Physics Department

Professor Francis David Correll
Chair

Physics Department faculty and students were actively engaged in research and scholarship during the 2003-2004 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 independent scholars.

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

External research sponsors included the Army Research Laboratory (ARL), the Army Research Office (ARO), the Max Born Institute, the National Center for Physical Acoustics, the National Science Foundation (NSF), the Naval Research Laboratory (NRL), the Naval Surface Warfare Center (NSWC), the Office of Naval Research (ONR), and the Research Corporation. Internal support came from the Kinnear Fellowship Program and the Naval Academy Research Council (NARC).

Our faculty shared the results of their efforts by publishing scholarly works and making presentations at meetings and conferences. This year, physics faculty and students published 22 articles in refereed journals, seven articles in conference proceedings, three books, one book chapter, and several articles/newsletters on the internet. In addition, they issued two technical reports and three Trident Scholar reports. Finally, faculty, midshipmen, and their collaborators made 47 presentations at scientific conferences and other meetings, including some at international meetings in Canada, France, Germany, Italy, Oceania, and the Slovak Republic.

As always, the scholarly bond between our faculty and our students was close and productive. One Trident Scholar studied the sensitivity of a planned space-based laser interferometer for the detection of gravitational waves, another investigated the properties of polymer proton-exchange membranes for fuel cells that were fabricated using a novel method, and a third studied optical limiting in single-mode waveguide systems. Two midshipmen developed successful new Trident Scholar proposals, one in nonlinear dynamics and one in ferromagnetism, which they will carry out during the next academic year, and six midshipmen participated in research course projects in astronomy, materials science, nonlinear acoustics, optics, and nuclear physics.

Sponsored Research

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

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

The broad goal of this research is to use 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. This research represents the extension and application of discoveries made in the course of our National Science Foundation (NSF) grant. The NSF results 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 research investigation extends the NSF results to include new thermoplastic polymer analogues based on bisaryl monomers such as trifluoromethylated, siloxane, formal, and geminal-dimethyl analogues of bis(biarylphenols). The primary focus and objective in this new work was the evaluation and testing of 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. This work is a multi-year effort and is on-going.

Synthesis, Modeling and Testing of Polymer Nanocomposites for Impact Protection

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

The scientific goal of this project is 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 is 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 focuses 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 last summer and testing has begun at the Rodman Materials Center at ARL in Aberdeen, MD.

Modeling Linear and Nonlinear Optical Properties of III-V Quantum-Well Structures Under Anisotropic In-Plane Strain and Applied Electric Fields

Researcher: Associate Professor Mark L. Biermann
Sponsor: Naval Research Laboratory (NRL), Photonics Technology Branch (Code 5650)

Anisotropic, in-plane strain in quantum-well structures is of interest for several reasons. In-plane strain can be used to probe the fundamental nature of quantum-well structures, and to produce optical, polarization anisotropies of particular interest with regard to potential device applications. In this research, optical anisotropies and other optical effects that arise due to anisotropic, in-plane strain and piezoelectric fields in quantum wells were modeled. These optical anisotropies can provide the basis for an optical technique to map out complicated strain geometries arising on micromachined, quantum-well structures. One goal of the project was the ongoing comparison of computer model predictions for various strain geometries to experimental results. A further goal of the project was the enhancement of the current model to allow the modeling of the second-order, nonlinear optical susceptibility in quantum well structures under anisotropic strain. Anisotropically strained quantum wells could potentially provide very large nonlinear optical effects. An enhanced computer model would provide a means of predicting the size of optical nonlinearities that could be obtained.

Packaging-Strain-Induced Interband Energy Shifts in High-Power, "cm-bar" Lasers Using a Realistic Strain Model

Researcher: Associate Professor Mark L. Biermann
Sponsor: Max Born Institute for Nonlinear Optics and Short-Pulse Spectroscopy, Berlin, Germany

High-power "cm-bar," quantum-well lasers must be mounted onto a heat sink if they are to function properly. However, the packaging of the "cm-bar" laser onto the heat sink leads to an applied strain in the optically active region of the laser due to the different thermal expansion coefficients of the laser material and the heat sink. This packaging-induced strain degrades the performance of the laser, and tends to shorten the lifetime of the laser.

The focus of the research project was to attempt to accurately model the packaging-induced strain the in the quantum wells for the first time. The application of a strain to a quantum well leads to a shift in the interband transition energy of the quantum well. Hence, the optical output of the lasers can be used to characterize the strain situation in the laser. A computer model of the "cm-bar" laser quantum wells was used to model the interband-transition, energy shift as a function of applied strain. The packaging-induced strain was modeled using a sophisticated model of the induced strain. The long-term goal of the research is to develop an accurate, convenient, optical means of characterizing the general strain situation in a packaged laser, and then to develop means of minimizing the strain in the laser. A minimization of strain in the quantum well lasers should improve their reliability and lifetime. The theoretical predictions showed excellent agreement with relevant experimental results, and important differences between the realistic strain model results, and the results based on simpler strain models.

Nonlinear Optics in Capillaries and Capillary Arrays

Researcher: Assistant Professor James J. Butler
Sponsor: Research Corporation

Arrays of coupled nonlinear waveguides are proving to be an important arena for the study of discrete nonlinear systems. Researchers have only recently begun to explore the fundamental physics of these structures. Furthermore, the unique properties of these arrays open avenues for the development of new photonic devices. The goals of this research project are (1) to provide the first experimental study of the optical properties of two-dimensional arrays of coupled waveguides and (2) to investigate low-intensity nonlinear optical phenomena in capillary waveguides.

Optically Active Photonic Crystal and Holey Fibers

Researcher: Assistant Professor James J. Butler
Sponsor: Naval Research Laboratory (NRL), Optical Physics Branch (Code 5613)

The objectives of this project are to develop and study a new class of materials – active photonic crystal and holey fibers – whose optical properties (dispersion, modal behavior, diffraction, nonlinear behavior) can be easily engineered by control of the fiber structure. This will lead to an analytical understanding of the optical properties of active photonic crystal and holey fibers; experimental verification of models; high power fiber light sources and amplifiers; efficient optical limiters for fiber amplifier protection; high power continuum light sources, and all-fiber optical switches.

Optical Properties of Limiting Compounds and Single Mode Capillary Waveguides in the Visible and Near Infrared

Researcher: Assistant Professor James J. Butler
Sponsor: Naval Research Laboratory (NRL), Optical Physics Branch (Code 5613)

Optical limiters that operate in the near infrared (800-1000nm) are expected to play a vital role in the future of military safety on the battlefield due to the fact that this is the operational wavelength range of night vision instrumentation. This report describes the preparatory work that marked the beginning of an intensive study of optical limiting materials and devices that operate in this important range of wavelengths.

Previous studies have shown that Ru-PZn-Ru is a promising choice for optical limiting in the near infrared. In the work reported here, z-scan data was taken using 7 ns pulses at a wavelength of 750nm. At low energies, the transmission of the sample increases near focus (sample position equal zero). Furthermore, as the energy increases the width of the transmission curve broadens. Both of these observations are consistent with a material that exhibits a saturable absorption. However, as the energy is increased even further the character of the observed z-scan transmission changes dramatically. A drop in transmission appears near focus. This is consistent with a material that exhibits a reverse saturable absorption. It is this behavior at large energies that makes this material promising for optical limiting applications.

The observed z-scan data can be explained using a 5-level model for the energy level structure of Ru-PZn-Ru. Theoretical calculations of the nonlinear transmission were performed based upon the rate equations predicted by this model.

The theoretical curve fits the data reasonably well, which provides evidence for the model. However, because the lifetimes and cross-sections were taken as free-parameters the uniqueness of the fit must be evaluated.

In the past several years, many experiments on optical limiters within capillary waveguides have been conducted. The results of those investigations indicate that the usefulness of Ru-PZn-Ru as an optical limiter will be enhanced by housing it within the core of a capillary waveguide. The waveguides used in previous experiments were highly multimode because of their large core diameters and/or large refractive index differences between the core and the cladding. The waveguides that demonstrated the lowest thresholds for optical limiting had the fewest allowed modes. This was due, in part, to the small core size, which keeps the light confined to a smaller region thereby maximizing the energy density. Therefore, it is reasonable to assume that single-mode waveguides, which generally place the most restrictions on the optical energy distribution within the core, will optimize the optical limiting ability of the solutions that are housed within them. In order to achieve single-mode behavior it is necessary to tune the refractive index so that the refractive index difference between the core and the cladding is sufficiently small. This was achieved by controlling the temperature of the waveguide.

Review of Science and Technology in India

Researcher: Professor Douglas W. Edsall
Sponsor: Office of Naval Research, International Field Office (ONRIFO)

Scientists in Office of Naval Research International Field Offices routinely report on progress in foreign science and technology. This review was directed at identifying the major governmental, academic and private institutions and agencies, as well as leading scientists involved in ocean, atmosphere and space research in India. The data obtained was used to help focus U.S. efforts on those institutions and scientists with the greatest potential for mutual benefit in technical areas of significance to the Navy and Marine Corps.

Optically Stimulated Luminescence of Diatoms

Researcher: Professor Douglas W. Edsall
Sponsor: 2003 Kinnear Fellowship

The objective in this project was to establish the feasibility, reliability and accuracy of dating diatoms tests by the Optically Stimulated Luminescence (OSL) technique. If ultimately successful, this multi-year research effort will expand the range of age dating methods available to geoscientists. Initial work included travel to New Zealand to prepare and date samples in collaboration with Dr. Uwe Riser and Dr. John Collen, both of Victoria University of Wellington (VUW), New Zealand.

Properties of Glass-Forming Materials and Proton-Conducting Materials

Researchers: Professor John J. Fontanella, Professor Mary C. Wintersgill, Associate Professor John T. Bendler, and Associate Professor Charles A. Edmondson
Sponsor: National Science Foundation (NSF), Division of Materials Research

The scientific goal of this project is to understand ion transport and dipole reorientation mechanisms in polymer electrolytes. It is generally agreed that ion-polymer and ion-ion interactions are of crucial significance in determining the ion transport properties. Both alkali metal salt-polyether complexes and proton-conducting materials such as hydrogels were studied. Experimental information concerning both structural and dynamic properties (the free volume microstructure of the polymer matrices, the segmental motions of the polymer chains and the diffusional motions of the ions) over a wide range of temperature, pressure and time (frequency) were obtained. In addition, modeling and computer simulations of the various systems were carried out.

Search for Wobbling Excitations in ^{174}Hf

Researcher: Assistant Professor Daryl J. Hartley
Sponsor: National Science Foundation (NSF), Division of Physics, Heavy Ion Nuclear Science Program

Nuclei exist in various shapes, such as spherical, prolate (like a football), oblate (like a doorknob), and octupole (like a pear). All of these shapes are similar in one aspect: they have an axis of symmetry for their mass distribution. A nucleus with no symmetry axis (referred to as triaxial) is rarely seen – in fact only one nucleus (^{163}Lu) has had this shape confirmed. If such a nucleus were rotated, it would have a wobbling motion, similar to the spinning of an asymmetrical top. Observing wobbling motion is in fact the most conclusive way to confirm triaxial shapes.

In this research effort, an experiment was conducted at the international facility Gammasphere, with the goal to produce high-spin states in ^{174}Hf (which recent theory suggested could have triaxiality at high spin and excitation energy). This nucleus was produced by bombarding a ^{130}Te target with ^{48}Ca at an energy of 205 MeV. The data was collected on 8 mm tape and analyzed at the U.S.Naval Academy. Unfortunately, there was no conclusive evidence for wobbling; however, it was determined that the possible configuration in ^{174}Hf that may be triaxial is much more complex than that seen in ^{163}Lu. This information is quite useful to theorists as they try to understand the exact conditions necessary for nuclei to possess asymmetrical shapes.

Low-frequency Observations of Extragalactic Radio Objects

Researcher: Associate Professor Debora M. Katz
Sponsor: Naval Research Laboratory (NRL), Astrophysics Branch (Code 7213)

The Very Large Array (VLA) is a set of 27 radio telescopes in New Mexico. It is the most sensitive, flexible instrument of its kind. Each telescope can be placed on a railroad track and moved along the array. This allows for more complete coverage and resolution. In recent years, the VLA has been upgraded to include low-frequency receivers. Low-frequency observations require significant computing power because: 1) these observations require that the curvature of the sky be accounted for, 2) the ionosphere causes time-dependent interference and 3) artificial interference is a strong factor. Until recently, this computing power has been unavailable and, therefore, many questions have remained unaddressed.

Astronomical radio sources such as galaxies, quasars and supernova remnants emit synchrotron radiation due to relativistic electrons spiraling around magnetic field lines. The history of these electrons is not well understood. How are they accelerated to relativistic speeds? Where does this acceleration take place in the source? Where do they lose their energy? Low-frequency observations provide an important clue because they reveal the energetics of the lowest energy, longest living electrons.

This project has three main components: 1) a brief survey of the brightest radio sources at low frequencies, with the intent to find what new information can be gained by observations at low frequency. 2) a detailed low-frequency study of the large radio galaxy Fornax A. Its size and brightness will allow a determination of the history of the relativistic electrons in this galaxy. 3) a detailed study of a small sample of radio sources to determine the low-frequency spectral index of these sources. This is an important parameter for all acceleration models and cannot be well determined at higher frequencies.

These projects required years of observations with the VLA because they required several configurations of the array that were scheduled over the time of the observations. These data are in various states of reduction and analysis. 1) The survey of the bright radio galaxies has been fully reduced and analyzed. The results are exciting, as the electrons show unexpected energies millions of light years from their central engines. Efforts are underway to try to account for these unexpected results. 2) Fornax A was observed at three frequencies (n=74, 330, 1420 MHz). These data are extremely difficult to calibrate. Fornax A is the largest and lowest source ever observed at low frequencies. It size and position make it especially vulnerable to ionospheric interference. In addition, its size required that it be observed in mosaic mode; that is, six images of Fornax A had to be calibrated and imaged separately, and then properly fit together. 3) The study of radio galaxies was fully calibrated and mapped, and the results are interesting. The spectral index at low frequencies is slightly steeper than predicted by the limit of the standard acceleration model. This will help constrain the theoretical models. This work is in the final stages, with a draft manuscript being prepared for submission.

Nonlinear Acoustic Techniques for Landmine Detection: Tuning Curves and Two-tone Tests

Researcher: Professor Murray S. Korman
Sponsors: National Center for Physical Acoustics
and the U. S. Army Communications-Electronics Command RDEC, NVESD

Measurements of the top surface vibration of a buried, inert VS 2.2 anti-tank plastic landmine reveal significant resonances in the frequency range between 80 and 650 Hz. Resonances from measurements of the normal component of the acoustically induced soil surface particle velocity (due to sufficient acoustic-to-seismic coupling) have been used in detection schemes. Since the interface between the top plate and the soil responds to pressure fluctuations nonlinearly, characteristics of landmines, the soil, and the interface are rich in nonlinear physics and allow for new methods of buried landmine detection not previously exploited.

Tuning curve experiments (revealing "softening" and a back-bone curve linear in particle velocity amplitude versus frequency) helped characterize the nonlinear resonant behavior of the soil-landmine oscillator. When two primary waves $f_1$and f_2 drive the soil over the mine, a rich spectrum of nonlinearly generated tones was measured with a geophone on the surface over the buried landmine in agreement with Donskoy [Proc. SPIE 3392 (1998); 3710, 239--246 (1999)]. In profiling, particular nonlinear tonals can improve the contrast ratio compared to using either primary tone in the spectrum.

Investigating Nonlinearity in Acoustic Landmine Experiments Using a Clamped-Plate Soil Oscillator

Researchers: Professor Murray S. Korman and Midshipman 1/C Dang V. Duong, USN
Sponsors: National Center for Physical Acoustics
and U. S. Army Communications-Electronics Command RDEC, NVESD

This project investigated the nonlinear effects involved in the detection of plastic landmines using the acoustic-to-seismic coupling techniques developed by Sabatier (linear methods) and Donskoy (nonlinear methods). The soil-plate oscillator is a laboratory apparatus that represents a good physical model for the VS 1.6 and VS 2.2 inert anti-tank plastic landmines. 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.

Tuning curve experiments were performed using a loudspeaker located over the soil that was driven by a swept sinusoid. The vibration amplitude *vs* frequency was measured on a swept spectrum analyzer using an accelerometer located on the soil-air interface or under the plate. The backbone curve showed a linear decrease in peak frequency *vs* increasing amplitude. A two-tone test experiment was performed using two loudspeakers generating acoustic frequencies closely spaced on either side of resonance (typically ~ 100 Hz). A collection of combination frequency component profiles (along with the primaries) was measured across the soil surface. In particular, a double peaked profile occurred at $2f_1+f_2$ corresponding to a common timpani mode.

Nonlinear Acoustic Experiments Involving Landmine Detection: A Connection between Mesoscopic/Nanoscale Effects in Geomaterials

Researcher: Professor Murray S. Korman
Sponsors: National Center for Physical Acoustics
and U. S. Army Communications-Electronics Command RDEC, NVESD

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 such as rocks (sandstone) or granular materials. Experiments were performed with an inert VS 1.6 anti-tank mine that was buried 3.6 cm deep in dry sifted loess soil. Airborne sound at two primary frequencies f_1 = 120 Hz and f_2 = 130 Hz underwent acoustic-to-seismic coupling. Interactions with the compliant mine and soil generated combination frequencies that, through scattering, affected the vibration velocity at the surface. Profiles of the soil surface particle velocity at f_1 and f_2 and the nonlinearly generated $f_1 - (f_2 - f_1)$ component were characterized by a single peak. Doubly peaked profiles at $2f_1 + f_2$ and $2f_2$

+ f_1 were attributed to the familiar mode shape of a timpani drum. Near resonance, the bending (a "softening") of a family of tuning curves for the soil surface vibration over a landmine exhibited a linear relationship between the peak frequency and the corresponding peak particle velocity; which also exhibited hysteresis effects.

Nonlinear Acoustic Techniques for Landmine Detection: The Significance of the Top Plate Normal Modes

Researcher: Professor Murray S. Korman
Sponsors: National Center for Physical Acoustics
and the U. S. Army Communications-Electronics Command RDEC, NVESD

In nonlinear acoustic detection experiments involving a buried inert VS 2.2 anti-tank landmine, airborne sound at two closely spaced primary frequencies f_1 and f_2 couple into the ground and interact nonlinearly with the soil-top pressure plate interface. Scattering generates soil vibration at the surface at the combination frequencies $|mf_1 \pm nf_2|$, where m and n are integers. The normal component of the particle velocity at the soil surface has been measured with a laser Doppler velocimeter (LDV) and with a geophone by Sabatier et al. [SPIE Proceedings Vol. 4742, (695-700), 2002; Vol. 5089, (paper No. 57), 2003] at the gravel lane test site. Spatial profiles of the particle velocity measured for both primary components and for various combination frequencies indicate that the modal structure of the mine is playing an important role.

In this work, an experimental modal analysis was performed on a VS 1.6 inert anti-tank mine that was resting on sand but was not buried. Five top-plate mode shapes were described. The mine was then buried in dry finely sifted natural loess soil and excited at $f_1 = 120$ Hz and $f_2 = 130$ Hz. Spatial profiles at the primary components and the nonlinearly generated $f_1 - (f_2 - f_1)$ component were characterized by a single peak. For the $2f_1+f_2$ and $2f_2 + f_1$ components, the doubly peaked profiles can be attributed to the familiar mode shape of a timpani drum (that is shifted lower in frequency due to soil mass loading). Other nonlinear profiles appear to be due to a mixture of modes.

Ground-based Passive Remote Sensing of the Overcast Sky

Researcher: Adjunct Assistant Professor Raymond L. Lee, Jr.
Sponsor: National Science Foundation (NSF), Division of Atmospheric Sciences, Physical Meteorology Program

This research project involved visible-wavelength remote sensing of the overcast sky as seen from the earth's surface. The scientific objective of this proposed research is to quantify and better understand overcasts' visible features by conducting the first long-term, systematic study of them using modern instruments. In turn, this improved understanding of the overcast sky's visible-wavelength structure will provide a new standard for testing the realism of numerous atmospheric radiative transfer models.

To perform this analysis, spectroradiometry and digital imaging was used to analyze (at high spectral, spatial, and temporal resolutions) the photometric, colorimetric, and polarimetric details of a wide range of overcasts. This research investigated not only the spectral details of overcast irradiances, but also the angular distribution of chromaticities in various kinds of overcasts. While some work has been done on chromaticities derived from overcast irradiances, there appears to be no published research on the angular details of chromaticities from overcasts' spectral radiances. Such details of overcasts are not only inherently interesting, but they also can be used to describe the spatial distribution of cloud optical depth and possibly absorptivity. This in turn offers insights into details of the near-surface heat budget.

In addition to advancing atmospheric science itself, this research: (1) benefits science education and (2) has broader impacts on the general public. On point (1), digital imaging techniques developed for NSF-sponsored research have been translated into remote-sensing lab exercises for Naval Academy midshipmen. Because these lab exercises integrate theory, instruments, and everyday visual phenomena, midshipmen have rated them as the very valuable components of their education. On point (2), an improved understanding of the spatial and spectral distribution of overcast radiances has practical applications in many areas ranging from interior lighting to plant growth and development.

Probing Nucleon Spin Structure via Electron Scattering from Polarized Helium-3

Researcher: Assistant Professor Kevin L. McIlhany
Sponsor: Naval Academy Research Council (NARC)

The Bates Large Acceptance Spectrometer Toroid (BLAST) is a particle detector located at the Bates Laboratory near the Massachusetts Institute of Technology. The BLAST Physics Program calls for several years of scattering polarized electrons from polarized internal gas targets at an electron energy of one GeV, with the purpose of probing nuclear and sub-nucleon structure.

Several basic goals were laid out for this project. The first was to install the helium-3 internal gas target and to maximize helium-3 polarization. The second goal built upon earlier work. After years of using the target apparatus in a manual configuration, a computer-based system of monitoring and controlling nearly all electronic channels was implemented. As a third goal, work was done with a student from Dartmouth College to develop and analyze a target polarization measurement by looking at the decay constant of the polarization signal as it depolarizes due to gas-wall bounces. The fourth goal was to participate in the BLAST collaborations activities as the detector was being commissioned and production level data began to be collected. Typical days included data taking, with the analysis done in near real time to track down any and all problems with the detector. Problems of this nature included drifting high voltage, unusual gains, timing imbalances and wiring errors. Thousands of plots were made to understand and analyze these issues.

Molecular Dynamics Simulations of the Friction and Wear of Self-assembled Monolayers and Amorphous Carbon Films

Researchers: Assistant Professor Paul T. Mikulski, and Professor Judith A. Harrison,
Dr. Guangtu Gao and Dr. Ginger M. Chateauneuf (all of USNA Chemistry Department)
Sponsor: Naval Academy Research Council (NARC to PM)

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 that models both chemical reactions (the breaking and forming of bonds) as well as long-range non-bonded interactions was used. Computationally feasible systems are typically composed of tens of thousands of atoms simulated over hundred of picoseconds with time steps of a few tenths of a femptosecond. This project focused on computer simulations of an amorphous carbon tip across a self-assembled monolayer (SAM). Methods of analysis were developed to allow an observation for how friction and load is distributed across individual SAM chain groups at the sliding interface. This method of analysis, when applied to the study of pure versus mixed-component SAMs in sliding contact with an amorphous tip, showed that the lower friction observed in the pure systems is the result of greater symmetry between forces exerted by SAM chain groups that resist the motion of the tip and forces exerted by SAM chain groups that push the tip along (as opposed to lower friction due to an overall decrease in the scale and/or frequency of interactions).

Molecular Dynamics Simulations of the Bending of Filled Carbon Nanotubes

Researchers: Dr. Susan Sinnott and Dr. Boris Ni (University of Florida)
Assistant Professor Paul T. Mikulski, and Professor Judith A. Harrison (USNA Chemistry Department)
Sponsor: Naval Academy Research Council (NARC to PM))

The overall goal of this project is to examine the mechanical properties of carbon nanotubes. Nanotubes were filled with CH_4, C_{60}, and Ne. Mechanical properties, as a function of filling gas, tube length, and temperature, were examined.

Solid-State Laser Cooling of Organic Dyes in Modified Polymers

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

A new laboratory, that includes position-sensitive detectors, a differential preamplifier, a diode laser, a precision chemistry balance, and optics & electronics supplies, was established. In addition, a photothermal deflection spectrometer was developed. Some analysis was performed on the power efficiency of laser cooling of solids and the resolution limit of photothermal deflection spectroscopy was investigated.

In addition, Nova Phase Inc. provided samples of high-purity ytterbium-doped tungstate crystals, which have special application to radiation-balanced lasing, in which a pump laser source is used to simultaneously stimulate high-power laser emission and optically cool the medium. Absorption, emission, and laser cooling spectra measurements have been made on these crystal samples.

Chemically Active Luminescent Layers for Sensor Applications

Researcher: Assistant Professor Carl E. Mungan
Sponsor: Naval Research Laboratory (NRL), Optical Physics Branch (Code 5615)

Optical sensors have been proposed for real-time detection of biological molecules in soil samples. The advantages of using an integrated, all-organic thin-film device include portability, low cost, and the ease with which it can be tailored to particular molecular agents. A critical component of the sensor is the active layer, which must bind a molecule of interest and change emission properties in an easily detectable manner. For the preferred back-detection geometry, in which the optical source and photodetector are both behind the sensing plane, this layer must be thin enough to let the excitation light through, while optically thick enough to permit sufficient luminescence of the fluorophores. Patterning or pixelation of the layer may be used. Both high chemical specificity and luminescence quantum efficiency is necessary. A monolithic device also requires a good match between the emission by the active sites and the detection by the photoreceptor.

Experimental measurements were performed to compare electroluminescent quantum efficiency measurements inside and outside an integrating sphere for both a green-emitting ALQ device and a red-emitting DMXP device. For the more conventional ALQ device, the external quantum efficiency measured in the sphere was found to be about 50% larger than that measured solely in the forward direction outside the sphere, indicating a substantial amount of light waveguided away from the forward direction by the substrate. The emission spectrum inside the sphere was also found to be spectrally narrower and somewhat redshifted. In contrast, the DMXP device had a similar spectral profile both inside and outside the sphere, but showed a quantum efficiency almost 3 times larger inside the sphere. This is a substantial difference and at least four issues require further investigation in order to explain it: the DMXP is known to have a non-Lambertian angular emission pattern; the device degrades quite rapidly with time; a direct calibration of the integrating sphere against the luminance camera is needed, especially at wavelengths far removed from the photopic peak; and measurements on devices of other layer thicknesses would help determine the extent of reabsorption of emitted light scattered back to the device by the sphere walls.

Effects of Biaxial Stress on Ferromagnetism

Researcher: Professor Carl S. Schneider
Sponsors: Office of Naval Research (ONR), Magnetic Signatures (Code 334),
and Naval Surface Warfare Center, Carderock Division (NSWC-CD), Electromagnetic Signatures (Code 751)

The recently published anisotropic cooperative domain field model of ferromagnetic hysteresis has been extended first to a differential form valid for the virgin curve and all reversals, and second to a reversible and irreversible theory of coaxial stress on ferromagnets, called ferromagnetoelasticity. Using directional magnetization and field and stress, magnetostriction and susceptibility, physical and normalized equations are derived from magnetoelastic thermodynamics for Brown's and Bozorth's stress fields on 90˚ walls between [100] domains, causing a stress bifurcation and the Villari reversal. Single valued equations for magnetization changes in $H\sigma$ and $H\sigma\sim$ processes and susceptibility and anisotropy changes in σH and $\sigma\sigma H$ processes are derived in quantitative agreement with experimental data including nonlinear stress loops up to residual stress and saturate magnetization. The primarily linear magnetization dependence of cooperation and

magnetostriction derivative cause magnetization changes with stress to be self proportionate with an asymmetry between tension and compression and coherence between Brown and Bozorth fields.

Optical Debris Analysis Techniques for Mechanical Systems in Military Environments

Researcher: Professor Lawrence L. Tankersley
Sponsor: Naval Research Laboratory (NRL), Optical Physics Branch (Code 5614)

This work is part of program to develop real time, full flow optical analysis for turbine engine and gearbox lubricants and for hydraulic fluids as its ultimate goal. Detected debris particles are to be characterized to provide failure projection. Less capable versions of the system are to be used to monitor drawn fluid samples off-line and to provide sampling of fluids in active on-line systems. In addition to hardware, image analysis algorithms must be developed and implemented to classify debris candidates.

A Portable Fluid Analysis (PFA) System consisting of the suspended particle monitor (the NRL LaserNet FINES system), an IR spectral analyzer and a viscometer was assembled and integrated under the control of a single program. Two copies of the analyzer were provided to the Fleet Technical Support Centers (FTSCLANT and FTSCPAC) for evaluation.

Andes2: A Help-Oriented Intelligent Tutoring System

Researchers: Professor Donald J. Treacy, Professor Mary C. Wintersgill, and Professor Emeritus Robert N. Shelby; Professor Kay G. Schulze (Computer Science Department); and Kurt VanLehn (University of Pittsburgh)
Sponsor: Office of Naval Research (ONR), Cognitive, Neural and Biomolecular Science and Technology Division

The Andes project is developing an intelligent tutoring system for teaching physics to students at the U.S. Naval Academy. It is based on three key ideas: (1) It should help students with their physics homework rather than replace classroom instruction. (2) Several types of help systems are necessary for effective learning. and (3) Principle-based dialog between the students and Andes is an effective method to give useful advice as a tutor. Andes covers about half of college physics course, with the material split between both semesters. The project has conducted several evaluations at the Naval Academy and in laboratories at the University of Pittsburgh. The current research is expanding the scope of the tutor, seeking to increase its acceptance at the Academy and conducting several types of evaluations in order to measure and increase the effectiveness of the tutor. In the past year, Andes was extended to cover about half of the second semester and a grading rubric was integrated. The topic coverage of the tutor has been expanded to include substantial portions of the second semester, including electric and magnetic forces, circuits and optics. Current work is focused on increasing the coverage both in topics and in problems and making a version for distribution at the summer meeting of The American Association of Physics Teachers.

Gamma-ray Spectroscopy of Tellurium–130

Researchers: Professor Jeffrey R. Vanhoy, Ensign Tyler H. Churchill, USNR, and Sally F. Hicks (University of Dallas)
Sponsor: National Science Foundation (NSF), Division of Physics, Nuclear Physics Program

Tellurium-130 is the heaviest stable nucleus in the isotopic chain. The lighter tellurium nuclei are generally vibrational in character while the heavier tellurium nuclei are thought to prefer a stronger independent particle approach. Very few specific details are known about the tellurium-130 nucleus. Although it is naturally abundant, it is not well studied because it is not accessible with as many reactions as the lighter tellurium nuclei. Totally absent from the existing data are extensive transition rate information required for validating various nuclear model descriptions. The present investigation provides level lifetimes required to determine those transition rates.

The excited levels of ^{130}Te have been studied using inelastic neutron scattering followed by gamma ray detection. Excitation functions, gamma ray coincidences, angular distributions, and Doppler shifts were measured for gamma rays from levels up to an excitation energy of 3.3 MeV; multipole-mixing and branching ratios and transition rates were deduced.

Experimental values of electromagnetic transition rates were compared with particle-core vibration model calculations. The particle-core vibration model shows promise, but the best technique to improve the understanding of the observed level scheme and properties may still have to await the availability of large-scale shell model calculations.

Recoil-Distance Lifetime Measurements in Tellurium–120

Researcher: Professor Jeffrey R Vanhoy
Sponsor: National Science Foundation (NSF), Division of Physics, Nuclear Physics Program

Tellurium-120 is used as a textbook example of a vibrational nucleus. Its sequence of excited states closely resembles that of a system undergoing simple-harmonic vibrations. Work performed over the last 3 years indicates this is a naive interpretation. The apparent simplicity is the actually result of the interactions between several complex modes of motion. To unfold the interactions and examine the detailed components of individual wavefunctions, the lifetime of each excited state is required.

Lifetimes in the picosecond range were determined using the recoil-distance Doppler-shift technique and associated gamma-ray detector array at the University of Cologne. Tellurium-120 nuclei are generated using ^{13}C reactions on a ^{110}Pd target. By examining the fraction of ^{120}Te nuclei decaying in flight after being knocked out of the target foil, the lifetimes may be extracted. The (^{13}C,xn) reaction populated the yrast band to spin-16 and other states of spin 6-14 in ^{120}Te. Lifetimes are extracted for the low-spin states, but data on the spin-8 and -10 states indicate the presence of a long-lived feeder level. It was hoped that more spin-4 and -6 states would have been populated, as these states are important for understanding the disappearance of the intruder band at lower spins. We may revisit this nucleus with a lower-spin reaction (Be or B projectiles) if suitable targets can be purchased. No nuclear structure conclusions are possible at the present time.

Properties of Fuel Cell and Battery Materials

Researcher: Professor Mary C. Wintersgill, Professor John J. Fontanella,
and Associate Professor Charles A. Edmondson
Sponsor: Office of Naval Research (ONR), Electrochemical Power Science and Technology Program

The long-term objective of the project is to provide basic studies of the structure, properties and dynamics of fuel cell and battery materials and to link these to performance. The immediate objective is to elucidate electrical transport in various ion-conducting systems with the goal of improving fuel cell ion-exchange membranes and battery electrolyte materials. This includes ion-conducting polymers and liquid and solid electrolytes. The approach was to carry out state-of-the-art complex impedance, differential scanning calorimetry (DSC), and thermogravimetric analysis (TGA) measurements on a variety of ion-conducting systems. Dynamical mechanical analysis (DMA), thermomechanical analysis (TMA), viscosity and infrared or visible spectroscopic studies were also carried out. The complex impedance and DSC measurements were made at high pressures. All work was done in collaboration with the group at Hunter College where Nuclear Magnetic Resonance (NMR) studies were conducted.

Independent Research

Intermediate Velocity Clouds

Researcher: Professor C. Elise Albert and Dr. Laura Danly, University of Denver

Intermediate Velocity Clouds (IVCs) refer to dynamically significant gas in the Milky Way Galaxy with velocities outside the range that can be ascribed to normal galactic rotation, but not so extreme (<100 km/s) as to be considered High Velocity Clouds. This phenomenon may include material accelerated in supershells, recycling in a galactic fountain, or infalling from outside our galaxy. The study of IVCs has progressed both from direct radio detection of intermediate velocity neutral hydrogen gas in emission at 21 cm and optical and ultraviolet observations of trace elements seen in absorption at these velocities toward distant stars. For this study, we gathered and organized all relevant observations from the literature and reviewed our ongoing work in this field and the contributions of other researchers.

Characterization of Optical Anisotropy in Quantum Wells Under Compressive, Anisotropic In-Plane Strain

Researchers: Associate Professor Mark L. Biermann,
Ensign Matthew Walters, USN, and Ensign James Diaz-Barriga, USN

Anistropic in-plane strain in quantum wells leads to an optical polarization anisotropy that can be exploited for device applications. We have determined that for many anisotropic, compressive-strain cases, the dependence of the optical anisotropy is linear in the strain anisotropy. This result holds for a variety of well and barrier materials and widths, and for various overall strain conditions. Further, the polarization anisotropy per strain anisotropy goes as the reciprocal of the energy separation of the relevant hole sub bands. Hence, a general result for the polarization anisotropy per strain anisotropy is available for cases of compressive, anisotropic, in-plane strain. The polarization anisotropy for any given quantum well structure under anisotropic, compressive strain can be characterized in terms of a single constant. A computer model was employed to analyze quantum-well structures under compressive, anisotropic strain in order to determine the general result of interest.

Structure and Composition of Metal Fittings from HMS DeBraak and HMS Pandora

Researcher: Professor Francis D. Correll, Professor Jeffrey R. Vanhoy
and Assistant Professor Daryl J. Hartley

The goal of this project is to provide new information about 18th-century naval production methods and metallurgy using Particle Induced X-Ray Emission (PIXE), which is a modern ion beam analysis technique.

HMS DeBraak was a 16-gun brig-sloop that sank in a squall on 25 May 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. It is now part of the collection of the Delaware State Museums. Among the items recovered from the hull are copper-alloy bolts and fasteners as well as copper sheathing and sheathing nails. They constitute a valuable record of the materials and techniques used in the construction of naval vessels in the late 18th century.

HMS Pandora was a 24-gun frigate that was sent in 1790 to the South Pacific to find the infamous Bounty mutineers. Eventually, 14 mutineers were captured; but on 29 August 1971, as Pandora was heading home, she struck the Great Barrier Reef and sank. Like DeBraak, Pandora quickly became covered with sand and was well preserved until the wreck was discovered in 1977. It is now being excavated and studied by the Queensland Museum.

We agreed to be part of a multi-disciplinary team organized by the Delaware State Museums to study DeBraak. We are conducting PIXE measurements using the Naval Academy's tandem accelerator to determine the composition of her metal fittings and, we hope, to document phases in the 18th-century development of alloys for shipboard use. Colleagues at the Delaware State Museums have tentatively arranged to borrow similar fittings from Pandora that we will analyze for comparison.

Aerial Study of Coral Reefs in Vietnamese Waters

Researcher: Professor Douglas W. Edsall

This is a continuation of a project the researcher initiated while serving as Associate Director for Ocean and Atmospheric Science in the Tokyo Field Office of the Office of Naval Research. He is now working with Clive Wilkinson (Coordinator Global Coral Reef Monitoring Network), Al Strong (NOAA/NESDIS), Dr. Sydney Thurston (NOAA) Dr. John Brock (USGS), Dr. Vo Si Tuan (Vietnam), Barbara Best (USAID) and others to obtain dedicated funding for such a study.

Refinement of Global Planetary Magnetosphere Models of Saturn

Researcher: Professor Irene M. Engle

The objective of this research 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.

Mr. Jeremy Bruch (Trident Scholar, USNA Class of 1999) solved the problem of incorporating a modified magnetotail model into two of the incident solar-wind direction versions of the Saturnian magnetosphere model during his 1998-1999 Trident Scholar year. Engle has expanded upon that initial work to having a full range of models for the total range of possible incident solar wind directions. A crucial 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. Much progress has been made. Consultation with the Cassini mission experimenters (Michel Blanc and others) regarding the incorporation of these results into the working model for the encounter has continued. In a separate but parallel effort, two others (Tom Armstrong and Jerry Manweiler) are incorporating the results of the magnetospheric modeling into software that also integrates the Cassini trajectory data for use by the low-energy-charged particle data analysis team.

Global Planetary Magnetosphere Boundary Representations

Researcher: Professor Irene M. Engle

An ongoing difficulty associated with making sophisticated magnetospheric models optimally useful in applications is adequately specifying the region of applicability. A well-developed mathematical model essentially constructs its own domain if a sufficient number of magnetic field lines that are "footed" on the planet surface are traced. None of the lines will go beyond what is known as the magnetopause, the boundary to the local magnetosphere. Unfortunately, in general, a mathematical model will also readily permit the tracing of field lines that start at points outside the model, but these lines, and the magnitudes and directions of the magnetic fields at locations along them are entirely irrelevant. When a position $r(\theta,\phi)$ or, alternatively (x,y,z) is specified, it is helpful to know whether that spatial location is inside or outside the magnetopause boundary. The goal is to be able to specify an $R(\theta,\phi)$ representing the maximum distance r from the planet center along a particular spatial direction (θ,ϕ). The original calculation of the magnetopause is generally done via an angular grid and the shapes, especially where magnetotails are incorporated, are not at all simple (e.g. $R = R_0$ would represent a sphere). Although the near-planet magnetosphere can be in some cases considered to be a misshapen sphere with dimples on the side facing the solar wind, the extended magnetotail on the side away from the solar wind is more closely approximated by an elliptical cone that expands as one is further away from the planet. Sufficiently accurately representing the boundaries is an ongoing challenge for the magnetospheric models of Mercury, Jupiter, and Saturn.

Mr. Robert Carnell (Trident Scholar, USNA Class of 1998) is joining the effort in conjunction with Mr. Jacob Scott (USNA Class of 1998) to effect a concise description of the extensive boundary so carefully mapped out by Scott and Engle.

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

Researchers: Associate Professor John P. Ertel and Joseph W. Dickey,
Material Science and Engineering Department, The Johns Hopkins University

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 Joseph W. Dickey,
Material Science and Engineering Department, The Johns Hopkins University

Our latest work looks to improve user interaction with acoustical sensing by acoustical analog of false-color imagery. The process has been named "auralization" (by analogy to "visualization") and seeks to allow the trained listener to detect small soft tissue masses by heterodyning the ultrasonic signal down to the human audible range.

Student Experiments During a 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. This past year, the equipment for eclipse meteorology experiments to use a Vernier LabPro interface (instead of the older Texas Instruments Calculator Based laboratory interface) was updated. The LabPro has four analog inputs whereas the CBL had only three. The interface is driven using a Palm handheld computer instead of a TI-92 Plus calculator. The Palm can hold more data, and is smaller and lighter than the TI-92. This new system was tested at the annular eclipse of 10 June 2002 in Puerto Vallarta, Mexico and at the total eclipse of 23 November 2003 in Antarctica. The instruments all performed satisfactorily in Puerto Vallarta, however, it rained during the eclipse. In Antarctica, the Palm Pilot failed catastrophically for reasons not yet understood.

The Transit of Venus on 8 June 2004

Researcher: Associate Professor James R. Huddle

On 8 June 2004, Venus transited the sun for the first time since 6 December 1882. Only five transits of Venus have been observed since Kepler discovered in 1631 that the phenomenon was possible. Although transits of Venus are exceedingly rare, they have a rich history and played important roles in the determination of the size of the solar system and in the history of international cooperation in science. The purpose of this work was to recreate an experiment proposed in 1716 by Edmond Halley. That experiment used measurements during a transit of Venus to measure the astronomical unit, or au. Halley's method suffered from the Black Drop effect, which was unknown at that time, and was only explained in the 21st century. This research provided a way to modify Halley's method to avoid problems caused by the Black Drop effect and this modification was tested in June 2004.

Physical Proprieties of Near-Earth Objects: Optical and Infrared Astronomical Observations

Researchers: Ensign Luke R. Dundon, USNR, Associate Professor Debora M. Katz
and Dr. Jeffery A. Larsen, University of Arizona

The majority of asteroids and comets are far from Earth. A few, known as near-Earth objects (NEOs), are on orbits that bring them close to the planet. Their close proximity permits more detailed observations, yet it also makes them a threat to the biosphere. Despite their relevance, the physical properties of these objects have not been widely studied.

The goal of this ongoing project is to measure the infrared and optical light curves (magnitude versus time plots) for a number of NEOs. We have had success making these unprecedented observations, with the results providing important clues into the rotational motion and composition of these objects.

Effect of Stress on the Shape of Ferromagnetic Hysteresis Loops

Researcher: Professor Carl S. Schneider

Experimentally determined stress fields, symmetric and antisymmetric in magnetization, have been shown to be the Brown and Bozorth fields, respectively, identified theoretically in a recent publication. Data revealed a magnetization form factor showing nucleation and annihilation of domain walls and a stress form factor showing domain structure changes with stress. The stress form factor was approximated as an exponential representing reduction of domain degrees of freedom as stress increases. These factors enabled prediction and experimental verification of the coercive field, remanence and maximum susceptibility dependence on stress through thermodynamic magnetostrictive energy density.

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

Researchers: Commander Edward J. Tucholski, USN,
and Robert J. Green, Jr., Materials Science and Engineering Department, The Johns Hopkins University

Polymeric and ceramic foams and composites are bonded to metallic structures in spacecraft 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 were evaluated to determine their viability to accomplish this task. The most promising methods are being studied further, to optimize their performance at detecting the smallest possible disbonds.

Trident Scholar Projects

Measuring Gravitational Waves: A Sensitivity Analysis of the LISA Gravitational Wave Detector (Trident Report # 318)

Researcher: Midshipman 1/C Drew R. Barker, USN
Advisers: Professor Lawrence L. Tankersley
and Visiting Professor Richard P. Fahey (USNA Aerospace Engineering Department)
Sponsor: Office of Naval Research (ONR)

Modern theories of gravity predict ripples in space and time, which are known as gravitational waves. Very large interacting masses, such as binary systems of neutron stars or black holes are predicted to generate gravitational waves that may be intense enough to be detected. This study presents a response analysis for the proposed gravitational wave experiment known as the Laser Interferometer Space Antenna (LISA). The analysis focuses on the gravitational wave distortion patterns, or polarizations, predicted by the Brans-Dicke Scalar-Tensor Theory of Gravity (BD). Several plausible metric theories of gravity, such as BD, predict gravitational wave polarizations that differ from the traditionally expected polarizations predicted by General Relativity (GR). LISA, a cooperative venture between the National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA), is a proposed space-based gravitational wave experiment with the potential to distinguish between polarizations of gravitational waves. LISA is scheduled for launch in 2012, so much of the current work for LISA involves the design and construction of systems that will allow LISA to attain its projected performance.

For a gravitational wave experiment, the projected sensitivity is determined by using a transfer function, referred to as an instrument response function, which relates the disturbance generated by the gravitational wave to the disturbance measured by the instrument. This study compared the response functions for BD polarizations to the published response functions of GR. NASA researchers have determined that several different data collection methods will result in different instrument response functions. Furthermore, a response function for any particular method of data collection will depend upon the polarization, frequency, and incident direction of the gravitational wave.

For this study, MATLAB® was used to produce two programs to numerically evaluate and compare response functions with respect to four different data collection methods. The first program computes the response functions for each

polarization and data collection method by averaging over all incident source directions. The second program calculates the instrument response at each point in LISA's orbit to gravitational waves originating from the galactic center. From the results obtained via the two MATLAB® programs, the optimal data collection method required to detect a gravitational wave of a given polarization, frequency, and source direction, was identified.

Complex Impedance Studies of Electrosprayed and Extruded Nafion Membranes (Trident Report # 324)

Researcher: Midshipman 1/C Joshua M. Mueller, USN
Adviser: Associate Professor Charles A. Edmondson
Sponsor: Office of Naval Research (ONR)

Fuel cells, and other alternate forms of power and power generation have recently become a focal point of increased technological interest. One promising type of fuel cell is based on the Proton Exchange Membrane (PEM). Nafion is one of the current benchmark membranes being used in these fuel cells. The aim of this study was to conduct fundamental scientific research into the proton transport properties of Nafion polymer membranes produced using various deposition techniques. The main focus was a comparison between electrosprayed and traditional extruded films. In addition, a study of the orientation effects in extruded Nafion membranes was conducted. Although the deposition technique of electrospraying has been used for nearly a century, it has only recently been applied to PEM fuel cell membranes. In this application, the method of deposition is designed to reduce the fabrication costs of fuel cells.

Various tests were performed on samples of the two different techniques including measurements of conductivity, swelling effects, and activation volumes in relation to changing environmental pressures and relative humidities. Conductivity is a measurement of the ease of passing charge carriers, while activation volume is a method of determining proton transport mechanisms. Activation volumes in certain regimes are indicative of either polymer side chain deformation, grotthus transport, or vehicular transport of protons. The orientation studies in low water content extruded Nafion showed an approximate difference of two orders of magnitude in conductivity when comparing cross-plane measurements to the traditionally studied in-plane measurements. Studies found no significant difference in the bulk conductivities for the two deposition techniques. No significant difference for the activation volumes were found between the electrosprayed and extruded membranes. Electrosprayed Nafion was found to have greatly increased water absorption at high relative humidities in comparison to the traditional extruded samples, however the bulk conductivities remained comparable. These results indicate that electrospraying is an effective and efficient means of depositing PEM fuel cell membranes that may lead to mass production of fuel cells.

Optical Limiting in Single Mode Waveguide Systems (Trident Report # 326)

Researcher: Midshipman 1/C Jeffrey C. Payne, USN
Adviser: Assistant Professor James J. Butler
Sponsor: Office of Naval Research (ONR)

The objective of this project was to study the optical properties of single mode waveguide systems that exhibit an absorption that increases with the intensity of the light incident upon them. These devices limit the transmission of optical energy and are referred to as "optical limiters". Such systems are of great value to both the military and the telecommunications industry because of their ability to protect sensitive equipment from exposure to high intensity light.

Experiments were performed using very small glass capillaries filled with materials that exhibit a nonlinear absorption. In this case, the materials absorb a greater amount of light as the intensity increases. These systems act as waveguides, confining the light to a small "core" region where the nonlinear material resides. Furthermore, only one intensity distribution (or "mode") is allowed if the index of refraction of the core is very close to that of the surrounding glass. In this case, the waveguide is called "single mode". Single mode behavior was achieved by controlling the temperature of the waveguide in order to tune the index of refraction of the core material. Pulses of visible light (wavelength = 532 nm, pulse width = 4ns) were coupled into single mode waveguides and the input and output intensities were measured. These results were compared to optical limiting observed in multi-mode waveguides.

Midshipman Research Course Projects

Analysis of the Conductivity of Li-BETI

Researcher: Midshipman 1/C Kevin R. Booher, USN
Adviser: Professor John J. Fontanella

High-pressure conductivity measurements have been carried out on $P(EO)_{20}$LiBETI from about 293.1 K to 383.1 K. For $P(EO)_{20}$LiBETI the decrease of electrical conductivity with pressure was found to be larger in the crystalline phase (low temperature or high temperature and high pressure) than in the fully amorphous phase (high temperature and low pressure). It was found that if the phase transition is approached from the crystalline phase (decreasing pressure), the temperature of the phase transition varies from about 336.1 K to about 358.1 K as pressure increases from 10^{-4} GPa (1 bar) to about 0.23 GPa. If the material was above 338.1 K and in the fully amorphous phase, the material initially super-presses (*i.e.,* remains in the amorphous phase) for extended periods of time after the pressure was increased. When the material was in the super-pressed state, further increases in pressure initiated crystallization.

Investigating Nonlinearity in Acoustic Landmine Experiments using a Clamped-Plate Soil Oscillator Resonator: Tuning Curves and Two-Tone Tests

Researcher: Midshipman 1/C Dang V. Duong, USN
Adviser: Professor Murray S. Korman
Sponsor: Bowman Scholar Program (BSP)

Nonlinear effects were investigated in the detection of plastic landmines using acoustic-to-seismic coupling techniques. The soil-plate oscillator is a laboratory apparatus that represents a good physical model for an inert anti-tank plastic landmine. 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. Using a loudspeaker, tuning curve experiments were performed showing a linear decrease in peak frequency *vs* increasing amplitude of the soil surface acceleration. A two-tone test experiment was performed using frequencies closely spaced near resonance ~ 100 Hz. Combination frequency component profiles were measured across the surface. A double peaked profile occurred at $2f_1+f_2$ corresponding to a common timpani mode.

Electrical Properties of Polymer-Coated Aerogels

Researcher: Midshipman 1/C Michael C. Graham, USN
Adviser: Professor John J. Fontanella
Sponsor: Bowman Scholar Program (BSP)

Audio frequency complex impedance measurements from about 0.01 Hz to 106 Hz were carried out on the model aerogel systems, silica and Nafion-coated silica, at various relative humidities. The electrical response of the silica aerogel consisted of at least two impedance arcs and these depended on the pore size of the aerogel. The electrical response of the Nafion-coated silica aerogel consisted of two different impedance arcs. A model for each of the systems was proposed.

Experimental Uses of a Clover Detector

Researcher: Midshipman 1/C Christopher S. Hathaway, USN
Adviser: Assistant Professor Daryl J. Hartley

The Physics Department at the Naval Academy recently purchased a Clover Detector for the detection of gamma rays, which then needed to be integrated with an existing data acquisition system. The Clover Detector is composed of four segmented germanium crystals enclosed in the same cryostat. Germanium is used as it has extremely good energy resolution for gamma-ray detection; however it is not very efficient for detecting gamma rays with energies exceeding about 1 MeV. This is due to the fact that these high-energy gamma rays Compton scatter from electrons in the germanium atoms and do not deposit their full energy into the detector. By encasing four crystals in the same cryostat, the Compton scattered gamma ray can often be detected by the neighboring crystal. The energies deposited in the two crystals can be added together to record the correct energy of the radiation.

This research effort involved a study of the detector, with an emphasis on its operation and electronics. The investigation also focused on the coding necessary to achieve the desired addition of energies from the crystals. As a result of this work, a very nice data acquisition system for use with the Clover Detector now exists. This system was used to test whether the efficiency of the Academy's Clover Detector was similar to that of other such detectors. The analysis showed a significant improvement in efficiency when the addition of energies was used, and a system efficiency that was nearly identical to results obtained elsewhere.

Computer Analysis of Quantum Wells under Realistic Stress Conditions

Researcher: Midshipman 1/C Kelsey C. Peterson, III, USN
Adviser: Associate Professor Mark L. Biermann

Quantum wells are crucial in the design and development of semiconductor devices, including lasers and modulators. The presence of strain resulting from the packaging of a quantum-well laser onto a heat sink degrades the performance and lifetime of the laser. It is therefore advantageous to minimize the packaging-induced strain in the laser. However, one must first be able to quantify the strain configuration in the laser before one can test the efficacy of an approach implemented to minimize packaging-induced strain. Packaging-induced strain leads to complicated strain configurations in quantum wells and an understanding of these subtle conditions is only now being achieved. Recent work has shown that it is possible to obtain quantitative data regarding the strain configuration in quantum wells by optical measurements.

This project focused on the relationship between packaging-induced strain and the shifts in interband transition energies due to strain. In this project, a computer model was used to determine interband energy shifts as a function of packaging-induced strain, and intrinsic, lattice-mismatch-induced strain. By studying scenarios with different intrinsic strains, how this parameter affected quantum wells used in high-power lasers was discussed. Experimental results have been compared to the theoretical results achieved by the computer model, and the theoretical model fits the experimental data well. It was determined that the computer model provided a vital link in the optically based approach to quantifying the strain configuration in the devices of interest. Limits of validity for a simple, optical approach to quantifying the strain were also established.

Modeling the Orbits of Near-Earth Asteroids

Researcher: Midshipman 1/C Cassidi A. Reese, USN
Advisers: Associate Professor Debora M. Katz and Assistant Professor Kevin L. McIlhany

There are an estimated 2000 near earth asteroids (NEAs) whose potential collisions would have devastating consequences for planet Earth. Astronomers have calculated reliable orbits for approximately 600 of these NEAs. When faced with the limits of weather, sky conditions, and observing time, it is quite obvious that a faster method is needed to determine the orbits of these objects. In theory, a neural network that has been properly trained would need only five data points to accurately predict an asteroid's orbit. Such a network would significantly reduce the amount of observation time needed to construct an orbit for a single asteroid. Thus, more orbits could be effectively modeled in a shorter amount of time. This may potentially lead to a quicker identification of "planet-killer" NEAs.

Using MATLAB software, a data set that models the orbits of NEAs was developed. This data set has been used to train a neural network to learn the elliptical shape and predict accurate orbit paths using minimal input. However, the error in the network remains quite large, and, as of yet, the network does not reliably model NEA orbits.

Neural Network Analysis of Experiments in Nonlinear Acoustic Landmine Detection

Researcher: Midshipman 1/C Cassidi A. Reese, USN
Advisers: Professor Murray S. Korman and Assistant Professor Kevin L. McIlhany

The detection of buried plastic landmines is a difficult but necessary task. Several research groups have shown that the nonlinear seismic/acoustic method is among the most promising means of detecting buried plastic landmines, but the data gathered from this test can be difficult to analyze. A neural network can aid in analysis by recognizing the characteristic signature of a buried plastic landmine and signal the presence of a mine.

This project was a synthesis of two distinct areas: nonlinear acoustics and neural computation. It involved laboratory measurements with a nonlinear seismic/acoustic test in which dry sifted mason sand over a buried mine simulant was excited by airborne sound from separate loudspeakers. The primary frequencies were chosen to be $f_1 = f_{res} - 5$ Hz and $f_2 = f_{res} + 5$ Hz where the resonant frequency f_{res} was typically on the order of 100 Hz depending on burial depth. All tests were performed in a concrete soil box located in an anechoic chamber. Using a spectrum analyzer and a small accelerometer the soil surface acceleration profile was obtained at the nonlinearly generated $f_+=f_1+f_2$ sum frequency. Next, the structure and training of the neural network used to analyze the data was investigated. The results obtained with the network revealed that the thin top plate of the simulant was vibrating in a common mode shape of a timpani drum, where the left half and right half were 180 degrees out of phase and there was a node along the middle.

Publications

Journal (Refereed) Manuscripts

BENDLER, J. T., Associate Professor, FONTANELLA, John J., Professor, Shlesinger, M. F., and WINTERSGILL, M. C., Professor, "The Need to Reconsider Traditional Free Volume Theory for Polymer Electrolytes," *Electrochimica Acta*, 48, pp. 2267-2272 (2003).

Pressure-temperature-volume (PVT) data have been obtained for poly(propylene glycol) of molecular weight 1025 containing $LiCF_3SO_3$ in the mole ratio 20:1. The PVT data were used to calculate the specific volumes, $V/V_{P=0,T=296K}$, associated with the pressures and temperatures for previously published variable temperature, high-pressure electrical conductivity data. It is found that the electrical conductivity depends strongly on temperature at a constant volume. Consequently, traditional free volume theory is not consistent with the data. Finally, it is shown that the features of the electrical conductivity data can be accounted for by a recently developed generalized Vogel theory.

BENDLER, John T., Associate Professor, FONTANELLA, John J., Professor, and Shlesinger, M. F., "Sources of Exponents," *Physica D*, 193, pp. 67-72 (2004).

Examples are given of scaling relationships governed by fractional exponents. Additional examples are presented with heavy tail probability distributions governed by a fractional exponent. This includes the analysis of the Boltzmann-Gibbs entropy, subject to an appropriate constraint, to generate long-tailed probability distributions. The stretched exponential distribution is employed to derive a time scale for the glass transition that contains an essential singularity at a critical temperature. These examples demonstrate that there are many routes to producing fractional exponents in physical systems.

BUTLER, James J., Assistant Professor, WATHEN, Jeremiah J., Ensign, USN, Flom, S. R., Pong, R. G. S., and Shirk, J. S., "Optical Limiting Properties of Nonlinear Multimode Waveguides," *Optics Letters*, 28, pp. 1689-1691 (2003).

An experimental investigation of the transmission of multimode capillary waveguides with a nonlinear absorber in the core shows an enhanced nonlinear absorption relative to the same length of bulk material. The results are consistent with partial mode filling within the cores of the waveguides. This study confirms the promising optical limiting capabilities of multimode nonlinear waveguides and implies that the mode structure should be considered in the design and evaluation of capillary array optical limiters.

Danchev, M., Balabanski, D. L., Yigitoglu, I., Akkus, B., Beausang, C. W., Bostan, M., Casten, R. F., Djongolov, M. K., Erduran, M. N., Erturk, S., Gladnishki, K. A., Gurdal, G., Goon, J. T. M., HARTLEY, Daryl J., Assistant Professor, Hecht, A. A., Krucken, R., Novak J. R., Oktem, Y., Rainovski, G., Riedinger, L. L., Zamfir, N. V., and Zeidan, O., "Delayed Backbending in the $\pi h_{9/2}$ Band of ^{187}Ir," *Physical Review C*, 68, 054307 (2003).

High-spin states of ^{187}Ir have been populated in the ^{176}Yb(^{15}N,4n) reaction and measured with the YRAST Ball spectrometer. The $\pi h_{9/2}$ rotational band has been extended beyond the first alignment crossing, which was found at rotational frequency $\hbar\omega_c \approx 0.39$ MeV . Two different scenarios for describing this crossing are considered: the

alignment of an $h_{9/2}$ proton or $i_{13/2}$ neutron pair and it is concluded that a proton band crossing is more likely. A systematic study of the rotational alignment crossings in the $\pi h_{9/2}$ bands in the N = 104,106,108 isotopes of $_{73}$Ta, $_{75}$Re, $_{77}$Ir, and $_{79}$Au is presented.

Filipova, Tsvetanka, Boyles, David A., BENDLER, John T., Associate Professor, Medalen, Marci, and Longbrake, Guy, "New Polyarylate and Polyarylate-co-polycarbonate Thermoplastics Incorporating a High-Aspect Ratio Tetraarylbisphenol," *Polymer Preprints*, 45(1), pp. 756-757 (2004).

Polyesters derived from bisphenol A (BPA) and aromatic acid chlorides possess a potentially valuable set of properties including: high heat resistance and thermal stability; toughness, effective insulating properties over a wide temperature range, resistance to the action of many chemical agents as well as to UV light and ionizing radiation. Polyestercarbonates (PE-PCs) made from BPA, isophthaloyl chloride (IC), terephthaloly chloride (TC) and phosgene likewise offer a combination of properties not found in other materials. PE-PCs have engineering uses in high-end automotive reflectors, medical instruments that require steam sterilization, and applications requiring high heat distortion temperatures, toughness at extreme temperatures, clarity, heat resistance, and flame retardancy performance. The incorporation of aromatic ester functionality increases glass transition temperatures (T_g) without significantly decreasing impact toughness or optical clarity. This paper outlines the synthesis and characterization of a new class of PE-PCs with improved heat resistance.

Gerhardt, Axel, Weik, Fritz, QuocTran, Tien, Tomm, Jens W., Elsaesser, Thomas, Biesenbach, Jens, Müntz, Holger, Seibold, Gabriele, BIERMANN, Mark L., Associate Professor, Behriger, Martin, and Luft, Johann, "Device Deformation During Low-frequency Pulsed Operation of High-power Diode Bars," *Applied Physics Letters*, 84 pp. 3525-3527 (2004).

Thermal tuning rates of single emitters in 'cm-bar' high-power diode laser arrays are analyzed. We find these tuning rates to consist of purely thermal and mechanical pressure contributions, of -0.48 and -0.08 $meV(K)^{-1}$, respectively. We estimate the mechanical deformation such a device experiences during pulsed operation to be 0.07%, and then externally apply this load to single segments of 'cm-bars'. These single segments model the central emitters within the array. Effects that arise due to gradual aging, such as non-equilibrium carrier lifetime decrease, sheet concentration increase, and defect concentration rise are monitored and analyzed over up to 2×10^6 deformation cycles. These experiments provide the basis for a novel type of accelerated aging experiment for device testing, especially of devices designed for low-frequency pulsed operation.

Hao, Jiangtao, Boyles, David A., and BENDLER, John T., Associate Professor, "New Synthesis of 4'-[1-Methyl-1-(4'-Hydroxybiphenyl-4-yl)Ethyl]Biphenyl-4-ol Via Nickel-Catalyzed Suzuki Cross-Coupling of Aryl Tosylate with an Organoboron Reagent," *Polymer Preprints*, 44(2), pp. 402-403 (2003).

Bisphenol A (BPA) is one of the most widely used polymer building blocks due to its outstanding properties and moderate cost. of 4'-[1-Methyl-1-(4'-Hydroxybiphenyl-4-yl)Ethyl]Biphenyl-4-ol is a particularly interesting polymer monomer based on BPA since the polycarbonate from this monomer may combine a unique combination of liquid crystallinity, with improved high-temperature stability and good ductility, desirable properties which have never been commercially achieved. Bendler reported the first synthesis and polymerization of the polycarbonate therefrom. Here we report two new efficient, low-cost synthetic routes to this molecule.

Hao, Jiangtao, Boyles, David A., and BENDLER, John T., Associate Professor, "Synthesis and Characterization of Novel Polycarbonates Containing p-Biphenyl Moieties," *Polymer Preprints*, 44(2), pp. 421 – 422 (2003).

Bisphenol A (BPA) polycarbonates possess a unique combination of high impact and optical transparency, which makes it a resin of choice in many engineering, electronic, household and military applications. After 50 years of R&D efforts, no polymer has yet been found to match its performance and ease of processing. We report synthesis of 12 new polycarbonates and co-polycarbonates incorporating the p-biphenol unit, which has the potential to improve heat resistance and impact strength.

Hecht, A. A., Beausang, C. W., Amro, H., Barton, C. J., Berant, Z., Caprio, M. A., Casten, R. F., Cooper, J. R., HARTLEY, Daryl J., Assistant Professor, Krucken, R., Meyer, D. A., Newman, H., Novak, J. R., Pietralla, N., Ressler, J. J., Wolf, A., Zamfir, N. V., Zhang, J.-Y., and Zyromski, K. E., "Evidence for Chiral Symmetry Breaking in ^{140}Eu?" *Physical Review C*, 68, 054310 (2003).

High spin states in ^{140}Eu were populated following the reaction ^{92}Mo(^{51}V,2pn) at a beam energy of 205 MeV by the ESTU accelerator at the Wright Nuclear Structure Laboratory, Yale University. A total of 5 bands and 69 transitions were assigned to ^{140}Eu. The assignments were based on Kα x-ray coincidences and on excitation function measurements. γ-γ and γ-γ-γ coincidence matrices were created. Directional correlation of oriented states analysis, angular distributions, and Compton asymmetry measurements were performed and B(M1)/B(E2) branching ratios were extracted. The band assignments and structures are discussed in terms of the rotational model and interpreted following a series of cranked shell model and total Routhian surface calculations. In particular, two pairs of bands, one pair based on the $\pi h_{11/2} \otimes \upsilon h_{11/2}$ configuration, the other based on the $\pi(g_{7/2},d_{5/2}) \otimes \upsilon\, h_{11/2}$ configuration, are identified. These bands show some features expected of either chiral partners or shape coexistence, based on triaxial shapes with $\gamma \sim \pm 25°$. Further measurements are required to distinguish between these two possibilities.

HOLMES, M. J., 2nd LT, USMC, and MUNGAN, Carl E., Assistant Professor, "Photobleaching of Cresyl Violet in Poly(Methyl Methacrylate)," *Journal of Young Investigators*, Vol. 10, No. 5, May 2004. (published on the web at http://www.jyi.org/volumes/volume10/issue5/articles/holmes.html)

This study investigates the rapidity with which an optical dye in a solid plastic host irreversibly degrades when it is brightly illuminated by visible light. Specifically, the organic dye cresyl violet perchlorate dispersed in plexiglas was optically excited by a continuous-wave dye laser pumped by an argon-ion laser. After resonantly absorbing and emitting many times, an individual dye molecule photochemically bleaches. The decay of the overall fluorescence signal was measured and fit to a theoretical model describing the time dependence of the bleaching in terms of a quantum efficiency for photooxidation. Under ambient conditions, it takes a few million excitation-relaxation cycles to bleach a dye molecule at incident intensities on the order of 10^2 W/cm^2. This permanently destroys the dye, thereby limiting applications of such organic materials under exposure to high optical intensities, in laser sensors or fibers for example.

LEE, Jr., Raymond L., Adjunct Assistant Professor, and J. Hernandez-Andres, "Virtual Tunnels and Green Glass: The Colors of Common Mirrors," *American Journal of Physics*, 72, pp. 53-59 (2004).

When a pair of common second-surface plane mirrors face each other, repeated mirror-to-mirror reflections form a virtual optical "tunnel" with some unusual properties. One property readily analyzed in a student laboratory experiment is that objects' colors steadily grow darker and greener the deeper we look into the mirror tunnel. This simple observation is both visually compelling and physically instructive: measuring and modeling a tunnel's colors requires students to blend colorimetry and spectrophotometry with a knowledge of how complex refractive indices and the Fresnel equations predict reflectance spectra of composite materials.

McILHANY, Kevin L., Assistant Professor (co-author), "Measurements Of Electron Proton Elastic Cross-Sections For $0.4 < Q^2 < 5.5$ (GeV/c)^2," *Physical Review C*, (published on the web at: http://arxiv.org/abs/nucl-ex/0401030, e-print archive: nucl-ex/0401030)

We report on precision measurements of the elastic cross section for electron-proton scattering performed in Hall C at Jefferson Lab. The measurements were made at 28 unique kinematic settings covering a range in momentum transfer of $0.4<Q^2<5.5$(GeV/c)^2. These measurements represent a significant contribution to the world's cross section data set in the Q^2 range where a large discrepancy currently exists between the ratio of electric to magnetic proton form factors extracted from previous cross section measurements and that recently measured via polarization transfer in Hall A at Jefferson Lab.

McILHANY, Kevin L., Assistant Professor (co-author), "Search For $\pi^0 \rightarrow (\nu_\mu$ anti$-\nu_\mu)$ Decay in LSND," *Physical Review Letters,* 92 (2004) 091801, (published on the web at: http://arxiv.org/abs/hep-ex/0310060, e-print archive hep-ex/0310060)

We observe a net beam-excess of 8.7 +/- 6.3 (stat) +/- 2.4 (syst) events, above 160 MeV, resulting from the charged-current reaction of ν_μ and/or anti-ν_μ on C and H in the LSND detector. No beam related muon background is expected in this energy regime. Within an analysis framework of π^0->(ν_μ anti-ν_μ), we set a direct upper limit for this branching ratio of $\Gamma(\pi^0\text{->}(\nu_\mu \text{ anti-}\nu_\mu))/\Gamma(\pi^0\text{->all})<1.6\times10^{-6}$ at 90% confidence level.

MUNGAN, Carl E., Assistant Professor, "Reprise of a 'Dense and Tense Story'," *The Physics Teacher*, 42, pp. 292-294 (2004).

Suppose two uniform cubes have an average density equal to that of an incompressible fluid filling a beaker. The two cubes are glued together and fully immersed in the fluid with the lighter cube positioned above the heavier one, so that they are neutrally buoyant in the fluid. Under what conditions will the cubes break apart?

MUNGAN, Carl E., Assistant Professor, "Irreversible Adiabatic Compression of an Ideal Gas," *The Physics Teacher*, 41, pp. 450-453 (2003).

Suppose a frictionless, massive piston partitions a box vertically into two parts. The upper compartment is evacuated, while the lower contains an equilibrated ideal gas. A weight is suddenly placed on the piston. How much is the gas compressed when equilibrium is again restored, neglecting the heat capacity of the cylinder and piston?

Park, H. I., HARTLEY, Daryl J., Assistant Professor, Riedinger, L. L., Reviol, W., Zeidan, O., Zhang, J.-Y., Galindo-Uribarri, A., Janssens, R. V. F., Carpenter, M. P., Seweryniak, D., Sarantites, D. G., Devlin, M., Dong, B. G., and Ragnarsson, I., "Rotational Structures Near $40\hbar$ in ^{123}La," *Physical Review C*, 68, 044323 (2003).

The neutron-deficient nucleus ^{123}La was studied via the ^{92}Mo(^{40}Ca,2αp) reaction at a beam energy of 184 MeV . Previously known bands were extended to a much higher spin, and in two cases the structures are now observed near $40\hbar$. In addition, three new sequences were identified and linked into previously known bands. The lowest $(\pi,\alpha) = (+,-1/2)$ structure displays characteristics similar to those of analogous bands in ^{127,129}La, which have been proposed as examples of smooth band termination. Cranked Nilsson-Strutinsky calculations were compared with the experimental data in ^{123}La to determine whether this band is approaching a terminating state as well.

Roland, C. M., Schroeder, M. J., FONTANELLA, John J., Professor, and Ngai, K. L., "Evolution of the Dynamics in 1,4-Polyisoprene from a Nearly Constant Loss to a Johari-Goldstein β-relaxation to the α-relaxation," *Macromolecules*, 37, pp. 2630-2635 (2004).

The Johari-Goldstein (JG) secondary relaxation, presumed to be universal, has never been found in 1,4 poly(isoprene) (PI) by dielectric spectroscopy, despite very many measurements extending over the past half-century. By using a high-resolution capacitance bridge, we are able to show the existence of a secondary relaxation in PI that has the properties of the JG process. Measurements were also carried out at lower temperatures, which probe the dynamics of chain units "caged" by neighboring segments comprising the local structure. The caged dynamics precede by decades of time the JG relaxation and, for general physical principles, are also expected to be a property of all glass-forming materials. Collectively, the caged dynamics and the JG relaxation serve as precursors to structural relaxation (i.e., the glass transition) and thus are of central importance to understanding vitrification. The present data show that the dynamics of caged PI repeat units are manifested as a nearly constant loss (NCL). This NCL has been found in other glass-formers, both molecular and polymeric, and its temperature dependence in PI is similar to that for other materials. The experimental results are consistent with the predictions from the coupling model.

Sanders, H., McGrady, K. A., Wnek, G. E., EDMONDSON, Charles A., Associate Professor, MUELLER, Joshua M., Midshipman 1/C, USN, WINTERSGILL, Mary C., Professor, FONTANELLA, John J., Professor, Gustave, S., and Greenbaum, Steven G., "Characterization of Electrosprayed Nafion films," *Journal of Power Sources*, 129, pp. 5561 (2004).

Nafion has long served as a benchmark material when evaluating the performance of proton conducting membranes used in PEM fuel cells. Traditionally, the membranes are either extruded from dry polymer or cast from a liquid polymer solvent solution. Recently, a different technique for fabricating membranes has been developed. The new approach exploits electrostatic spraying, or electrospraying, to deposit PEM films, with the longer-term goal of fabricating membrane-electrode assemblies using this technique. The focus of this paper is to compare the proton transport and physical properties of electrosprayed membranes with those of extruded Nafion. Audio frequency complex impedance studies of the electrosprayed membranes were conducted at a variety of temperatures and pressures over a wide range of membrane water contents. The results are compared with similar data for Nafion 117 and for membranes cast from the electrosprayed solutions. Water uptake, dimensional changes, and electrical conductivity measurements indicate that extruded, cast, and electrosprayed Nafion films are similar, with the exception that the electrosprayed Nafion absorbs as much as 15 wt-% water more that the other two membranes with only a slight increase in conductivity. The activation volumes for electrosprayed Nafion are also consistent with those for Nafion 117 and concur with proposed mechanisms for proton transport in Nafion membranes. As in Nafion 117, a dielectric loss peak appeared in the electrosprayed Nafion at low temperatures after heating in vacuum at 380K, further demonstrating the similarity between the two materials.

SCHNEIDER, Carl S., Professor, "Anisotropic Cooperative Theory of Coaxial Ferromagnetoelasticity," *Physica B*, 343, pp. 65-74 (2004).

The recently published anisotropic cooperative domain field model of ferromagnetic hysteresis has been extended first to a differential form valid for the virgin curve and all reversals, and second to a reversible and irreversible theory of coaxial stress on ferromagnets, called ferromagnetoelasticity. Using directional magnetization and field and stress, magnetostriction and susceptibility, physical and normalized equations are derived from magnetoelastic thermodynamics for Brown's and Bozorth's stress fields on 90˚ walls between [100] domains, causing a stress bifurcation and the Villari reversal. Single valued equations for magnetization changes in $H\sigma$ and $H\sigma\sim$ processes and susceptibility and anisotropy changes in σH and $\sigma\sigma H$ processes are derived in quantitative agreement with experimental data including nonlinear stress loops up to residual stress and saturate magnetization. The primarily linear magnetization dependence of cooperation and magnetostriction derivative cause magnetization changes with stress to be self proportionate with an asymmetry between tension and compression and coherence between Brown and Bozorth fields.

SMALLWOOD, Lee M., Ensign, USN, KATZ, Debora. M., Associate Professor, and Richmond, Michael. W., "Near Earth Objects: A Brief Review and a Student Project," *American Journal of Physics*, 72, pp. 264-271 (2004).

We provide a general overview of asteroids that pass close to the Earth: Near Earth Objects (NEOs). NEOs provide information on the formation of the solar system, and may have played an important role in the history of life on Earth. They are easy targets for future space missions. We also describe how to measure the distance to an NEO: an observational exercise for undergraduates which is pedagogically rich, exciting, and requires only modest equipment. We use our own recent data to compute the distances to two objects: 2002 NY40 and 2002 HK12.

Stievater, T. H., Rabinovich, W. S., Boos, J. B., Katzer, D. S., and BIERMANN, Mark L., Associate Professor, "Laterally Patterned Band Structure in Micromachined Semiconductors," *Applied Physics Letters*, 83, pp. 4933-4935 (2003).

We demonstrate that micromachining lattice-matched InGasAs quantum wells grown on (001) InP with strained barriers produces precise laterally patterned modifications to the semiconductor band structure. The light hole and heavy hole excitonic transitions are mixed and differentially shifted by the micromachining, producing a large surface-normal optical anisotropy. The measured optical properties agree with calculations based on finite-element models of the strain combined with an 8-band k.p model that includes deformation potentials. The technique enables novel applications ranging from polarization modulators to quasi-phase matching to new piezoelectric materials.

VANHOY, J. R., Professor, COLEMAN, R. T., Ensign, USN, Crandell, K. A., Hicks, S. F., Sklaney, B. K., Walbrun, M. M., Warr, N., Garrett, P. E., Yates, S. W., Jolie, J., Corminboeuf, F., Genilloud, L., Kern, J., and Schenker, J. L., "Structure of ^{120}Te from the ^{118}Sn(α,2ng) Reaction and ^{120}I Decay," *Physical Review C*, 68, 034315 (2003).

The level structure of ^{120}Te has been examined utilizing gamma-ray spectroscopy following the (α,2nγ) reaction and ^{120}I decay. Excitation functions, gamma-gamma coincidences, branching ratios, and multipole-mixing ratios, was obtained for many new levels below 4.5 MeV in excitation energy. The level scheme was examined from the viewpoint of an anharmonic vibrator model, the general collective model, the particle-core coupling model, and IBM-based intruder models. Particular aspects of the level sequence can be reproduced by each of these models, but the agreement with transition rate data is modest. The B(E2) transition rate ratios are most consistent with the simple U(5) pattern. The higher-spin intruder states are identified in ^{120}Te by comparison to the known band structures and decay patterns of the N=66 and N=68 tin and cadmium nuclei. The intruder signature vanishes below spin-8, where there is strong mixing between states.

Conference Proceedings

BIERMANN, Mark L., Associate Professor, DURAN, Steven, Ensign, USN, Tomm, Jens W., Gerhardt, Axel, and Lorenzen, Dirk, "Dependence on Intrinsic Strain of Packaging-induced Strain in Quantum-well Laser Diodes," *Conference on Lasers and Electro-Optics*, CLEO/IQEC and PhAST Technical Digest (CD-ROM; paper CTuP3; The Optical Society of America, Washington, DC, 2004)

Intrinsic strain within quantum wells significantly influences interband energy shifts in diode lasers. We show that despite intrinsic strain, energy shifts permit quantitative determination of packaging-induced-strain configurations in commercial devices.

KORMAN, Murray S., Professor, Alberts, W. C., II, and Sabatier, James M., "Nonlinear Acoustic Techniques for Landmine Detection: The Significance of the Top-plate Modes," in *Detection and Remediation Technologies for Mines and Minelike Targets IX*, *SPIE Proceedings* Volume 5415, (editors: R. S. Harmon, J. T. Broach, and J. H. Holloway, Jr.), accepted.

In nonlinear acoustic detection experiments involving a buried inert VS 2.2 anti-tank landmine, airborne sound at two closely spaced primary frequencies f_1 and f_2 couple into the ground and interact nonlinearly with the soil-top pressure plate interface. Scattering generates soil vibration at the surface at the combination frequencies $|mf_1 +- nf_2|$, where m and n are integers. The normal component of the particle velocity at the soil surface has been measured with a laser Doppler velocimeter (LDV) and with a geophone by Sabatier et al. [SPIE Proceedings Vol. 4742, (695-700), 2002; Vol. 5089, (paper No. 57), 2003] at the gravel lane test site. Spatial profiles of the particle velocity measured for both primary components and for various combination frequencies indicate that the modal structure of the mine is playing an important role. Here, an experimental modal analysis is performed on a VS 1.6 inert anti-tank mine that is resting on sand but is not buried. Five top-plate mode shapes are described. The mine is then buried in dry finely sifted natural loess soil and excited at f_1 = 120 Hz and f_2 = 130 Hz. Spatial profiles at the primary components and the nonlinearly generated $f_1 - (f_2 - f_1)$ component are characterized by a single peak. For the $2f_1+f_2$ and $2f_2 + f_1$ components, the doubly peaked profiles can be attributed to the familiar mode shape of a timpani drum (that is shifted lower in frequency due to soil mass loading). Other nonlinear profiles appear to be due to a mixture of modes.

Stievater, T. H., Rabinovich, W. S., Boos, J. B., D. Katzer, S., and BIERMANN, Mark L., Associate Professor, "Laterally Patterned Band Structure and Surface-Normal Anisotropy in Micormachined (001) InGaAs Multiple Quantum Wells," *Integrated Photonics Research Topical Meeting,* Technical Digest Series, Optical Society of America, Washington, D.C., 2003.

We demonstrate that micromachining lattice-matched InGaAs quantum wells grown with barriers under tensile strain produces a large built-in optical anisotropy. This surface-normal anisotropy can be laterally patterned, enabling novel applications ranging from polarization modulators to quasi-phase matching to new piezoelectronic materials.

Stievater, T. H., Rabinovich, W. S., Park, D., Goetz, P. G., Boos, J. B., Katzer, D. S., and BIERMANN, Mark L., Associate Professor, "Laterally Patterned Band Structure in Micromachined InGaAs," *Conference on Quantum Electronics and Laser Science*, CLEO/IQEC and PhAST Technical Digest (CD-ROM; paper CTuF5; The Optical Society of America, Washington, DC, 2004)

We demonstrate that micromachining lattice-matched InGaAs quantum wells grown with strained barriers produces laterally patterned modifications to the semiconductor band structure. Finite element structural models combined with an eight band k.p calculation accurately predict the measured band structure.

Tomm, J. W., Gerhardt, A., BIERMANN, Mark L., Associate Professor, and HOLLAND, J. P., Ensign, USN, "Quantitative Spectroscopic Strain Analysis of AlGaAs-Based High-Power Diode Laser Devices," *Proceedings of the 10th International Conference on Defects - Recognition, Imaging and Physics in Semiconductors (DRIP X)*, Batz-Sur-Mer, France, (2003).

Results of quantitative spectroscopic analysis of packaging-induced strain in $In_{0.06}Ga_{0.86}Al_{0.08}As/Ga_{0.7}Al_{0.3}As/GaAs$ high-power 'cm-bars' diode laser arrays are presented. Theoretically, the influence on the results of particular device structure properties, such as intrinsic strain, is analyzed. We compare these theoretical results, which are based on a unaxial stress model, with photocurrent data. For In-soldered devices on copper heatsinks, we find a strain difference of (0.050±0.015)% between edge and center of the device. Almost complete strain-relaxation toward the device edges is experimentally demonstrated. The general approach is also applicable to the analysis of all data that refer to changes of the electronic bandstructure, such as absorption and photoluminescence.

Tucker, John E., Reintjes, John, Sebok, Tom, Henning, Pat, and TANKERSLEY, Lawrence L., Professor, "Diesel Engine Portable Fluid Analyzer - A Shipboard CBM Enabling Technology," *Proceedings of the Department of Defense Joint Oil Analysis Program International Condition Monitoring Conference*, Pensacola, FL. (CD-ROM)

Oil sample analysis often suffers in a shipboard environment due to the long time it takes to deliver a sample to an analysis lab, and to get the results back to the ship. Many times, when the results arrive back to the ship, a piece of equipment has failed and an opportunity was lost to identify it prior to the failure. Having the capability to perform an on-site evaluation of machinery health through a comprehensive machinery fluid monitor significantly improves the effectiveness of equipment inspections. The Naval Research Laboratory with Lockheed-Martin and Foster-Miller under an ONR Tech Solutions program, have combined several advanced diagnostics in a single instrument package to provide an on-site comprehensive oil monitor for use by diesel engine inspectors. This instrument combines the LaserNet Fines wear debris monitor, the FluidScan oil condition monitor and a compact viscometer and is designed to be used on-site, away from a laboratory environment. The LaserNet Fines instrument determines the type, severity and rate of progression of mechanical faults by measuring the size distributions, rate of production and the morphological analysis of debris particles in fluids. It has been used to monitor a wide range of equipment including diesel engines, cranes and hydraulic system. The FluidScan instrument monitors fluid properties through the infrared transmission of the fluid and has been installed inline on several US Navy ships. It monitors fluid properties such as water, soot, oxidation, nitration, sulfation, glycol, anti-oxidation depletion and TBN in diesel lubricating oil. Software was developed to control each instrument and to combine their results in a combined report assessing machinery health. We present results obtained by the diesel inspectors during an evaluation period of shipboard oil samples.

Tucker, John E., Reintjes, John, Sebok, Tom, Henning, Pat, and TANKERSLEY, Lawrence L., Professor, "Diesel Engine Portable Fluid Analyzer - A Shipboard CBM Enabling Technology," *Proceedings of the Society For Machinery Failure Prevention Technology Conference - MFPT 58*, pp. 13-20 (2004).

Oil sample analysis often suffers in a shipboard environment due to the long time it takes to deliver a sample to an analysis lab, and to get the results back to the ship. Many times, when the results arrive back to the ship, a piece of equipment has failed and an opportunity was lost to identify it prior to the failure. Having the capability to perform an on-site evaluation of machinery health through a comprehensive machinery fluid monitor significantly improves the effectiveness of equipment inspections. The Naval Research Laboratory with Lockheed-Martin and Foster-Miller under an ONR Tech Solutions program, have combined several advanced diagnostics in a single instrument package to provide an on-site comprehensive oil monitor for use by diesel engine inspectors. This instrument combines the LaserNet Fines wear debris monitor, the FluidScan oil condition monitor and a compact

viscometer and is designed to be used on-site, away from a laboratory environment. The LaserNet Fines instrument determines the type, severity and rate of progression of mechanical faults by measuring the size distributions, rate of production and the morphological analysis of debris particles in fluids. It has been used to monitor a wide range of equipment including diesel engines, cranes and hydraulic system. The FluidScan instrument monitors fluid properties through the infrared transmission of the fluid and has been installed inline on several US Navy ships. It monitors fluid properties such as water, soot, oxidation, nitration, sulfation, glycol, anti-oxidation depletion and TBN in diesel lubricating oil. Software was developed to control each instrument and to combine their results in a combined report assessing machinery health. We present results obtained by the diesel inspectors during an evaluation period of shipboard oil samples.

Books

MOSCA, Eugene P., Professor, and Ruskell, Todd, *Study Guide to Accompany Physics for Scientists and Engineers, Vols. 1 & 2*, Fifth Edition, W. H. Freeman, New York, NY, 2004.

Each chapter contains a description of key ideas, potential pitfalls, true-false questions that test essential definitions and relations, questions and answers that require qualitative reasoning, and problems and solutions. This edition uses the same two-column format for equations as the Worked Examples in the text, and includes "Try it Yourself" features with answers in the back.

Schwarz, Cindy, and ERTEL, John P., Associate Professor, *Interactive Physics Player Workbook*, Second Edition, Prentice-Hall, Upper Saddle River, NJ, 2003.

Motion is what much of physics is about. We have equations that we can solve for velocity, acceleration, energy and more. We can think about the motion, analyze it, and try to understand it, but until recently we could not "see" it demonstrated so clearly on the computer. Interactive Physics, first introduced in 1989, is now the premier simulation software for introductory physics and mechanics, adding a new dimension to the way physics is taught and offering a place for students (and teachers) to explore motion in ways they never could before. Through our Interactive Physics Player Workbook, the student learns the tools and capabilities of the simulation language while they are lead step-by-step through many standard physics problems from the simplest to those that usually bring tears to the their eyes. In each prepared simulation, the student is first introduced to the physics principle(s) and then experiences the physics or motion caused by those principles. At each point, they are encouraged to try their hand and experience the pleasure of solving problems of their own choice and/or creation.

Tipler, Paul A. and MOSCA, Eugene P., Professor, *Physics for Scientists and Engineers 2*, Fifth Edition, W. H. Freeman, New York, NY, 2004.

This is the second volume of a two-volume calculus-based physics textbook that has been used at the U.S. Naval Academy for the introductory physics sequence for physics majors since the 1970s. Volume 2 consists of 21 chapters that cover electricity and magnetism, optics, and modern physics. This constitutes a significant revision with an emphasis in making the subject more accessible to students. The book is used at leading universities both in the United States and abroad. The 5th edition is in the process of being translated into Korean, Portuguese, French, Spanish, and German.

Book Chapter

MIKULSKI, Paul. T., Assistant Professor, "The Friction of Model Self-Assembled Monolayers", in *Encyclopedia of Nanoscience and Nanotechnology*, Vol. 3, ed. H. S. Nalwa, American Scientific Publishers, Los Angeles, CA, pp. 511-527 (2004).

This book chapter is a comprehensive overview (containing 139 references) of the potential energy functions and modeling that has examined the structure and friction of self-assembled monolayers.

Technical Reports

BENDLER, J. T., Associate Professor, FONTANELLA, John J., Professor, and Shlesinger, M. F., "Physical Basis of Fragility," Office of Naval Research (ONR) Technical Report # 31, 18 June 2003.

> Fragility of glass-forming liquids in the supercooled region is considered in the context of a defect diffusion theory. It is shown that a necessary condition that a liquid be "fragile" is that there is an attractive interaction between the mobile defects, i.e. that the defects cluster with falling temperature. The relationship between the model parameters and a widely used fragility index is described. Each of the model parameters provides a contribution to and insight into the fragility value. The behavior of exceptional cases, such as orientationally disordered crystals and aliphatic monohydric alcohols, is also naturally accounted for in terms of the model.

BENDLER, J. T., Associate Professor, FONTANELLA, J. J., Professor, and Shlesinger, M. F., "Anomalous Diffusion near the glass transition," Office of Naval Research (ONR) Technical Report # 32, 18 June 2003.

> Anomalous diffusion is employed to model defect motion in materials near their glass transition temperature. Even though the motion of a single defect possesses no characteristic time scale the overall effect of a concentration of defects is to produce stretched exponential relaxation in the glass. This function has a well-defined time scale that depends on the concentration of mobile defects. In our model, the time scale diverges as the temperature is lowered, as well as, increasing with increasing pressure. We use the manner in which this time scale diverges to derive equations for conductivity, dielectric relaxation and viscosity as a function of temperature and pressure that are in good agreement with experimental data.

Newsletters

"Solar Eclipse Newsletter":

HUDDLE, James R., Associate Professor, "Magnetic Declination," Solar Eclipse Newsletter Vol. 8, No. 6, p. 12 (June 2003). http://www.mreclipse.com/SENL/SENLinde.htm. Magnetic Declination is discussed, and its value is given for some locations important to eclipse observers.

HUDDLE, James R., Associate Professor, "Mercury Transit Fogged Out," Solar Eclipse Newsletter Vol. 8, No. 6, p. 19 (June 2003). http://www.mreclipse.com/SENL/SENLinde.htm. Report of a failure to observe the transit of Mercury of 7 May 2003.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 8, No. 6, p. 30 (June 2003). http://www.mreclipse.com/SENL/SENLinde.htm. On double transits.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 8, No. 6, p. 58 (June 2003). http://www.mreclipse.com/SENL/SENLinde.htm. Advice for novices who want to observe an eclipse.

HUDDLE, James R., Associate Professor, "Beating the Black Drop," Solar Eclipse Newsletter Vol. 8, No. 10, p. 13 (October 2003). http://www.mreclipse.com/SENL/SENLinde.htm. An improvement to Halley's Venus transit experiment.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 8, No. 10, p. 14 (October 2003). http://www.mreclipse.com/SENL/SENLinde.htm. Response to a comment on "Beating the Black Drop."

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 8, No. 10, p. 13 (October 2003). http://www.mreclipse.com/SENL/SENLinde.htm. On observing polarization in the solar corona.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 8, No. 11, p. 15 (November 2003). http://www.mreclipse.com/SENL/SENLinde.htm. A good target for testing photographic equipment before an eclipse.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 8, No. 11, p. 29 (November 2003). http://www.mreclipse.com/SENL/SENLinde.htm. Report of observation of a large sunspot group with binoculars.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 8, No. 11, p. 48 (November 2003). http://www.mreclipse.com/SENL/SENLinde.htm. On blackbody radiation and sunspot visibility.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 9, No. 2, p. 24 (February 2004). http://www.mreclipse.com/SENL/SENLinde.htm. How small can be the footprint of a short hybrid eclipse?

"Dance of the Planets Newsletters": "Dance of the Planets" is an e-mail newsletter written for the Naval Academy community about interesting things to see in the sky. Copies are available from the author by writing to huddle@usna.edu.

HUDDLE, James R., Associate Professor, "Dance of the Planets #13: MARS." 25 August 2003. Mars approaches Earth more closely than it has in 60,000 years.

HUDDLE, James R., Associate Professor, "Dance of the Planets #14: A total eclipse of the moon." 4 November 2003. Details of the total lunar eclipse of 8 November 2003.

HUDDLE, James R., Associate Professor, "Dance of the Planets #15: Venus." 29 March 2004. Mars was bright last August, now it is Venus's time to shine.

HUDDLE, James R., Associate Professor, "Dance of the Planets #16: A NEAT Comet!" 03 May 2004. Comet NEAT will be visible for about two weeks.

Presentations at Professional Meetings and Conferences

Bartos, J., Sausa, O., Kristiak, J., FONTANELLA, John J., Professor, and WINTERSGILL, Mary C., Professor, "Correlations Between Various Crossover Phenomena in the PALS Response and Dynamic Properties in Small Molecular and Polymer Glass Forming Liquids," Workshop on Dynamics in Viscous Liquids, Munich, Germany, 14-17 March 2004.

Batchelder, J. C., Carter, H. K., Spejewski, E. H., Grzywacz, R., Rykaczewski, K. P., Stacener, D. W., Bilheux, J., Bingham, C. R., HARTLEY, Daryl J., Assistant Professor, Tantaway, M. N., Fong, D., Hamilton, J. H., Hwang, J. K., Ramayya, A. V., Krolas, W., Garrett, P. E., Kulp, D., Wood, J., Piechaczek, A., Zganjar, E. F., Winger, J. A., and Larochelle, Y., "Beta Decay Spectroscopy From ^{116}Ag," Division of Nuclear Physics Meeting, Tucson, AZ, 30 October – 1 November 2003.

BIERMANN, Mark L., Associate Professor, DURAN, Steven, Ensign, USN, Tomm, Jens W., Gerhardt, Axel, and Lorenzen, Dirk, "Dependence on Intrinsic Strain of Packaging-induced Strain in Quantum-well Laser Diodes," Conference on Lasers and Electro-Optics, San Francisco, CA, 16-21 May 2004.

BENDLER, John T., Associate Professor, FONTANELLA, John J., Professor, and Shlesinger, M. F., "Generalized Vogel Relation and the Pressure, Volume and Temperature Variation of the Dielectric Relaxation in Glass-Forming Liquids," Workshop on Dynamics in Viscous Liquids, Munich, Germany, 14-17 March 2004.

BENDLER, John T., Associate Professor, FONTANELLA, John J., Professor, and Shlesinger, M. F., "Influence of High Pressure on the Electrical Conductivity of Ion-Conducting Polymers" The Pennsylvania State University, Materials Science and Engineering Seminar Series, State College, PA, 30 October 2003. (Invited lecture)

BOOHER, K. R., Midshipman 1/C, USN, FONTANELLA, John J., Professor, and Passerini, S., "High Pressure Electrical Conductivity Studies of PEO-LiN$(SO_2CF_2CF_3)_2$," 18th National Conference on Undergraduate Research (NCUR), Indianapolis, IN, 15-17 April 2004.

DUONG, Dang V, Midshipman 1/C, USN, and KORMAN, Murray S., Professor, "Investigating Nonlinearity in Acoustic Landmine Experiments Using a Clamped-plate Soil Oscillator," 58th Annual Eastern College Science Conference (ECSC), Manhattan College, New York, NY, 2-3 April 2004.

DUONG, Dang V, Midshipman 1/C, USN, and KORMAN, Murray S., Professor, "Investigating Nonlinearity in Acoustic Landmine Experiments Using a Clamped-plate Soil Oscillator," 147th Meeting of the Acoustical Society of America, New York, NY, 24-28 May 2004.

EDMONDSON, Charles A., Associate Professor, MUELLER, Joshua M., Midshipman 1/C, USN, FONTANELLA, John J., Professor, Gustave, S., Greenbaum, Steven G., Sanders, E. H., McGrady, K. A., and Wnek, G. E., "Complex Impedance and NMR Studies of Electrosprayed Nafion Membranes," 14th International Conference on Solid State Ionics, Monterey, CA, 22-27 June, 2003.

EDSALL, Douglas W., Professor, "Self-contained Apparatus for Harvesting Water from Humid Atmosphere," 32nd Annual SOPAC/STAR Session, Niue, Oceania, 19-26 September 2003.

EDSALL, Douglas W., Professor, "Coral Atolls: Can They Survive the 21st Century?" Annual Meeting of the Geological Society of America, Seattle, WA, 2-5 November 2003.

EDSALL, Douglas W., Professor, "Developing Geoscience Research Partnerships with Colleagues from SOPAC," Annual Fall Meeting of the American Geophysical Union, San Francisco, CA, 8-12 December, 2003.

Filipova, Tsvetanka, Boyles, David A., BENDLER, John T., Associate Professor, Medalen, Marci, and Longbrake, Guy, "New Polyarylate and Polyarylate-co-polycarbonate Thermoplastics Incorporating a High-Aspect Ratio Tetraarylbisphenol," Division of Polymer Chemistry, 227th American Chemical Society National Meeting, Anaheim, CA, 31 March 2004.

FONTANELLA John J., Professor, "Physical Properties of Ion-Conducting Polymers," University of Padova, Padova, Italy, 7 July 2003.

FONTANELLA John J., Professor, "Physical Properties of Ion-Conducting Polymers," Slovak Academy of Sciences, Bratislava, Slovak Republic, 10 July 2003.

FONTANELLA John J., Professor, COX, Lou A, USNA Institutional Research Department, WATHEN, Michael, USNA Information Technology Services, and WINTERSGILL, Mary C., Professor, "A Paperless Physics Laboratory," AAPT 127th National Meeting, Madison, WI, 2-6 August, 2003.

HARRISON, Judith A., Professor, CHATEAUNEUF, Ginger M., Assistant Research Professor, and GAO, G. T., Assistant Research Professor (all of the USNA Chemistry Department) and MIKULSKI, Paul. T., Assistant Professor, "Filling Carbon Nanotubes: Mechanics and Nanofluidics," NASA Ames Research Center, Moffett Field, CA, 11 August 2003.

HARRISON, Judith A., Professor, CHATEAUNEUF, Ginger M., Assistant Research Professor, and GAO, G. T., Assistant Research Professor (all of the USNA Chemistry Department) and MIKULSKI, Paul. T., Assistant Professor, "Molecular-Scale Tribology in Model SAMs and Amorphous Carbon Films," American Vacuum Society's 50th International Symposium, Baltimore, MD, 2-7 November 2003.

HARRISON, Judith A., Professor, CHATEAUNEUF, Ginger M., Assistant Research Professor, and GAO, G. T., Assistant Research Professor (all of the USNA Chemistry Department) and MIKULSKI, Paul. T., Assistant Professor, "Molecular-Scale Tribology in Amorphous Carbon Films and Model SAMs," Naval Research Laboratory, Washington, DC, 24 November 2003.

HARRISON, Judith A., Professor, CHATEAUNEUF, Ginger M., Assistant Research Professor, and GAO, G. T., Assistant Research Professor (all of the USNA Chemistry Department) and MIKULSKI, Paul. T., Assistant Professor, "Molecular-Scale Tribology in Model SAMs," American Physical Society March Meeting, Montreal, Canada, 22-26 March 2004.

HARRISON, Judith A., Professor, CHATEAUNEUF, Ginger M., Assistant Research Professor, and GAO, G. T., Assistant Research Professor (all of the USNA Chemistry Department) and MIKULSKI, Paul. T., Assistant Professor, "Compression- and Shear-Induced Polymerization in Model SAMs," 227th American Chemical Society National Meeting, Anaheim, CA, 28 March-1 April 2004.

Hernandez-Andres, Javier, Lopez-Alvarez, Miguel A., and LEE, Raymond L., Jr., Adjunct Assistant Professor, "Towards a Skylight Spectral Remote Sensing Camera," 8th International Conference on Atmospheric Optics, Bad Honnef, Germany, 15 June 2004.

HUDDLE, James R., Associate Professor, "An Antarctic Midnight Eclipse and an Egyptian Transit of Venus," Alexander Trust Lecture, U. S. Coast Guard Academy, New London, CT, 15 March 2004.

Kondev, F.G., Janssens, R. V. F., Carpenter, M. P., Lister, C. J., Abu-Saleem, K., Ahmad, I., Heinz, A., Khoo, T. L., Lauritsen, T., Seweryniak, D., Wiedenhoever, I., HARTLEY, Daryl J., Assistant Professor, Balabanski, D., Danchev, M., Goon, T. M., Riedinger, L. L., Zeidan, O., Riley, M. A., Chowdhury, P., Shestakova, I., El-Masri, H., Walker, P. M., Dracoulis, G. D., Sletten, G., Cullen, D. M., Wheldon, C., and Kaye, R., "Configuration and Decay of a 9-quasiparticle Isomer in ^{175}Hf," Division of Nuclear Physics Meeting, Tucson, AZ, 30 October-1 November 2003.

KORMAN, Murray S., Professor, Sabatier, James M., and Fenneman, Douglas J., "Nonlinear Acoustic Techniques for Landmine Detection: Tuning Curves and Two-tone Tests," 146th Meeting of the Acoustical Society of America, Austin, TX, 10-14 November 2003.

KORMAN, Murray S., Professor, Alberts, W. C., II, and Sabatier, James M., "Nonlinear Acoustic Techniques for Landmine Detection: The Significance of the Top-plate Modes," SPIE's Defense and Security Symposium, Orlando, FL, 12-16 April 2004.

KORMAN, Murray S., Professor, "Nonlinear Acoustic Experiments Involving Landmine Detection: A Connection between Mesoscopic/nanoscale Effects in Geomaterials," 147th Meeting of the Acoustical Society of America, New York, NY, 24-28 May 2004.

KORMAN, Murray S., Professor, "Hands on Demonstrations for High School Students," 147th Meeting of the Acoustical Society of America, New York, NY, 24-28 May 2004.

LEE, Raymond L., Jr., Adjunct Assistant Professor, "Colors of Clear and Overcast Skies," 8th International Conference on Atmospheric Optics, Bad Honnef, Germany, 15 June 2004.

LEE, Raymond L., Jr., Adjunct Assistant Professor, "Temporal Variability of Overcast Illuminances," 8th International Conference on Atmospheric Optics, Bad Honnef, Germany, 15 June 2004.

MUNGAN, Carl E., Assistant Professor, "Radiation Thermodynamics with Application to Laser Cooling," American Association of Physics Teachers 127th National Meeting, Madison, WI, 2-6 August 2003.

PETERSON, Kelsey, Midshipman 1/C, USN, and BIERMANN, Mark L., Associate Professor, "Computer Analysis of Strained Quantum Wells in High-Power Diode Lasers," Undergraduate Research Poster Session on Capitol Hill, Washington, DC, 20 April 2004.

Radford, D.C., Baktash, C., Beene, J. R., Fuentes, B., Galindo-Uribarri, A., Gomez del Campo, J., Gross, C. J., Halbert, M. L., Larochelle, Y., Lewis, T. A., Liang, J. F., Mas, J., Mueller, P. E., Padilla, E., Shapira, D., Stracener, D. W., Varner, R. L., Yu, C.-H., Barton, C. J., Caprio, M. A., HARTLEY, Daryl J., Assistant Professor, and Zamfir, N. V., "Nuclear Structure Studies with Heavy Neutron-rich RIBS at the HRIBF," The 6th International Conference on Radioactive Nuclear Beams, Argonne, IL, 22-26 September 2003.

Radford, D.C., Baktash, C., Beene, J. R., Fuentes, B., Galindo-Uribarri, A., Gomez del Campo, J., Gross, C. J., Halbert, M. L., Larochelle, Y., Lewis, T. A., Liang, J. F., Mas, J., Mueller, P. E., Padilla, E., Shapira, D., Stracener, D. W., Varner, R. L., Yu, C.-H., Barton, C. J., Caprio, M. A., HARTLEY, Daryl J., Assistant Professor, and Zamfir, N. V., "Results with N-rich Beams," In-beam Gamma-ray Spectroscopy Workshop, Oak Ridge, TN, 5-7April 2004.

Sanders, H., McGrady, K. A., Wnek, G. E., EDMONDSON, Charles A., Associate Professor, MUELLER, Joshua M., Midshipman 1/C, USN, WINTERSGILL, Mary C., Professor, FONTANELLA, John J., Professor, Gustave, S., and Greenbaum, Steven G., "Electrosprayed Nafion," High Energy Density Electrochemical Power Sources 2003, Nice, France, 17-19 September, 2003.

SCHNEIDER, Carl S., Professor, "Anisotropic Cooperative Vector Field Model of Biaxial Ferromagnetoelasticity," 2004 U.S. Navy Workshop on Acoustic Transduction Materials and Devices, State College, PA, 12 May 2004.

Stievater, T. H., Rabinovich, W. S., Boos, J. B., Katzer, D. S., and BIERMANN, Mark L., Associate Professor, "Laterally Patterned Bandstructure and Surface-Normal Anisotropy in Micormachined (001) InGaAs Multiple Quantum Wells," 2003 Integrated Photonics Research Topical Meeting, Washington, DC, 16-18 June 2003.

Stievater, T. H., Rabinovich, W. S., Park, D., Goetz, P. G., Boos, J. B., Katzer, D. S., and BIERMANN, Mark L., Associate Professor, "Laterally Patterned Band Structure in Micromachined InGaAs," Quantum Electronics and Laser Science, San Francisco, CA, 16-21 May 2004.

Tomm, J. T., Gerhardt, A., BIERMANN, Mark L., Associate Professor, and HOLLAND J. P., Ensign, USN, "Quantitative Spectroscopic Strain Analysis of AlGaAs-Based High-Power Diode Laser Devices," 10th International Conference on Defects - Recognition, Imaging and Physics in Semiconductors (DRIP X), Batz-Sur-Mer, France, 29 September-2 October 2003.

Tucker, John E., Reintjes, John, Sebok, Tom, Henning, Pat, and TANKERSLEY, Lawrence L., Professor, "Diesel Engine Portable Fluid Analyzer - A Shipboard CBM Enabling Technology," Department of Defense Joint Oil Analysis Program International Condition Monitoring Conference, Pensacola, FL, 18-22 April 2004.

Tucker, John E., Reintjes, John, Sebok, Tom, Henning, Pat, and TANKERSLEY, Lawrence L., Professor, "Diesel Engine Portable Fluid Analyzer - A Shipboard CBM Enabling Technology," Proceedings of the Society For Machinery Failure Prevention Technology Conference - MFPT 58, Virginia Beach, VA, 26-30 April 2004.

VANHOY, Jeffrey R., Professor, Moeller, O., Dewald, A., Christen, S., Fitzler, A., Fransen, C., Heinze, S., Jolie, J., Linnemann, A., Pietralla, N., Saha, B., Warr, N., and Werner, V., "Lifetimes of Near-Yrast States in ^{120}Te from Plunger Measurements," Southeastern Section of the American Physical Society, Wilmington, NC, 6-8 November 2003.

VANHOY, Jeffrey R., Professor, "Radiological Awareness," Winterfest EMS 2004, Tilghman Island, MD, 31 January-1 February 2004.

Wiggins, M. J., Taunay, T. E., Wright, B. M., Flom, S. R., Shirk, J. S., and BUTLER, James J., Assistant Professor, "Transmission Properties of Nonlinear Multimode Waveguide Arrays," Conference on Lasers and Electro-Optics, San Francisco, CA, 16-21 May 2004.

WINTERSGILL, Mary C., Professor, SHELBY, Robert N., Professor Emeritus, TREACY, Donald J., Professor, and SCHULZE, Kay G., Professor, "Does it Matter How Students Solve Physics Problems?" American Association of Physics Teachers 127th National Meeting, Madison, WI, 2-6 August 2003.

WINTERSGILL, Mary C., Professor, FONTANELLA, John J., Professor, and EDMONDSON, Charles A., Associate Professor, "Fuel Cell and Battery Material Properties," AFOSR/ONR Electrochemistry Science and Technology Review, Annapolis, MD, 19-20 April, 2004.