones near the Proton-drip Line," *European Physical Journal A,* Vol. 25, pp. s1.151-s1.154, 2005.

The evolution of the $\pi h_{11/2}\nu h_{11/2}$ and $\pi h_{11/2}\nu s_{1/2}$ isomeric configurations was studied for the $N = 77$ isotones near the proton drip line. The decays of metastable levels in ^{140}Eu, ^{142}Tb , and ^{144}Ho were measured by means of X-, gamma- and conversion electron spectroscopy at the Recoil Mass Spectrometer at Oak Ridge. The sequence of isomeric levels in ^{140}Eu was experimentally determined. The half-life of the $\pi h_{11/2}\nu h_{11/2}$ state in ^{142}Tb was remeasured to be 25(1) μs. The spins and parities of 5^- and 8^+ for the $\pi h_{11/2}\nu s_{1/2}$ and $\pi h_{11/2}\nu h_{11/2}$ ^{142}Tb isomers, respectively, were established from measured multipolarities. No evidence for the expected 1^+ ground state was found in the ^{144}Ho decay data.

HARTLEY, Daryl J., Assistant Professor (co-author), "Coulomb Excitation and Transfer Reactions with Neutron-rich Radioactive Beams," *European Physical Journal A,* Vol. 25, pp. s1.383-s1.388, 2005.

Neutron-rich radioactive ion beams available from the HRIBF allow a variety of measurements around the ^{132}Sn region, including Coulomb excitation and single-nucleon transfer. The $B(E2;0^+ \rightarrow 2^+)$ values for first 2^+ excited states of even-even neutron-rich $^{132\text{-}136}$Te and $^{126\text{-}130}$Sn have been measured by Coulomb excitation in inverse kinematics. Neutron transfer onto a ^{134}Te beam from ^{9}Be and ^{13}C targets, to populate single-particle states in ^{135}Te, has also been studied. Gamma rays from the ^{13}C(^{134}Te, ^{12}C) reaction were used to identify the $\nu i_{13/2}$ state in ^{135}Te, at an energy of 2109 keV. These and other results, and plans for future experiments with these neutron-rich beams, were presented.

KORMAN, Murray S. Professor (co-author), "Nonlinear Acoustic Experiments Involving Landmine Detection: Connections with Mesoscopic Elasticity and Slow Dynamics in Geomaterials", *Proceedings of the 17th ISNA International Symposium on Nonlinear Acoustics*, 18-22 July 2005, Session WePM1, paper WePM103.

The vibration interaction between the top-plate of buried VS 1.6 and VS 2.2 plastic, anti-tank landmines and the soil above it appears to exhibit similar characteristics to the nonlinear mesoscopic/nanoscale effects that are observed in geomaterials like rocks or granular materials. [J. Acoust. Soc. Am. **116**, 3354-3369 (2004)]. When airborne sound at two primary frequencies f_1 and f_2 (closely spaced near resonance) undergo acoustic-to-seismic coupling, interactions with the mine and soil generate combination frequencies which affect the surface vibration velocity. Profiles at f_1, f_2, f_1-(f_2-f_1) and f_2+(f_2-f_1) exhibit single peaks whereas $2f_1$-(f_2-f_1), f_1+f_2 and $2f_2$+(f_2-f_1) involve higher order modes. A family of increasing amplitude tuning curves, involving the surface vibration over the landmine, exhibits a linear relationship between the peak particle velocity and corresponding resonant frequency. Subsequent decreasing amplitude tuning curves exhibit hysteresis effects. New experiments for buried M 14 and VS 50 plastic anti-personal landmines, a laboratory clamped elastic (soil loaded) plate and a "plastic drum head" mine simulant behave similarly. Slow dynamics explains the amplitude difference in tuning curves for first sweeping upward and then downward through resonance, provided the soil modulus drops after periods of high strain.

SCHULZE, K.G., Professor (USNA Computer Science Department), SHELBY, Robert N., Professor Emeritus, TREACY, Donald J., Professor, and WINTERSGILL, Mary C., Professor, (co-authors), "The Andes Physics Tutoring System: Five Years of Evaluations," in G. I. McCalla and C.-K. Looi (Eds.), *Proceedings of the Artificial Intelligence in Education Conference*. Amsterdam: IOS, pp. 1-47, 2005.

This paper was awarded "Best Paper" at the conference.

Andes is a mature intelligent tutoring system that has helped hundreds of students improve their learning of university physics. It replaces pencil and paper problem solving homework. Students continue to attend the same lectures, labs and recitations. Five years of experimentation at the United States Naval Academy indicates that it significantly improves student learning. This report describes the evaluations and what was learned from them.

Book Chapter

SCHNEIDER, Carl S., Professor, "Cooperative Anisotropic Theory of Ferromagnetic Hysteresis," in Trends in Materials Science Research, B.M. Caruta, ed., Nova Science Publishers, Hauppauge NY, 2005, pp. 1-57, ISBN 1-59454-367-4

Measurement of B(H) curves of mild steel, nickel, cobalt, Terfenol and Othonol have lead to an analytic macromagnetic model in precise agreement and deeper understanding of ferromagnetic hysteresis in terms of saturation magnetization, coercive field, reversible susceptibility and domain cooperation. Sample design, experimental control and analysis are described including details of homogeneous field, stress and magnetization, shape demagnetization, eddy currents, coercive smearing, magnetoelastic vibrations and strain gage use and interpretation for both magnetostriction and stress measurement. The theory is observed from virgin and reversal hysteresis curves and reversible susceptibility. Approximations are made to describe minor loops which further reduce to the Rayleigh laws. The effects of stress before and after magnetic field change are derived from magnetoelastic energy and coherent action of Brown's micromagnetic stress field and Bozorth's global magnetostrictive stress field, with excellent agreement with experiments. Verified predictions include stress variation of coercivity, remanence and maximum susceptibility as well as a stress crossover on the saturate hysteresis curve due to domain structure. Brown's and Bozorth's stress fields are found to act in all stress processes and are found to be nonlinear for large stress and magnetization due to their effect on domain structure. Bozorth's stress field is predicted and observed to cause creeping of stress loops and the stress demagnetization effect up to remanence where the Villari reversal occurs. Vector fields and stresses have been applied and vector magnetizations measured to extend this model to three dimensions. Rate dependent eddy current and temperature effects are described theoretically using effective fields and material anisotropy effects. The change in elastic modulus of ferromagnetic transducers can be derived from this theory so that robotic actuators can be smoothly controlled and nonlinear transducers accurately interpreted. The behavior of ferroelectric transducers can also be described by changing the variables of this theory. Application of this model beyond the physics of materials is possible.

Letters

MUNGAN, Carl E., Assistant Professor, "Inverse Lawn Sprinkler," *Physics Teacher*, Vol. 43, pp. L1–L2, August 2005.

Paul Hewitt's encouragement to build an inverse lawn sprinker out of a soda pop can motivated me to make some simple modifications to his design so that I could more fully explore its rotational dynamics. Rather than poking holes with a nail, I drilled holes in the side of a can and inserted ribbed drinking straws, of the sort that can be bent into various shapes. I sealed the straws to the side of the can with clay, so that I could move the straws in and out radially to vary the moment arm of the torque delivered by the water as it strikes the bends in the straws. Also, instead of suspending the can from strings, I taped the can to a low-friction pulley spinning freely at the end of a short rod that I could grasp in my hand. I experimented with three

bend geometries of the straws: U-shaped, S-shaped, and L-shaped straws. In all three cases, when the can is filled with water and held by the rod in air above a sink, the can rotates in the expected direction, in reaction to the tangential water jets issuing outside the can. Now suppose we empty the can of water and submerge it in a full sink to just below the brim of the can, so that water flows into rather than out of the can through the straws. Which way will the can rotate for each of the three geometries?

Technical Reports

LARSEN, J. A., Assistant Professor (co-author), "Comet Observations [691 Steward Observatory, Kitt Peak]," Minor Planet Circular 54662, 23 (2005).

LARSEN, J. A., Assistant Professor, and ROE, E. A., Midshipman 1/C, USN, (co-authors), "2003 MW12," Minor Planet Electronic Circ., 2006-A28 (2006).

LARSEN, J. A., Assistant Professor (co-author), "2004 JQ1," Minor Planet Electronic Circ., 2006-C02 (2006).

LARSEN, J. A., Assistant Professor (co-author), "1998 UC50", Minor Planet Electronic Circ., 2006-D25 (2006).

LARSEN, J. A., Assistant Professor (co-author), "2006 DD42", Minor Planet Electronic Circ., 2006-D49 (2006).

Trident Scholar Report

ROE, Eric A., Midshipman 1/C, USN, "The Search for Planet X: Testing Inferences from the Kuiper Cliff", Trident Report # 347, (advisers: Assistant Professor Jeffrey A. Larsen and Professor C. Elise Albert).

This project involved an extensive search of a sizeable archive of astronomical CCD imagery to test the validity of arguments regarding the existence of a hypothetical "Planet X". This object was proposed by Brunini and Melita (2002) to be a low inclination Mars-sized body residing in the Kuiper Belt between 55 and 75 astronomical units (AU) from the Sun. Resonances with this hypothetical planet form a convenient explanation of the "Edgeworth-Kuiper Cliff": the observation that no low eccentricity Kuiper Belt objects are found more than 47 AU from the Sun despite numerous searches. Although relatively bright, the distance to this object indicates that it could easily have been mistaken for a stationary object in previous searches.

In particular, image archives of the University of Arizona's Spacewatch Project, a near-Earth asteroid survey based at Kitt Peak National Observatory, between May of 2003 and April of 2006, were reviewed in detail. Images were obtained with a CCD mosaic camera on the observatory's 0.9 meter telescope, with the camera programmed to take images with a 2.7 square degree field of view at 1" resolution to a limiting magnitude of 21.7. To obtain multiple night orbits on its detected asteroids, the survey re-imaged the same sky area every 2 - 3 days, allowing for rate sensitivity to the proposed planet.

The results also included a search of over 12,000 square degrees of sky within 20 degrees of the ecliptic. Although an automated detection program was modified for the unique circumstances of the search and it processed approximately 3 terabytes of imagery, visual validation of the candidates produced in the images was still required. The efficiency of the software and human validation were measured as a function of rate, field clutter andsignal-to-noise. Quality control on the data was performed and methodologies were developed to aid in determining the unique coverage of the search and the probability of detecting a planetary candidate. This survey discovered the current tenth largest Kuiper Belt asteroid, 2003 MW12,as well as redetections of many already known Kuiper Belt objects and Centaur asteroids. Follow-up observations of 2003MW12 were obtained in February of 2006 via the Spacewatch Project's 1.8 meter telescope at Kitt Peak National Observatory.

Internet Publications

Huddle, James R., Associate Professor, "Re: Welder's glass availability in the UK," SEML 2 Aug 2005. http://groups.yahoo.com/group/SEML/

Huddle, James R., Associate Professor, "Lost in the Desert," SEML 2 Aug 2005. http://groups.yahoo.com/group/SEML/

Huddle, James R., Associate Professor, "Re: Limb Profile Effects on the Duration of Totality," 30 Aug 2005. http://groups.yahoo.com/group/SEML/

Huddle, James R., Associate Professor, "Re: Let's get back to some physics…," SEML 2 Jan 2006. http://groups.yahoo.com/group/SEML/

Huddle, James R., Associate Professor, "Re: Let's get back to some physics…," SEML 3 Jan 2006. http://groups.yahoo.com/group/SEML/

Huddle, James R., Associate Professor, "Re: Ideas about eclipses from non-scientific cultures," SEML 8 Jan 2006. http://groups.yahoo.com/group/SEML/

Huddle, James R., Associate Professor, "Re: Say goodbye to film," SEML 16 Jan 2006. http://groups.yahoo.com/group/SEML/

Huddle, James R., Associate Professor, "Re: Slow motion head for eclipse video," SEML 27 Jan 2006. http://groups.yahoo.com/group/SEML/

Huddle, James R., Associate Professor, "Re: Libya Info and Eclipse Goggles," SEML 6 Feb 2006. http://groups.yahoo.com/group/SEML/

Presentations at Professional Meetings and Conferences

BENDLER, John T., Professor (co-author), "Novel Aromatic Polycarbonate Blends with High Aspect Ratio Polycarbonates", 230th American Chemical Society National Meeting, Washington, D.C., 29 August 2005.

BENDLER, J. T., Professor, FONTANELLA, J. J., Professor, WINTERSGILL, M. C., Professor, and Shlesinger, M. F., "The Defect Diffusion Model of the Glass Transition and the Physical Properties of Glass-Formers," 5th International Discussion Meeting on Relaxations in Complex Systems, Lille, France, 7-13 July 2005.

BENDLER, J. T., Professor, FONTANELLA, J. J., Professor, Shlesinger, M. F., WINTERSGILL, M. C., Professor, and Bartos, J., "The Defect Diffusion Model of Glasses and Supercooled Liquids," 6th Liquid Matter Conference, Utrecht, The Netherlands, 2-6 July 2005.

BENDLER, J.T., Professor, "Mechanical Properties and Entanglement Lengths in Polycarbonate," Workshop on Nanomaterials for Transparent Military Armor Protection, Army Research Laboratory, Aberdeen, MD, 8 December 2005.

BENDLER, John T., Professor (co-author), "Design and Synthesis of Polycarbonates for Transparent Armor Military Applications," Society for the Advancement of Material and Process Engineering (SAMPE 06) National Meeting, Longbeach, CA, 3 May 2006.

BOOHER, Kevin R., First Lieutenant, USMC, Passerini, S., WINTERSGILL, Mary C., Professor, EDMONDSON, Charels A., Associate Professor, and FONTANELLA, John J., Professor, "Super-Pressed and Super-Cooled $P(EO)_{20}$LIBETI," SSI-15 International Conference on Solid State Ionics, Baden-Baden, Germany, 17-22 July 2005.

EDMONDSON, C. A., Associate Professor and FONTANELLA, J.J., Professor, "Properties of Capacitor Materials," Office of Naval Research Capacitor Program Review, La Jolla, CA, 6-8 March 2006.

EDSALL, Douglas W., Professor, "Health on the Rocks: A Call for SOPAC Action," 34th Annual SOPAC Session, Apia, Samoa, 24-28 September 2005.

EDSALL, Douglas W., Professor and Bunnell, J. E., "Not a Tsuanmi, Not a Hurricane, Just an Opportunity," Annual Fall Meeting AGU, San Francisco, CA, 4 – 9 December 2005.

EDSALL, Douglas W., Professor, "Catastropic vs. Chronic Geology," European Geosciences Union Meeting, Vienna, Austria, 3-7 April 2006.

ERTEL, John P., Associate Professor, Schwarz, C. and Burt, P.E., "W23: Introduction to Interactive Physics III and Its Use in the Undergraduate Classroom/Laboratory", *Summer Meeting of the American Association of Physics Teachers,* Salt Lake City, UT, 7 August 2005.

ERTEL, John P., Associate Professor, Schwarz, C., and Burt, P. E., "W40:Intermediate & Advanced Interactive Physics III and Its Use in the Undergraduate Classroom/Laboratory", *Summer Meeting of the American Association of Physics Teachers,* Salt Lake City, UT, 7 August 2005.

FONTANELLA, John J., Professor, BENDLER, John T., Professor, Shlesinger, M. F., "The Defect Diffusion Model and the Properties of Glasses and Liquids", 5th International Discussion Meeting on Relaxation in Complex Systems, Lille, France, 6 July 2005.

FONTANELLA, J. J., Professor (co-author),"Free Volume from PALS and its Relationships to the Dynamic and Ion Transport Properties in Undoped and Doped Poly(propylene glycol)," 6th Liquid Matter Conference, Utrecht, The Netherlands, 2-6 July 2005.

HARTLEY, Daryl J., Assistant Professor, MOHR, William H., Midshipman 1/C (USN), and VANHOY, Jeffrey R., Professor, (co-authors), "In Search Of: Stable Triaxial Deformation," Gudrunfest: A Retirement Celebration for Gudrun Hagemann, Niels Bohr Institute, Copenhagen, Denmark, 15-16 December 2005.

HARTLEY, Daryl J., Assistant Professor (co-author), "Strongly Deformed Structures in ^{171,172}Hf," Division of Nuclear Physics Meeting, Maui, HI, 18-22 September 2005.

HARTLEY, Daryl J., Assistant Professor (co-author), "A New Isomeric State in ^{116}Ag," Division of Nuclear Physics Meeting, Maui, HI, 18-22 September 2005.

HARTLEY, Daryl J., Assistant Professor, MOHR, William H., Midshipman 1/C (USN), and VANHOY, Jeffrey R., Professor, (co-authors), "Where's the Wobbling? A Search for Triaxiality in ^{171}Ta," Gordon Research Conference on Nuclear Chemistry, New London, NH, 26-30 June 2005.

HARTLEY, Daryl J., Assistant Professor, (co-author), "What Lies Beyond Band Termination in N~90 Erbium Isotopes and the Strange Behavior of Strongly Deformed A~174 Hf Nuclei at High Spin," International Conference on Finite Fermionic Systems: Nilsson Model 50 Years, Lund University, Lund, Sweden, 14-18 June 2005.

HARTLEY, Daryl J., Assistant Professor, MOHR, William H., Midshipman 1/C (USN), and VANHOY, Jeffrey R., Professor, (co-authors), "Search for the Wobbling Mode in ^{171}Ta," APS April Meeting, 22-25 April 2006.

HARTLEY, Daryl J., Assistant Professor (co-author), "Internal Conversion Coefficient Measurements of Transitions in ^{167}Lu," APS April Meeting, 22-25 April 2006.

HARTLEY, Daryl J., Assistant Professor (co-author), "The Continued Pursuit of Stable Triaxiality," ATLAS Users Meeting, Argonne National Laboratory, Argonne, IL, 8 April 2006.

KORMAN, Murray S., Professor and Sabatier, J. M., "Nonlinear Acoustic Experiments Involving Landmine Detection: Connections with Mesoscopic Elasticity and Slow Dynamics in Geomaterials, Part III", 150th Meeting of the Acoustic Society of America, Minneapolis, MN, 17 – 21 October 2005.

KORMAN, Murray S., Professor, and Sabatier, J. M., **"**Demonstration of Nonlinear Effects in Acoustic Landmine Experiments using a Clamped-plate Soil Oscillator", 150th Meeting of the Acoustic Society of America, Minneapolis, MN, 17 – 21 October 2005.

KORMAN, Murray S., Professor, and Bond, A., "Nonlinear Acoustic Landmine Detection: Comparison of "off target" Soil Background and "on target" Soil-mine Nonlinear Effects," 150th Meeting of the Acoustic Society of America, Minneapolis, MN, 17 – 21 October 2005.

KORMAN, Murray S., Professor, *"*Acoustic Landmine Detection**",** SPIE Defense & Security Symposium, Orlando, FL, 17-21 April 2006.

KORMAN, Murray S., Professor, and Sabatier, J. M., "Nonlinear Acoustic Experiments Involving Landmine Detection: Comparison of Off-target Background with On-target Soil-mine Nonlinear Effects", SPIE Defense & Security Symposium, Orlando, FL, 17-21 April 2006.

KORMAN, Murray S., Professor, "Nonlinear Acoustic Demonstration Experiments Involving Landmine Detection", 17th ISNA, International Symposium on Nonlinear Acoustics, State College, PA, 18-22 July 2005.

KORMAN, Murray S., Professor, and Sabatier, J. M., "Nonlinear Acoustic Experiments Involving Landmine Detection: Connections with Mesoscopic Elasticity and Slow Dynamics in Geomaterials", Local Washington DC Acoustical Society of America Meeting, Baltimore, MD, 16 February 2006.

KATZ, Debora M., Associate Professor, Dyer, K. K, Kassim, N. E., Perley, R. A. Blundell, K. M. and Erickson, W. C., "74 and 330 MHz VLA Survey of Bright Sources from the 3rd Cambridge Catalogue," 207th Annual Meeting of the American Astronomical, Washington, DC, 8-13 January 2006.

LARSEN, J.A., Assistant Professor and the Spacewatch Team, "The Size Distribution of Small Near-Earth Asteroids from the Spacewatch Survey," 207th Meeting of the American Astronomical Society, 9 January 2006.

MIKULSKI, Paul T., Assistant Professor, HERMAN, Lawrence A., Midshipman 1/C, USN, and HARRISON, Judith A., Professor (USNA Chemistry Department), "A Molecular Dynamics Study of the Odd-Even Effect in Self-Assembled Monolayers," APS March Meeting 2006, Baltimore, MD, 13-17 March 2006.

MUNGAN, Carl E., Assistant Professor, Buchwald, M.I., and Mills, G.L., "All-Solid-State Optical Coolers: History, Status, and Potential," 14th International Cryocooler Conference, Annapolis, MD, 14–16 June 2006.

MUNGAN, Carl E., Assistant Professor, "Escape Speeds and Asteroid Collisions," Capital Science 2006, National Science Foundation, Arlington, VA, 25–26 March 2006.

MUNGAN, Carl E., Assistant Professor, "Generalizing the Definition of Buoyant Force," American Physical Society National Meeting, Baltimore, MD, 13–16 March 2006.

MUNGAN, Carl E., Assistant Professor (co-author), "Fiber-Pumped Radiation Balanced Laser," 8th Annual Directed Energy Symposium, Lihue, HI, 14–18 November 2005.

MUNGAN, Carl E., Assistant Professor, "Atwood's Machine Without Hanging Masses," Chesapeake Section of the American Association of Physics Teachers, College Park, MD, 4–5 November 2005. (won the Frank Haig Prize for best talk at the meeting)

MUNGAN, Carl E., Assistant Professor, "What is a Radiation-Balanced Laser?" American Association of Physics Teachers National Meeting, University of Utah, Salt Lake City, UT, 7–10 August 2005.

SCHNEIDER, Carl S., Professor, "Unified Field Theory of Ferromagnetic Hysteresis," 7th International Symposium on Technology and the Mine Problem, Naval Postgraduate School, Monterey, CA, 2-4 May 2006.

SCHNEIDER, Carl S., Professor, "Unified Field Theory of Ferromagnetic Hysteresis," U.S. Navy Workshop on Transduction Materials and Devices, Penn State University, State College, PA, 9 May 2006.

TANKERSLEY, L. L., Professor, "Coordinate System Visualization: a Basic Skill Supporting Vector Calculus," Gordon Conference on Physics Research and Education: Electromagnetism, Mount Holyoke College, South Hadley, MA, 11-16 June 2006.

TUCHOLSKI, Edward J., CDR, USN and Assistant Professor, "Standing Wave Patterns on a Drum Head," Education in Acoustics: Acts of Sound – Hands on Workshop for High School Students, 150th Meeting of the Acoustical Society of America, Minneapolis, MN, 18 October 2005. (invited presentation)

VANHOY, Jeffrey R., Professor, and HARTLEY, Daryl J., Assistant Professor, "Radiological Emergencies", EMS Care 2006, Baltimore, MD, 28-30 April 2006. (invited talk/training session)

VANHOY, J.R., Professor and Hicks, S.F., "Gamma-ray Spectroscopy of the ^{126,128,130}Te Nuclei", 231st American Chemical Society National Meeting, Atlanta, GA, 26-30 March 2005.

VANHOY, Jeffrey R., Professor, and Hicks, S.F., "Structural characteristics of ^{120,122,124}Te Observed Through Gamma-ray Spectroscopy", 231st American Chemical Society National Meeting, Atlanta, GA, 26-30 March 2005.

WINTERSGILL, M. C., Professor, BENDLER, J. T., Professor, FONTANELLA, J. J., Professor, Shlesinger, M. F., Bartos, J., Sausa, O., and Kristiak, J., "Pressure, Temperature, Volume and the Properties of Pure and Ion-Containing Liquids and Solids," 5th International Discussion Meeting on Relaxations in Complex Systems, Lille, France, 7-13 July 2005.