Physics Department

Professor Francis David Correll
Chairman

Physics Department faculty and students were actively engaged in research and scholarship during the 2002-2003 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, atomic physics, condensed matter physics, nonlinear optics, nuclear structure physics, and planetary physics. They also relate work in a variety of interdisciplinary fields, including cognitive science, imaging and pattern recognition, materials science, optical communications and photonics. Additionally, they describe important efforts to understand how students learn physics and how to teach it more effectively.

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

Our faculty shared the results of their efforts by publishing scholarly articles and making presentations at conferences. This year, physics faculty and students published 28 articles in refereed journals, 10 articles in conference proceedings, one book, two book chapters, and 20 articles on the Internet. In addition, they issued two faculty technical reports and two Trident Scholar reports. Finally, faculty, midshipmen, and their collaborators made 53 presentations at scientific conferences and other meetings, including some at international meetings in Canada, Germany, Ireland, Italy, Japan, Mexico, Russia, and Spain.

As always, the scholarly bond between our faculty and our students was close and productive. One Trident Scholar used inelastic neutron scattering to study the nuclear structure and excitation modes of Tellurium-130. Another Trident Scholar used optical and infrared observations to investigate the physical properties of near-earth objects. Three midshipmen developed successful new Trident Scholar proposals, one in general relativity, one in materials physics, and one in nonlinear optics, which they will carry out during the next academic year. Nine midshipmen participated in research projects in astronomy, condensed matter physics, optics, and nuclear physics.

Sponsored Research

Molecular Design and Synthesis of Novel, High-Performance Polycarbonates

Researcher: Associate Professor John T. Bendler
Sponsor: National Science Foundation (NSF)

The goal of the project was to use computer modeling methods and molecular theory to design new polycarbonate molecules having improved mechanical and thermal properties. Based on earlier theoretical studies and ab initio quantum mechanical calculations, a particular class of new monomers was identified, containing bisaryl units separated by small, flexible organic units such as ethers, carbonates, and isopropylidenes. Force fields appropriate to these new structures were developed and molecular dynamics simulations of stress strain responses conducted. Predictions of the modeling work to date have lead to the synthesis of five new aryl polycarbonates, including a bisaryl formal, a gem dimethyl propyl, and a hexafluoro polycarbonate. Samples of these new polymers have recently been tested for glass transition temperatures T_gs and molecular weights Mw using GPC. Triaryl and tetraaryl polycarbonates have been synthesized in a reproducible and efficient way and they are amorphous, high T_g, and tough.

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

Researcher: Associate Professor John T. Bendler
Sponsor: National Science Foundation (NSF)

The goal of this research is to use molecular modeling, synthesis, and small-scale testing of several new aromatic polycarbonate molecules to assess their potential to be applied in various U.S. Army protection systems such as transparent armor for face shields, goggles, vehicle vision blocks, windshields, blast shields and aircraft canopies. This research represents an extension and application of discoveries made in the course of our recent National Science Foundation (NSF) Grant. The NSF results include 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 work extends these recent results to several new thermoplastic polymer analogues based on bisaryl monomers including, but not limited to, trifluoromethylated, siloxane, formal, and geminal-dimethyl analogues of bis(biarylphenols). The primary focus and objective in this new work is to evaluate and test these novel polymers for enhanced high-impact mechanical properties, oxidative, UV, flame, laser, environmental and chemical stability, as well as improved aging and embrittlement resistance. Last summer saw the implementation of laser light scattering and GPC to characterize molecular weights of the synthesized polymers. Theory and modeling focused on development of an entanglement model of fracture toughness and simulations of single molecule oligomers.

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)

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 are 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) are obtained. In addition both modeling and computer simulations of the various systems are carried out.

Synthesis, Modeling and Testing of Polymer Nanocomposites for Impact Protection

Researcher: Associate Professor John T. Bendler
Sponsor: Army Research Office (ARO)

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 researcher are utilized and filled with carbon nanotubes, mineral sheets, and silica particles, coated and uncoated.

Modeling Optical and Electronic Properties of III-V Quantum Wells Under Anisotropic Strain

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

Strained quantum wells have a wide variety of uses, including a number of opto-electronic applications. The goal of this work is to guide development of opto-electronic devices that employ these quantum wells, and to identify specific

systems that show promise for desired applications. I model the behavior of III-V quantum-well structures that are experiencing anistotropic, in-plane strain. Anisotropic strain leads to important and potentially useful phenomena in quantum wells such as the possible enhancement of nonlinear optical effects. Of particular interest for this work are the optical properties of $Ga_{1-x}In_xAs$ / $Al_{1-y}In_yAs$ and $Ga_{1-x}In_xAs$ / $Ga_{1-y}Al_yAs$ quantum wells. Through lattice mismatch and micromachining, these quantum wells can exhibit anisotropic, in-plane strain. This work focuses on calculating the electric dipole matrix elements for transitions between valence and conduction subbands within these strained quantum wells. The electronic band structure of the quantum wells is also modeled as a part of this project.

Modeling Packaging-Strain-Induced Interband Energy Shifts in High-Power, "cm-bar" Lasers

Researcher: Assistant Professor Mark L. Biermann
Sponsor: Max Born Institute, Berlin, Germany

High-power "cm-bar," quantum-well lasers must be mounted onto a heat sink in order 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 this research project was to attempt to accurately model the packaging-induced strain the in the quantum wells for the first. The application of \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 is modeled using a uniaxial stress. The theoretical predictions showed excellent agreement with relevant experimental results. 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.

Nonlinear Optics in Capillaries and Capillary Arrays

Researcher: Assistant Professor James J. Butler
Sponsor: Research Corporation (RC)

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: Optical Physics Branch, Naval Research Laboratory (NRL)

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 Limiting Within Nonlinear Multimode Waveguides

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

Optical limiters are devices that can be used to control the intensity of light and have many applications in areas where the protection of optical sensors is required. In particular, the use of optical fibers in the areas of telecommunication and optical imaging has become standard practice. As information data rates become larger and higher power lasers are used, protection of sensitive pieces of optical equipment becomes a necessity. Thus, devices that can limit the intensity of transmitted light and that are compatible with optical fibers will play a crucial role in the future development of these areas. Waveguides that consist of nonlinear compounds housed within glass capillaries provide a unique opportunity for the construction of compact optical power limiters that are easily integrated into fiber optic systems. The waveguide geometry provides longer interaction lengths between the light and the nonlinear compound as well as higher energy densities due to the confinement of the light to a small region. Both of these characteristics lead to larger nonlinear responses by the compound and an enhanced optical limiting effect. In this study, the capillaries were filled with compounds that exhibit reverse saturable absorption. These materials have an absorption coefficient that increases as the intensity of the light increases, thereby making them useful optical limiters. Furthermore, the compounds had a refractive index substantially larger than the glass capillary, making them highly multimode. The optical properties of these capillary waveguides were investigated.

Fuel Cell and Battery Materials

Researcher: Associate Professor Charles A. Edmondson
Sponsor: Office of Naval Research (ONR)

A fuel cell is a device that is similar in purpose and function to a battery. Within the cell a chemical fuel is used to produce an electric potential that can be used as a power source in a wide variety of applications. Unlike a battery, which is a closed system and consequently can deliver only a limited amount of energy, a fuel cell may run indefinitely with the continued addition of fuel and oxygen. A fuel cell also offers a considerably higher theoretical efficiency than systems which combust the fuel for thermal energy. Generically, a fuel cell consists of two electrodes, where the chemical reactions take place, separated by an ion conducting membrane. The membrane allows the transport of ions, often protons, from one electrode to the other while keeping the constituents separate. This transport is required to sustain the energy-generating chemical reactions. The goal of this project is to determine the ion transport mechanism in promising materials proposed for use in fuel cell Proton Exchange Membranes (PEM). Nafion is one such membrane material that has undergone significant testing and application. Recent efforts have focused on new processes that will reduce the cost of Nafion by the incorporation of less costly materials. Wnek and coworkers at Virginia Commonwealth University have developed a new process called electrospraying for the production of membranes that may support mass production of fuel cells. Our primary objective in this work is to gain insight into differences in electrosprayed ion exchange membranes via complex impedance measurements. Detailed studies of the complex impedance as a function of water content and pressure are ongoing.

Data Mining of OAS Activities in India

Researcher: Professor Douglas W. Edsall
Sponsor: Office of Naval Research (ONR)

The U.S. Navy, in particular its Science and Technology arms, has an interest in opening new and expanding established contacts in Ocean, Atmosphere and Space Sciences (OAS) research with India. This effort, funded by the Chief of Naval Operations, attempts to identify for future contacts the major university, corporate and research facilities and scientists involved in OAS related research. The Office of Naval Research previously performed a data mining effort in South America in advance of establishing a field office in Santiago, Chile.

This project focused on: (1) identifying those institutions, governmental agencies and individual scientists involved in OAS-related research and (2) analyzing the current level of research within India, highlighting any significant research efforts or scientists that the Office of Naval Research should attempt to cultivate/fund future bilateral working relationships.

ONRIFO Associate Director for OAS

Researcher: Professor Douglas W. Edsall
Sponsor: Office of Naval Research (ONR)

As Associate Director for Ocean, Atmosphere and Space Sciences (OAS) in the Tokyo field office of the Office of Naval Research (ONR) from 15 June 2001 to 24 December 2002, this researcher was responsible for providing current information on Science and Technology developments over a major portion of the earth. The area of responsibility for this effort included the Pacific Ocean Islands, Pacific-rim nations, Southeast Asia, Eastern Russia, China, India and the nations around the Indian Ocean. To assess these activities, travel to international scientific meetings, meetings with governmental, university and industry scientists, and tours of research facilities occurred on a routine basis. In addition, the researcher served as an intermediary between these foreign nationals and the ONR/NRL scientists and researchers at various U.S. universities. Travel and conference support funding for foreign scientists was also provided, and this research effort helped to initiate, develop and secure financial support for bilateral/multilateral scientific research projects. Every trip, meeting, or other contact was the subject of a written report or Memorandum for the Record. These reports can be found under the researcher's by-line on the ONRIFO home page or the ONRIFOASIA homepage.

Properties of Fuel Cell and Battery Materials

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

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 is 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 are also conducted when required. The complex impedance and DSC measurements are carried out at high pressures. All work is carried out in collaboration with the group at Hunter College where Nuclear Magnetic Resonance (NMR) studies are performed.

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)

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 are 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) are obtained. In addition both modeling and computer simulations of the various systems are carried out.

Investigation of Novel Nano-Composite Molten Salt Gel Electrolytes

Researcher: Professor John J. Fontanella
Sponsor: Air Force Office of Scientific Research (AFOSR)

The purpose of this project is to carry out synthesis and basic electrical studies of molten salts. The ultimate goal of the work is to develop a new electrolyte for use in either batteries or fuel cells. The primary experimental technique used at USNA is electrical conductivity. New molten salt gel electrolytes were synthesized and the electrical conductivity at room temperature was measured. The results were encouraging concerning possible use of this class of materials in batteries and fuel cells.

Triaxial Superdeformation in Nuclei Near N ~ 100

Researcher: Assistant Professor Daryl J. Hartley
Sponsor: National Science Foundation (NSF)

During this year, a research proposal to the National Science Foundation (NSF) which focused on examining triaxial superdeformed structures in ^{174}Hf and neighboring nuclei was prepared and submitted. It was awarded full funding for the next three years. This research will be a continuation of work the researcher was performing before his arrival at the Naval Academy.

Nuclei come in many different shapes: spherical, prolate (like a football), oblate (like a doorknob), and octupole (like a pear). All of these shapes have their mass distribution symmetric about at least one axis. One of the most difficult shapes to identify is a nucleus with no symmetry axis, which would look like a kiwi fruit. Such a nucleus is defined to be triaxial. Calculations suggest that ^{174}Hf and neighboring nuclei are good candidates for this shape when they are in a severely excited state known as superdeformation (the nucleus is unusually elongated).

A journal article, published this year, reported the first indication of a triaxial structure in ^{174}Hf. Efforts are now underway to confirm the superdeformed state from a second experiment. A third experiment, which will be performed at the international user facility Gammasphere at Argonne National Laboratory, is scheduled to run in the summer of 2003. The purpose of this experiment is to establish experimental proof of the triaxial nature by finding and determining the nature of linking transitions between triaxial structures and the ground-state sequence. This researcher is the principal investigator on the second and third experiments for ^{174}Hf. The data from the upcoming experiment will be written to 8mm tape and will be analyzed at the Naval Academy over the next year or two, with the help of the Academy's students (midshipmen).

Observations of Near-Earth Objects

Researcher: Associate Professor Debora M. Katz
Sponsor: 2002 Kinnear Fellowship

This on-going research centers around three goals: 1) tracking recently discovered near-Earth objects, 2) measuring the distance to especially close near-Earth objects through parallax observations and 3) measuring the physical and rotation properties with infrared and optical observations. The Michelson Hall observatory was used to track near-Earth objects. These data were submitted to the Minor Planet Center. This observatory was also used to make simultaneous observations with Dr. Richmond at the Rochester Institute of Technology. These data were used to make direct distance measurements by observing a parallax shift. Four telescopes on Kitt Peak, Arizona were used to measure the physical and rotational properties of a small sample of recently discovered near-Earth asteroids.

Nonlinear Tuning Curve Vibration Response of a Buried Land Mine

Researcher: Professor Murray S. Korman
Sponsor: National Center for Physical Acoustics (University of Mississippi, University, MS)

Measurements of the acoustic impedance of a VS 2.2 anti-tank plastic landmine reveal significant resonances in the frequency range between 80 and 650 Hz. The top surface resonances are due to its complicated mechanical structure vibrating in air. The lowest mode of the landmine results in a high Q simple harmonic oscillator resonance of the top surface, which behaves like a rigid mass. At higher frequencies the top surface behaves like thin circular plate acoustic modes. When these landmines are buried in soils, the modes are mass loaded. Resonances from measurements of the normal component of the acoustically induced soil surface particle velocity (due to sufficient acoustic-to-seismic coupling) are used for 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. The structure of a family of resonant tuning curves for relatively low amplitude, but nonlinear drive levels, reveals the "nonclassical" nonlinear resonant behavior of the soil-landmine oscillator. It was discovered that the nonlinear resonant acoustic behavior of the soil surface vibration over a buried landmine has a tuning cure response that is similar in behavior to the mesoscopic nonlinear resonant behavior found in geomaterials like rock, in particular sandstone.

Linear and Nonlinear Acoustic Measurements of Buried Landmines: Detection Schemes Near Resonance

Researcher: Professor Murray S. Korman

Sponsor: National Center for Physical Acoustics (University of Mississippi, University, MS)

Measurements of the acoustic impedance of an anti-personnel and anti-tank plastic, blast-hardened landmine reveal resonances in the frequency range between 100 and 1000 Hz. The top surface resonances are due to its complicated mechanical structure vibrating in air. The lowest mode results from the blast hardened design of the landmine. Typically, a portion or cavity of the landmine is designed to absorb the shock from an explosion that is intended to detonate the landmine but still allow the landmine to trigger its explosive device when a slow steady pressure is applied. The mechanical design of the blast hardened aspects results in a high Q simple harmonic oscillator resonance of the top surface. At higher frequencies the top surface behaves like thin circular plate acoustic modes. When these landmines are buried in soils, the modes are mass loaded. Resonances from measurements of the normal component of the acoustically induced soil surface particle velocity are used for 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 landmine detection not previously exploited. It was discovered that the soil surface vibration profiles above a buried landmine depend greatly on frequency and can be related to the mass loaded vibration modes of a thin elastic circular plate subjected to certain boundary conditions around the rim.

Nonlinear Acoustic Techniques for Land Mine Detection

Researcher: Professor Murray S. Korman

Sponsor: National Center for Physical Acoustics (University of Mississippi, University, MS)

Donskoy [SPIE Proceedings 3392, 211-217 (1998); 3710, 239-246 (1999)] has suggested a nonlinear technique that can detect an acoustically compliant buried mine that is insensitive to relatively noncompliant targets. Airborne sound at two primary frequencies f_1 and f_2 undergo acoustic-to-seismic coupling and a superimposed seismic wave interacts with the compliant mine and soil to generate a difference frequency component that can effect the vibration velocity at the surface. Geophone measurements scanning the soil's surface at the difference frequency (chosen at a resonance) profile the mine with more relative sensitivity than the linear profiles - but off the mine some nonlinearity exists. Amplitude dependent frequency response curves for a harmonically driven mass-soil oscillator are used to find the parameter of nonlinearity of the soil acting as a "soft" spring. Donskoy's nonlinear mechanism (over the mine) involves the top surface of the mine-soil planar surface. During the compression phase of the wave, the surfaces stay together and then separate under the tensile phase due to a relatively high compliance of the mine. This effect is thought to be a bi-modular oscillator that is inherently nonlinear. It was discovered that a buried plastic landmine is a highly nonlinear vibro-acoustical system. Upon exciting the ground with airborne sound at two primary frequencies f_1 and f_2, there exists a rich spectrum of nonlinearly generated combination frequencies at which the ground over the mine will subsequently vibrate. It was shown that the contrast sensitivity ratio for mapping out the surface profile of a mine is much greater using combination tones than either primary tone.

Ground-Based Passive Remote Sensing of the Overcast Sky

Researcher: Adjunct Assistant Professor Raymond L. Lee, Jr.

Sponsor: National Science Foundation (NSF)

This research project involves visible-wavelength remote sensing of the overcast sky as seen from the earth's surface. The scientific objective of the 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, we use both spectroradiometry and digital imaging to analyze at high spectral, spatial, and temporal resolutions the photometric, colorimetric, and polarimetric details of a wide range of overcasts. This research analyzes 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 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.

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 detector located twenty miles north of MIT at the Bates electron accelerator laboratory. The BLAST physics program calls for several years of taking data on the scattering of polarized electrons from polarized internal gas targets at an electron energy of one GeV. The scattering process that ensues is used to probe nuclear and sub-nucleon structure. The summer 2002 NARC grant allowed Professor McIlhany to travel to Bates to continue efforts towards installing and commissioning the Helium-3 internal gas target. Several basic goals were laid out at the beginning of the summer, which were subsequently completed by the end. One goal was to investigate stable performance of the polarization of Helium-3. Long term stability is a key factor in smooth experimental performance, so several problems were tracked down that had led to long term instability. These problems range from temperature gradients across the room with the laser to the expansion of the glassware as the laser heats the optics on the table. The second goal was to work on the daily problems met by the BLAST collaboration while working on shift. Typical days would include an eight hour shift of data taking, where physicists analyze data in near real time to track down any and all problems the detector is showing. Problems of this nature range from drifting high voltage, unusual gains, and timing imbalances to simple mistakes in wiring. Literally thousands of plots are made during one summer in order to understand and analyze these issues. Periodically, the DOE holds a review panel to assess the progress of BLAST. Last summer, the DOE panel found that reasonable progress was being made and that no failure points were detectable.

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

Researchers: Assistant Professor Paul Mikulski, with
Associate Professor Judith A. Harrison, Dr. Guangtu Gao,
and Dr. Ginger Chateauneuf (Chemistry Department)
Sponsor: Naval Academy Research Council (NARC)

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. We employ an empirical classical hydrocarbon potential that models both chemical reactions (the breaking and forming of bonds) as well as long-range non-bonded interactions. Computationally feasible systems are typically composed of tens of thousands of atoms simulated over hundred of picoseconds with timesteps of a few tenths of a femptosecond. My primary project has focused on computer simulations of an amorphous carbon tip across a self-assembled monolayer (SAM). New developments this year include implementation of a feedback loop for controlling load, analysis of energy modes at the level of individual atoms, and the running of multiple runs with the same run parameters to gain better statistics. The present study requires keeping 16 separate simulations running in parallel over a period of months. Preliminary analysis shows that the instantaneous friction can reflect the periodic structure of the SAM even though the probing tip has no such periodic structure. In addition, at zero load (but in contact), single component SAMs and mixed component SAMs exhibit similar average friction, but at a higher load (20 nN) the mixed component SAM exhibits significantly higher friction.

Solid-State Laser Cooling of Organic Dyes in Modified Polymers

Researcher: Assistant Professor Carl E. Mungan
Sponsor: Research Corporation (RC)

The research plan consists of: (i) preparing dye-doped polymeric thin films and bulk samples; (ii) characterizing them by optical spectroscopy; (iii) measuring laser cooling by photothermal techniques; and (iv) modeling the results in a unified optical and thermodynamic viewpoint. This will lead to a better understanding of laser materials and eventually to two applications. The first is a novel refrigerator that could be used to cool infrared detectors aboard satellites. Current cryocoolers have drawbacks that an optical fridge would not. The ability of polymers to be easily cast into any desired shape and the wavelength tunability of organic dyes are significant advantages for this purpose. The other application of fluorescence cooling is to a new laser design. The internal heat generation in a lasing medium can be eliminated by balancing the heating due to the laser emission against the cooling from the spontaneous fluorescence. The broad bandwidth of dye lasers makes them an ideal material with which to test this concept. Recent work has demonstrated remarkably high fluorescence

efficiencies for pyrromethene dyes in advanced polymers. Other workers have modified poly(methyl methacrylate) using chemical additives and by copolymerization to achieve damage-resistant hosts which retain excellent dye compatibility and minimal scattering loss. So far we have achieved results by doping the organic dye cresyl violet perchlorate into a solid plastic host (plexiglas) and optically exciting it using 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 took a few million excitation-relaxation cycles to bleach a dye molecule at incident intensities on the order of 10^2 W/cm^2.

Optical Spectroscopy of Condensed Materials for Luminescent Device Applications

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

Co-mixtures of transparent polymers and of the optically active molecule Rhodamine B (RhB) in organic liquids were investigated as a precursor to spin coating. Polycarbonate (PC) forms a clear, hard plastic compatible with this red-emitting dye. Various solvents were tried including toluene, chloroform, xylene, dichlorobenzene, tetrahydrofuran, and dichloroethene, before settling on dichloromethane. Glass substrates were cleaned by a standard sonication and ozone plasma treatment. Films of pure PC and RhB were cast, as well as PC:RhB mixtures. The solutions and thin films were spectrally characterized. The absorption spectra were measured in a spectrophotometer, and the emission spectra under mercury arc illumination detected via a fiber optic link to a monochromator equipped with a cooled CCD array. Next, an ultraviolet helium-cadmium laser was used to measure the photoluminescence quantum efficiency of the samples inside an integrating sphere. Several published methods for analyzing the quantum efficiency (QE) were reviewed, including the desirability of using a luminance camera and of goniometrically measuring the angular emission pattern to characterize how nearly Lambertian it is. The solvated QE of a saturated co-mixture was found to be only 60%. Future measurements will determine whether the efficiency of the solid films is any higher and of the concentration dependence of this value, because energy transfer among chromophores can lead to fluorescence quenching.

Anisotropic Cooperative Theory of Ferromagnetoelasticity

Researcher: Professor Carl S. Schneider
Sponsors: Office of Naval Research (ONR) and Naval Surface Warfare Center (NSWC)

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 scaled 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 $H\sigma\sigma$ processes and susceptibility and anisotropy changes in σH and $\sigma\sigma H$ processes are derived using our model of hysteresis with stress fields, 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, causing a reversal in compression.

Optical Debris Analysis Techniques for Mechanical Systems in Military Environments

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

The ultimate goal of this work is to develop real time, full flow optical analysis for turbine engine and gearbox lubricants and for hydraulic fluids. Detected debris particles are characterized to provide failure projection. Less capable versions of the system are 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 are developed and implemented to classify debris candidates.

ANDES, An Intelligent Tutor

Researchers: Professor Donald J. Treacy and Professor Mary C. Wintersgill;
Professor Kay G. Schulze (Computer Science Department)
Sponsor: Office of Naval Research (ONR)

The ANDES project is developing an intelligent tutoring system that is being used to teach Physics to students at the U. S. Naval Academy. It is based on three key ideas: (1) that it should help students with their physics homework rather than take over instruction entirely, (2) that several types of help systems are necessary for effective learning, and (3) that principle based dialog between students and ANDES is an effective method to give useful advice as a tutor. The project has developed a fairly complete version of the tutoring system and 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 kinds of evaluations in order to measure and increase the effectiveness of the tutor. The ANDES program itself is being rewritten to a form in which individual instructors can add to the problem database. An added feature is the ability for ANDES to evaluate the students' work and give it a numerical score. The updated version will be ready for a trial in the fall semester of 2003 and additional material should allow it to be used for electricity in the spring semester of 2004.

Nondestructive Evaluation of Spacecraft and Aircraft Wiring

Researcher: Commander Edward J. Tucholski, USN, Permanent Military Professor
Sponsor: NASA Langley Research Center

This research applies several nondestructive techniques to assess their ability to determine the status or wiring systems in-situ and, consequently, to optimize the most successful ones for rapid inspection of aircraft and spacecraft wiring. Three techniques of primary focus are infrared thermographic imaging, time domain reflectometry and pulsed x-radiography.

Recoil-Distance Lifetime Measurements in Tellurium–120

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

Tellurium-120 (^{120}Te) is cited in textbooks as an 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 that this is a naive interpretation, however. 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 are measured using the recoil-distance Doppler-shift technique and a 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 of the various excited states 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. Initial analysis indicates that lifetimes can be deduced for approximately 15 levels. 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.

Independent Research

Variable Star Studies

Researcher: Professor C. Elise Albert

Cataclysmic variable (CV) stars are a class of binary star systems where the light of the combined stars appears to vary, sometimes quite dramatically, due to transient mass transfer from an extended primary star onto a compact white dwarf secondary star. Initial photometric observations of CV stars were obtained with a CCD camera system on the 20-inch

reflecting telescope on Michelson Hall. However, during the academic year, the telescope was used primarily by a Trident Scholar and, as of June 2003, it will be in storage indefinitely.

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

Researchers: Assistant Professor Mark L. Biermann, Ensign Matthew Walters, USN (Class of 2002) and Ensign James Diaz-Barriga, USN (Class of 2002)

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 subbands. 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.

Refinement of Global Planetary Magnetosphere Models

Researcher: Professor Irene M. Engle

The objective of this research is to incorporate a more realistic magnetotail model into the full range of global models of the Saturnian magnetosphere, in preparation for the Cassini spacecraft entry into polar orbits about Saturn. During his 1998-1999 Trident Scholar year, Lieutenant Junior Grade Jeremy Bruch (Class of 1999) solved a problem of incorporating a modified magnetotail model into two of the incident solar-wind direction versions of the Saturnian magnetosphere. Since then, Engle has expanded upon that work to obtain a range of models for all 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, and some results were presented at an international meeting during summer 2002. Consultation with the Cassini mission experimenters (including Michel Blanc) took place during the meeting regarding the incorporation of these results into the working model for the encounter.

Global Planetary Magnetosphere Boundary Representations

Researcher: Professor Irene M. Engle

An ongoing difficulty of 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 of 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,θ,ϕ) 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 maximum distance r from the planet center along a particular spatial direction (θ,ϕ). Since the original calculation of the magnetopause is generally done via an angular grid, the shapes, especially where magnetotails are incorporated, are not at all simple. 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 a elliptical cone that expands as one moves further away from the planet. Sufficiently accurately representing the boundaries is an ongoing challenge for the magnetospheric models of three planets, i.e., Mercury, Jupiter, and Saturn.

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

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

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.

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 metrology experiments was updated to use a Vernier LabPro interface instead of the older Texas Instruments Calculator Based Laboratory (CBL) interface. The LabPro has four analog inputs, whereas the CBL had only three. In addition, the interface is now driven with a Palm handheld computer instead of a TI-92 Plus calculator. The Palm can hold more data, and it 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. The instruments all performed satisfactorily; however, it rained during the eclipse.

The Transit of Venus on 8 June 2004

Researcher: Associate Professor James R. Huddle

On 8 June 2004, Venus will transit the sun for the first time since 6 December 1882. Only five transits of Venus have been observed since Kepler discovered the phenomenon in 1631. Although transits of Venus are exceedingly rare, they have a rich history and have played important roles in the determination of the size of the solar system and in the development of international cooperation in science. The purpose of this work will be to recreate the experiment proposed by Edmond Halley in the 17th Century, with an eye toward using the experiment to teach young people about the methods of scientific inquiry and about international scientific cooperation.

1243+226: A Galactic Merger

Researchers: Associate Professor Debora M. Katz
with Andrew Young and Lawrence Rudnick (University of Minnesota)

Galaxies are large collections of stars, gas and dust. Some galaxies show a lot of activity and are particularly bright. Radio galaxies are active galaxies that emit most strongly in the radio part of the electromagnetic spectrum. These galaxies often have large plumes of material that stretch well beyond the star population. These plumes are believed to be energized by supermassive black holes. Radio galaxy 1243+226 appears to be two galaxies in the process of merging. The plumes of material are tangled and difficult to distinguish. Using spectral tomography these plumes may be distinguished. Once this is done, it will be possible to see what features depend on environment and what features are intrinsic to the galaxy.

Nonlinear Acoustic Techniques for Landmine Detection: Experiments Using a Soil-Plate Oscillator

Researchers: Professor Murray S. Korman
and Waini Karen Tai (Anne Arundel County High School Mentorship Program, Annapolis High School)

A nonlinear acoustic technique for detecting buried landmines has been suggested by Donskoy [SPIE Proceedings 3392, 211 (1998); 3710, 239 (1999)]. Airborne sound at two primary frequencies f_1 and f_2 undergo acoustic-to-seismic coupling and a superimposed "slow" compressional wave interacts with the compliant mine and soil. The nonlinear mechanism involves a simple model of the top surface of the mine-soil planar surface separating two elastic surfaces. During the compression phase of the wave, the surfaces stay together and then separate under the tensile phase due to a relatively high compliance of the mine. This "bouncing" soil-mine interface is thought to be a bi-modular oscillator that is inherently nonlinear. A layer of soil in a large tube, terminated by a thin elastic plate is used to model the bi-modular nonlinearity. The soil-plate oscillator exhibits extremely strong nonlinear behavior that models the buried landmine's vibro-acoustic response. Experiments using two primary acoustic frequencies (chosen near the fundamental resonance and separated by 10 Hz) generate a series of nonlinear components separated by 10 Hz intervals ($f_{1,2} \pm 10$ Hz, $f_{1,2} \pm 20$ Hz,...) along with sum and difference frequency components across a broad band in the spectrum measured by a geophone placed on the soil's surface. Amplitude dependent frequency response curves for the harmonically driven soil-plate oscillator are measured and are used to understand some of the nonlinear effects of the soil- plate oscillator. The tuning curves (involving the acceleration response of the center of the underside of the plate vs. frequency) bend towards frequencies that are markedly lower as the amplitude increases. This phenomenon indicates that the "spring constant" is getting softer with increased amplitude. Results show that the relationship between the rms peak amplitude and the corresponding frequency is a linear relationship. Further experiments driving the oscillator with first incrementally increasing then incrementally decreasing acoustic drive levels show tuning curve results with hysteresis effects that are similar in nature to the nonlinearities observed in rocks and granular media. The nonlinear results reported here are observed using buried (inert) VS 1.6 and 2.2 landmines.

Complex Impedance Studies of Optically Stimulated SBN

Researcher: Associate Professor Steven R. Montgomery

The complex permittivity and impedance of undoped and unpoled single crystal strontium barium niobate (SBN) were measured with a computer interfaced impedance analyzer over a frequency range from 100 millihertz to 10 kilohertz using small AC signals with millivolt amplitudes. The thin (~2 mm) planar crystal sample was placed between the plates of a modified parallel plate capacitor and illuminated on the side with linearly polarized argon-ion laser light operating at select wavelengths in the blue-green with photon energies that are slightly below the bandgap energy of SBN. Impedance spectra were obtained in the dark between room temperature and 70°C and compared with impedance spectra obtained with laser illumination and no heating except that produced by absorption of the laser light. Dark measurements at all temperatures are consistent with studies in the literature that suggest electron hopping as the predominant charge transfer mechanism. Illumination markedly changed the conductivity of the crystal and the charge transfer mechanism by elevating significant numbers of charge carriers into the conduction band. This was found to be independent of the polarization of the light and slightly dependent on its wavelength over our wavelength range of 458 nm to 515 nm. The dielectric constant of the crystal under illumination changed less than twenty per cent and this change is probably due to the slight heating of the crystal by the laser. This project is a continuation of Midshipman 1/C Peter G. Brereton's Trident Scholar project during the 2000-2001 academic year.

Midshipman Research Course Projects

Exploring Small Telescope Visual Astronomy

Researcher: Midshipman 2/C Cassidi A. Reese, USN
Adviser: Professor C. Elise Albert

For hundreds of years, astronomers have been using small optical telescopes to observe the sky. New electronics and systems have blurred the line between amateurs, professionals and experts, making available to everyone tools once found only at large observatories. The Physics Department's new 10--inch Meade telescope and CCD are such tools and

represent the current state of the art in small telescope visual astronomy. Detailed procedures for assembling, aligning and calibrating the telescope were worked out. The CCD camera system was installed, tested and debugged, and good images of star clusters and the moons of the outer planets were obtained, laying the groundwork for future studies and for classroom use of this telescope.

Computer Analysis of Asymmetric Coupled Quantum Wells under Anisotropic Strain

Researcher: Midshipman 1/C Joseph P. Holland, USN
Adviser: Assistant Professor Mark L. Biermann

Quantum wells are crucial in the design and development of semiconductor modulators and lasers. Moreover, the incorporation of anisotropic strain while building quantum wells will provide much greater control in these systems, and therefore more control over the devices of which they are a part. Before device applications are possible however, quantum wells under anisotropic strain must be studied and understood. We have contributed to this basic understanding using a computer program we developed that allows us to analyze the following: 1) coupled well systems consisting of multiple well and barrier layers; 2) wells of varying widths or asymmetric coupled quantum wells; 3) systems under different types of strain, 4) useful opto-electronic quantities such as dipole matrix elements. Specifically, our work focused on GaInAs well layers and AlInAs barrier layers. By studying scenarios involving varying barrier widths, well widths, and different strain conditions, we were able to thoroughly describe how these parameters affect this class of coupled quantum wells.

Computer Analysis of Asymmetric Coupled Quantum Wells Under Uniaxial Anisotropic Stress

Researcher: Midshipman 1/C Stephen A. Duran, USN
Adviser: Assistant Professor Mark L. Biermann

Quantum wells are crucial in the design and development of semiconductor modulators and lasers. The presence of uniaxial stress resulting from the fabrication process for quantum wells provides a means of analyzing these systems. Uniaxial stress also provides a means of controlling the devices that employ these systems. However, before such device applications are possible, quantum wells under uniaxial stress must be thoroughly studied and understood. We have contributed to this basic understanding using a computer model that allowed us to analyze the following: 1) coupled well systems consisting of multiple well and barrier layers; 2) wells of varying widths or asymmetric coupled quantum wells; 3) systems under different types of strain, 4) useful opto-electronic quantities such as dipole matrix elements. Our work specifically focused on GaInAlAs well layers and GaAlAs barrier layers. By studying scenarios involving varying barrier and well widths, and different stress conditions, we were able to thoroughly describe how these parameters affect this class of quantum wells.

Optical Limiting In Single-Mode Waveguide Systems

Researcher: Midshipman. 2/C Jeffrey C. Payne, USN
Adviser: Assistant Professor James J. Butler

In recent years, technological advances, coupled by an aggressive expansion of the telecommunication industry, has lead to an increased interest in the properties of optical waveguide systems. One particularly interesting property that can, under certain conditions, occur in such systems is a phenomenon known as optical limiting. Optical limiting systems are used to limit the intensity of the light that the system emits. At low intensity inputs, the intensity of the output light will increase linearly. However, when the input intensity reaches a certain level, the output intensity will increase more slowly than the intensity of the input light. Clearly, this is advantageous for any fiber optic system that delivers an optical signal to equipment that could be damaged by high intensity light. In addition, it has been suggested that such a system could be used to protect the eyes of soldiers on the battlefield from the effects of laser weapons. In order for optical limiters to be practical in fiber optic systems, they must be able to be easily integrated into those systems. For instance, filling the core of an optical waveguide with such a substance allows one to limit the intensity transmitted by that waveguide. Many waveguides are large enough to allow light to transmit in a multitude of optical modes. Each mode corresponds to an allowed distribution of light within the waveguide core. However, there are waveguides with small enough core diameters (on the order of 3-5 microns) in which only the fundamental mode can be transmitted. Light propagating through the core in the

fundamental mode is confined to a smaller traverse area than light propagating in higher order modes. This confinement keeps the beam more intense. As a result of this higher intensity, nonlinear optical limiting effects become more pronounced. The goal of this project was to design and fabricate single-mode waveguides that exhibit optical limiting and to study the optical properties of these systems. Furthermore, arrays of closely spaced waveguides were also constructed and studied.

Complex Impedance Studies of Polyvinylacetate (PVA) Substituted Nafion Membranes

Researcher: Midshipman 2/C Joshua M. Mueller, USN
Adviser: Associate Professor Charles A. Edmondson

PVA substituted Nafion is being explored as a method to reduce the cost of fuel cell membrane materials. Despite the screening of a wide range of substitution concentrations and methods, no promising combinations have been identified.

Complex Impedance and NMR Studies of Electrosprayed Nafion Membranes

Researcher: Midshipman 2/C Joshua M. Mueller, USN
Adviser: Associate Professor Charles A. Edmondson

Nafion has long served as a benchmark material when evaluating the performance of proton conducting polymers used in PEM fuel cells. Traditionally, the membranes are cast from a liquid polymer-solvent solution. Recently, however, a different technique for fabricating membranes has been developed. The new technique makes use of the electrospraying process. The focus of this work was to compare the proton transport properties of electrosprayed membranes with those of traditionally cast Nafion. Complex impedance studies of the electrosprayed membranes were conducted in a controlled humidity chamber at atmospheric temperature and pressure for a wide range of relative humidities and a range of frequencies from about 1 mHz to about 1 MHz. The mass of each sample was determined in situ and the weight uptake of water was determined. The AC conductivity of the electrosprayed Nafion was calculated from the intercept of the highest frequency complex impedance arc. The AC conductivity as a function of weight percent of water uptake was compared with previously published data for commercial Nafion 117 films. Agreement between the cast and electrospray methods is good.

Analysis of the Conductivity of Li-BETI

Researcher: Midshipman 2/C Kevin R. Booher, USN
Adviser: Professor John J. Fontanella

The purpose of this project is to do a full analysis of the conductivity of a Lithium material suitable for use in batteries. The attempt to develop a polymer electrolyte that is useful in commercial application has been an important undertaking in recent years. One group of such polymers has a poly(ethylene oxide) (PEO) base and utilizes lithium. The material to be studied is $LiN(SO_2CF_2CF_3)_2$ (LiBETI). LiBETI utilizes a large counterion to maintain amorphous regions and thus conductivity. The amorphous regions still form at certain temperatures and pressures but at temperatures closer to that needed in commercial standards than many other lithium polymers. The research project comprises a systematic analysis of LiBETI of several different concentrations. The conductivity of the various samples is measured at varying temperatures and pressures. Initial experimentation has shown the pressure dependence to be very complex in nature.

Design and Analysis of Electron Scattering Experiments

Researchers: Midshipman 1/C Christopher R. Bickett, USN, Midshipman 1/C Nicholas C. Madren, USN, Midshipman 1/C Alexis F. Mosser, USN, Midshipman 1/C Christopher D. Roettgen, USN, Midshipman 2/C Cassidi A. Reese, USN and Midshipman 2/C Travis L. Wood, USN
Adviser: Assistant Professor Kevin L. McIlhany

It will be necessary to start analyzing up to one terabyte of data shortly after BLAST begins operation. There are several tasks well within the reach of midshipmen that can help the BLAST collaboration meet this challenge. Six students have been working on some of these throughout the 2002-2003 academic year. Midshipmen Bickett and Madren studied hardware concerns in the Helium-3 laboratory. Midshipman Bickett worked on the design of an RF field generator, while Midshipman Madren worked on the magnetic field simulation of a Helmholtz coil. Midshipman Roettgen wrote an event

generator for polarized electrons scattered from polarized helium-3. The events generated become the inputs to an accurate simulation of the BLAST detector. By creating simulated data within a computer model of the BLAST detector, one can analytically chase down problems found, such as collisions of particles with steel beams as well as heating issues and as well as identifying background rates. Midshipman Mosser worked on event simulation as well; however, the character of the events that she studied is dramatically different. Midshipman Mosser studied quasi-elastic scattering of polarized electrons from polarized helium-3. The main differences come from the final state of the collision; namely, there are more tracks as a result of a breakup of the helium-3 nucleus. Midshipman Wood worked to understand Midshipman Roettgen's efforts and continue where he has left off, furthering the study of polarized elastic scattering at BLAST. Midshipman Reese began work on neural network techniques for particle track reconstruction. Standard polygonal fitting algorithms are not as robust as non-linear routines such as neural networks, prompting the investigation by this midshipman.

Geometric Optics Demonstration Wheel

Researcher: Midshipman 1/C Charles C. Spivey, USN
Advisers: Professor Lawrence L. Tankersley and Professor Richard L. Martin (Electrical Engineering Department)

This physics demonstration apparatus was based on an Electrical Engineering design project to create a circuit that detects user inputs and responds by positioning a circular disk with mounted optical components. A five-beam laser ray box illuminates each optic in turn as it is positioned in the beam by the control/driver system. As a result, the basic actions of lenses, mirrors and plane refractive interfaces are illustrated.

Trident Scholar Projects

Investigation of Tellurium-130 Nuclear Structure Using Inelastic Neutron Scattering (Trident Report #303)

Researcher: Midshipman 1/C Tyler H. Churchill
Adviser: Professor Jeffrey R. Vanhoy

Tellurium (Te) has a wide range of abundant stable isotopes. Three different types of nuclear structure are anticipated to be active in these nuclei: collective, two-particle, and particle-hole excitations known as intruders. Because there are seven stable even-even Te nuclei, one can study the evolution of these excitation modes over a wide range in neutron number, allowing for good quantitative interpretation of the nuclear structure. Several models have been able to reproduce the level scheme of the lighter isotopes with masses A = 120 to 126. However, level energies are more important for evaluating whether a model has sufficient built-in complexity than distinguishing between alternate physical descriptions. Gamma-ray transition rates between levels can be a sensitive test of individual models.

In the present investigation, the excited states of ^{130}Te below 3.3 MeV in excitation energy were studied at the University of Kentucky Nuclear Structure Laboratory utilizing inelastic neutron scattering techniques (n,n'γ). The level scheme was constructed from gamma-ray excitation function and gamma-gamma coincidence data. The level scheme is comprised of approximately 100 energy levels and 170 gamma-ray transitions. Spectroscopic information about each level (lifetimes, electromagnetic transition rates, multipole mixing ratios, branching ratios, and level spins and parities) was deduced from measured gamma-ray angular distributions and Doppler shift data. These spectroscopic results contribute to the understanding of the behavior of vibrations in slightly deformed potential wells and the interplay of particle and collective structures in the tellurium isotopic chain.

The behavior of the ^{130}Te nucleus was examined from the viewpoints of the General Collective Model (GCM) and the Particle-Core Coupling Model (PCM). The GCM has difficulty reproducing the level scheme as an admixture of vibrational and rotational motion. Many of the low-lying states are severely misplaced. Using the PCM, the level scheme can be reproduced, but the agreement with transition rate data is lacking. In contrast to the lighter tellurium nuclei, the low-lying states of the ^{130}Te nucleus appear to be severe admixtures of the anticipated structures.

Physical Properties of Near-Earth Objects: Optical and Infrared Astronomical Observations (Trident Report #306)

Researcher: Midshipman 1/C Luke R. Dundon, USN
Adviser: Associate Professor Debora M. Katz

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 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 project was to determine the intrinsic characteristics of a sample of recently discovered NEOs. The sample was carefully chosen based on the NEOs' proper motion, magnitude, and position. Two weeks in Arizona were spent making thorough optical and infrared ground-based observations on the sample. Four telescopes were used: 1) the Kitt Peak National Observatory's 84-inch telescope with the Simultaneous Quad Infrared Imaging Device, 2) the University of Arizona's 90-inch Steward optical observatory, 3) Spacewatch's 72-inch optical telescope, and 4) the 16-inch Super Livermore Optical Transient Imaging System automatic telescope. These data were used to measure color photometry in six different bandpasses, and to make optical and infrared lightcurves.

These results were utilized to constrain the physical properties of the sample. The optical and infrared lightcurves were analyzed to determine the rotational properties and, where possible, the shape of the object. The taxonomic classification was constrained from three-color optical photometry, three-color infrared photometry, broadband spectra and albedo. From these taxonomic classifications, a chemical composition was assigned to each object. The combination of infrared and optical observations made in this Trident Project provides unique information about the physical characteristics of this sample of NEOs.

Journal (Refereed) Manuscripts

BENDLER, J. T., Associate Professor and FONTANELLA, J. J., Professor, "Anomalous Diffusion Near the Glass Transition," *Chemical Physics*, 284 (2002) p. 331.

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.

BENDLER, J. T., Associate Professor, EDMONDSON, C. A., Associate Professor, FONTANELLA, J. J., Professor, Shlesinger, M.F., and WINTERSGILL, M. C., Professor, "Electrical Conductivity in Glass-Forming Solid Electrolytes: Theory and Experiment*," Solid State Ionics*, 154-155 (2002) p. 337.

A theory of the ionic conductivity in polymer electrolytes based on defect diffusion is evaluated using previously published data. Those data include the pressure and temperature variation of the electrical conductivity for poly(dimethylsiloxane-ethylene-oxide) complexed with $NaCF_3COO$. In the defect diffusion model, ion transport is controlled by defects and ion motion occurs when the ion is encountered by a single defect. As temperature is lowered or pressure increases, the number of single defects decreases thus decreasing the ionic conductivity. Further, there exists a pressure dependent critical temperature, T_c, below which single defects do not exist. It is shown how the pressure dependence of the conductivity is controlled by the pressure dependence of T_c. The theory is used to predict the variation with temperature of both the apparent activation volume and curvature in plots of the logarithm of the conductivity with pressure.

BENDLER, J. T., Associate Professor and FONTANELLA, J. J., Professor, "Physical Basis of Fragility," Journal of Chemical Physics, 118 (2003) p. 6713.

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, Shlesinger, M. F., and WINTERSGILL, M. C., Professor, "The Need to Reconsider Traditional Free Volume Theory for Polymer Electrolytes," Electrochimica Acta, 48 (2003) p. 2267.

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/VP=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.

BIERMANN, Mark L., Assistant Professor and Rabinovich, W. S., "Double Polarization Anisotropy in Asymmetric, Coupled Quantum Wells under Anisotropic, In-Plane Strain," Optics Express, 10 (2002) p. 1105.

A novel coupled-quantum-well system is described in which the in-plane, anisotropic strain in successive well layers alternates between compression and tension. A polarization anisotropy in the interband optical matrix elements that arises due to anisotropic strain is reversed between the compressive and tensile cases. Hence, transitions associated with the different well layers have reversed polarization anisotropies. The structure of interest has great flexibility in the energies of successive interband transitions, and in the size of the anisotropy of the various transitions. The structure can be used in describing quantum-well properties, in optical multiplexing, and in devices such as modulators.

BIERMANN, Mark L., Assistant Professor, KATZ, Debora, Associate Professor, AHO, Robert, Midshipman 1/C (USN), DIAZ-BARRIGA, James, Midshipman 1/C (USN), and PETRON, Jerome, Midshipman 1/C (USN), "Wein's Law and the Temperature of the Sun," *The Physics Teacher*, 40 (2002) p. 398.

An experiment was conducted to test the validity of Wein's Law to determine the temperature of the sun based on the solar spectrum as measured at sea level. Apparently excellent results were obtained, but a closer analysis showed that the results were actually merely fortuitous and Wein's Law is not a valid means of determining the temperature of the sun using a sea-level solar spectrum. Specifically, the spectral response of the spectrometer offset the change in the solar spectrum due to atmospheric absorption and scattering in such a way that the result matched accepted values well. It was also determined that intervening clouds have little effect on this result and that the overall shape of the solar spectrum is the same on cloudy and clear days. Finally, it was found that the background light must be treated with care on a cloudy day since the direct light from the sun is, relatively speaking, much dimmer on a cloudy day.

BIERMANN, MARK L., Assistant Professor, DIAZ-BARRIGA James, Midshipman 1/C (USN), and Rabinovich, W. S., "Enhanced Optical Polarization Anisotropy in Quantum Wells under Anisotropic Tensile Strain," *Institute of Electrical and Electronics Engineers (IEEE) Journal of Quantum Electronics,* 39, #3 (2003) p. 401.

Anisotropic, in-plane strain in quantum wells leads to an optical, polarization anisotropy that can be exploited in opto-electronic devices such as modulators. A theoretical model shows that the behavior of the polarization anisotropy with increasing strain anisotropy is radically different for quantum wells under anisotropic tensile and

compressive strains of equal magnitude. This strikingly different behavior arises from the different valence-subband mixing that occurs in the cases of anisotropic tensile and compressive strain. Specifically, the mixing of the first heavy- and light-hole subbands that occurs only under anisotropic tensile strain is central to the polarization anisotropy.

BIERMANN, MARK L., Assistant Professor, DIAZ-BARRIGA James, Midshipman 1/C (USN), and Rabinovich, W. S., "An Optical Method for Determining Strain Anisotropy in Quantum Wells," *Applied Optics*, 42 (2003) p. 3558.

Anisotropic in-plane strain arises in quantum-well systems by design or unintentionally. We propose two methods of measuring the in-plane strain anisotropy based on the optical polarization anisotropy that arises with anisotropic, in-plane strain. One method uses purely optical means to determine the strain anisotropy in quantum wells under compressive strain that is spatially varying. A second approach, applicable to quantum wells under tensile strain or with strain that does not vary with position, requires the application of a uniaxial, in-plane stress. While the second method is experimentally more difficult, it allows analysis of systems that would otherwise be inaccessible.

Brown, T. B., Riley, M. A., Campbell, D., HARTLEY, D. J., Assistant Professor, Kondev, F. G., Pfohl, J., Janssens, R. V. F., Fischer, S. M., Nisius, D., Fallon, P., Ma, W. C., Simpson, J, and Sharpey-Schafer, J. F., "Rotational Band Structures in N = 89 ^{153}Gd," *Physical Review C,* 66 (2002) p. 064320.

The reactions ^{152}Sm(a,3n) at 37 MeV and ^{124}Sn(36S, a3n) at 165 MeV were used to produce high-spin states in the transitional rare-earth nucleus ^{153}Gd. Significant extensions in angular momentum and excitation energy with respect to earlier work were achieved and several new rotational sequences were observed. The rotational behavior of ^{153}Gd is described in terms of quasiparticle assignments and the observed alignment properties are analyzed within the framework of the cranked shell model. Detailed comparisons with other N = 89 nuclei are presented. These have led to corrections to the ^{157}Er level scheme.

BUTLER, James J., Assistant Professor, WATHEN, Jeremiah J. (Trident Scholar, Class of 2002), Flom, S.R., Pong, R.G.S., and Shirk, J.S., "Optical Limiting Properties of Nonlinear Multimode Waveguides," *Optics Letters*, 28 (2003) p. 1689.

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., HARTLEY, D. J., Assistant Professor, Kondev, F. G., Carpenter, M. P., Janssens, R. V. F., Riedinger, L. L., Abu Saleem, K. H., Ahmad, I., Amro, H., Balabanski, D. L., Cizewski, J. A., Davids, C. N., Heinz, A., Khoo, T. L., Lauritsen, T., Lister, C. J., Ma, W. C., Poli, G. L., Ressler, J., Reviol, W., Smith, M. B., Seweryniak, D., and Wiedenhover, I., "In-Beam γ-ray Spectroscopy of ^{172}Pt," *Physical Review C,* 67 (2003) p. 014312.

Collective structures in ^{172}Pt have been investigated by measuring in-beam γ rays with mass selection and the recoil-decay tagging technique. The discrepancy in the ground-state band from previous studies has been resolved, and a new collective structure that is likely based on an octupole vibration has been identified. A band-mixing model is used to determine the properties of the competing near-spherical and deformed ground-state sequences in the light Os-Pt-Hg-Pb region. Evidence for a reduction of deformation in the deformed vacuum structure below N = 98 is presented.

Djongolov, M. K., HARTLEY, D. J., Assistant Professor, Riedinger, L. L., Kondev, F. G., Janssens, R. V. F., Abu Saleem, K., Ahmad, I., Balabanski, D. L., Carpenter, M. P., Chowdhury, P., Cullen, D. M., Danchev, M., Dracoulis, G. D., El-Masri, H., Goon, J., Heinz, A., Kaye, R. A., Khoo, T. L., Lauritsen,T., Lister, C. J., Moore, E. F., Riley, M. A., Seweryniak, D., Shestakova, I., Sletten, G., Walker, P. M., Wheldon, C., Wiedenhover, I., Zeidan, O., and Zhang, Jing-ye, "Extending the Region of Triaxial Superdeformation: Candidate TSD Bands in ^{174}Hf," *Physics Letters B,* 560 (2003) p. 24.

Three, possibly four, regularly spaced rotational bands with large dynamic moments of inertia have been identified in ^{174}Hf. Their properties are consistent with known triaxial superdeformed bands of the Lu/Hf region. Calculations predict substantial triaxial deformation ($\gamma \sim \pm 17^{\circ}$) for ^{174}Hf structures with deformation $\varepsilon_2 \sim 0.45$, despite the fact that ^{174}Hf is eight neutrons away from the previously established N = 94 triaxial superdeformed gap. Shell gaps at N = 100 and 106 with $\gamma \geq 15^{\circ}$ are predicted for $\varepsilon_2 \sim 0.45$, and are most likely responsible for the calculated TSD minima in ^{174}Hf.

EDMONDSON, C. A., Associate Professor and FONTANELLA, J. J., Professor, "Free Volume and Percolation in S-SEBS and Fluorocarbon Proton Conducting Membranes," *Solid State Ionics,* 152-153 (2002) p. 355.

Electrical conductivity results at a variety of pressures, temperatures and water contents are evaluated for sulfonated styrene/ethylene-butylene/styrene (S-SEBS) triblock polymer, Nafion 117, and Dow 800 proton conducting membranes. In addition, room temperature and atmospheric pressure diffusion coefficients determined from conductivity and 1H pulsed gradient spin-echo nuclear magnetic resonance (NMR) studies are considered. While the S-SEBS and fluorocarbons exhibit a percolation threshold at 10 and 4 wt-%, respectively, all materials exhibit this phenomenon at a volume water fraction of C^{a}0.035. Above the threshold the conductivity exhibits a power law behavior. When the volume of the hydrophobic portion of the membrane is subtracted the threshold occurs at the adjusted volume fraction of CA^{a}0.12 which approaches that expected for continuum percolation. The activation volume results are shown to be consistent with free volume considerations.

ERTEL, J.P., Associate Professor, and Dickey, Joe, "The Focusing of Transient Response in Structural Networks: 'Hot Spots'", *Acoustics Research Letters Online*, 4, 1 (2003) p. 1.

When a structural network is driven at a point in one of its systems, other points in other systems may experience anomalously high response. These are termed "hot spots." The phenomena may be of importance in networks where one or more of the subsystems are fragile. Such networks may be driven in a robust system and break at a hot spot in a fragile system. The phenomena are demonstrated in the calculated spatial/temporal response of simple models of connected one-dimensional wave-bearing systems.

FONTANELLA, J. J., Professor, "Investigation of the Correlation between Structural Relaxation Time and Configurational Entropy under High Pressure in a Chlorinated Biphenyl," *Journal of Chemical Physics*, 117 (2002) p. 4901.

Dielectric relaxation measurements on a chlorinated biphenyl (PCB62) were carried out over a broad frequency range, by varying both temperature and pressure. Along with calorimetric determinations of the configurational entropy, these data were successfully described using the Adam-Gibbs model. Specifically, the experimental results were interpreted using a recently introduced equation which describes both temperature and pressure dependences of the structural relaxation time. The $\tau(T,P)$ data for PCB62 yielded values of the fitting parameters consistent with the known physical properties of the material. A change of the dynamics was evident in isobaric measurements at atmospheric pressure, corresponding to a value of the relaxation time $\tau_B \sim 10^6$ s. A likely-related change of dynamics was observed in isothermal experiments at varying pressures. It is noteworthy that the latter transpired similarly at $\tau = \tau_B$, which may be the first reported evidence of such a change of dynamics in experiments with pressure as a variable.

FONTANELLA, J. J., Professor, "Transport and Structural Studies of Sulfonated Styrene-Ethylene Copolymer Membranes," *Macromolecules*, 35 (2002) p. 5916.

A new class of proton-conducting membranes derived from sulfonation of commercial styrene-ethylene copolymers is reported. Conductivities in excess of 0.1 S/cm are obtained depending upon copolymer composition and

sulfonation level. The dependence of conductivity on humidity has been measured and compared with similar dependencies for Nafion and a sulfonated block copolymer. X-ray and neutron scattering studies suggest the presence of a bi-continuous network of hydrophilic and hydrophobic domains in water-swollen samples.

Hernandez-Andres, J., and LEE, R. L., Jr., Assistant Professor, "Color and Luminance Asymmetries in the Clear Sky," *Applied Optics*, 42 (2003) p. 458.

A longstanding assumption about the clear sky is that its colors and luminances are distributed symmetrically about the principal plane. As useful as this approximation is, our digital image analyses show that the clear-sky color and luminance routinely depart from exact symmetry. These analyses reconfirm our earlier measurements with narrow field-of-view spectroradiometers [Hernandez-Andres et al., J. Opt. Soc. Am. A 18, 2001], and they do so with much higher temporal and angular resolution across the entire sky dome.

Krolas, W., Grzywacz, R., Rykaczewski, K. P., Batchelder, J. C., Bingham, C. R., Gross, C. J., Fong, D., Hamilton, J. H., HARTLEY, D. J., Assistant Professor, Hwang, J. K., Larochelle, Y., Lewis, T. A., Maier, K. H., McConnell, J. W., Piechaczek, A., Ramayya, A. V., Rykaczewski, K., Shapira, D., Tantawy, M. N., Winger, J. A., Yu, C.-H., Zganjar, E. F., Kruppa, A.T., Nazarewicz, W., and Vertse, T., "First Observation of Excited States in ^{140}Dy," *Acta Physica Polanica*, B34 (2003) p. 2315.

A new 7 μs isomer in the drip line nucleus ^{140}Dy was selected from the products of the ^{54}Fe (315 MeV) + ^{92}Mo reaction by a recoil mass spectrometer and studied with recoil-delayed γ–γ coincidences. Five cascading γ transitions were interpreted as the decay of an $I^{\pi} = 8^{-}$ $\{\nu 9/2^{-}[514] \otimes \nu\ 7/2^{+}[404]\}$ K isomer (T1/2 = 7.0(5) μs) via the ground-state band. The probability of proton emission from ^{141}Ho to the 0^{+} ground state and to the 2^{+} excited state in ^{140}Dy is discussed.

LEE, R. L., Jr., Assistant Professor, and Hernandez-Andres, J., "Measuring and Modeling Twilight's Purple Light," *Applied Optics*, 42 (2003) p. 445.

During many clear twilights, much of the solar sky is dominated by pastel purples. This purple light's red component has long been ascribed to transmission through and scattering by stratospheric dust and other aerosols. Clearly the vivid purples of post-volcanic twilights are related to increased stratospheric aerosol loading. Yet our time-series measurements of purple-light spectra, combined with radiative transfer modeling and satellite soundings, indicate that background stratospheric aerosols by themselves do not redden sunlight enough to cause the purple light's reds. Furthermore, scattering and extinction in both the troposphere and the stratosphere are needed to explain most purple lights.

MIKULSKI, Paul. T., Assistant Professor, and HARRISON, Judith A., Professor (Chemistry Department), "The Molecular-Scale Tribology of Amorphous Carbon Coatings: Effects of Film Thickness, Adhesion, and Long-Range Interactions," *Journal of the American Chemical Society*, 124 (2002) p. 7202.

Classical molecular dynamics simulations have been conducted to investigate the atomic-scale friction and wear when hydrogen-terminated diamond (111) counterfaces are in sliding contact with diamond (111) surfaces coated with amorphous, hydrogen-free carbon films. Two films, with approximately the same ratio of sp^3-to-sp^2 carbon, but different thicknesses, have been examined. Both systems give a similar average friction in the load range examined. Above a critical load, a series of tribochemical reactions occur resulting in a significant restructuring of the film. This restructuring is analogous to the "run-in" observed in macroscopic friction experiments and reduces the friction. The contribution of adhesion between the probe (counterface) and the sample to friction was examined by varying the saturation of the counterface. Decreasing the degree of counterface saturation, by reducing the hydrogen termination, increases the friction. Finally, the contribution of long-range interactions to friction was examined by using two potential energy functions that differ only in their long-range forces to examine friction in the same system.

MUNGAN, C. E., Assistant Professor, "Thermodynamics of Radiation-Balanced Lasing," Journal of the Optical Society of America, B, 20 (2003) p. 1.

Athermal lasers dispose of their waste heat in the form of spontaneous fluorescence (i.e., by laser cooling) to avoid warming the medium. The thermodynamics of this process is discussed both qualitatively and quantitatively from the point of view of the first and second laws. The steady-state optical dynamics of an ytterbium-doped $KGd(WO_4)_2$ fiber is analyzed as a model radiation-balanced solid-state laser. A Carnot efficiency for all-optical amplification is derived in terms of the energy and entropy transported by the pump, fluorescence, and laser beams. This efficiency is compared to the performance of the model system.

MUNGAN, C. E., Assistant Professor, "Sliding on the Surface of a Rough Sphere," The Physics Teacher, 41 (2003) p. 2.

A point particle slides down a rough sphere starting from the top. Ultimately it either comes to rest or leaves the surface, depending on the initial speed and coefficient of friction.

Radford, D. C., Baktash, C., Galindo-Uribarri, A., Gross, C. J., Lewis, T. A., Mueller, P. E., Hausladen, P. A., Shapira, D., Stracener, D. W., Yu, C.-H., Fuentes, B., Padilla, E., HARTLEY, D. J., Assistant Professor, Barton C. J., Caprio M. and Zamfir, N. V.," Physics with Heavy Neutron-Rich RIBs at the HRIBF," *European Physical Journal,* A 15 (2002) p. 171.

The Holifield Radioactive Ion Beam Facility at Oak Ridge National Laboratory has recently produced the world's first post-accelerated beams of heavy neutron-rich nuclei. The first experiments with these beams are described, and the results discussed. Values for neutron-rich ^{126,128}Sn and ^{132,134,136}Te isotopes have been measured by Coulomb excitation in inverse kinematics. The results for ^{132}Te and ^{134}Te (N=80,82) show excellent agreement with systematics of lighter Te isotopes, but the B(E2) value for ^{136}Te (N=84) is unexpectedly small. Single-neutron transfer reactions with a ^{134}Te beam on Be and ^{13}C targets at energies just above the Coulomb barrier have also been studied.

Smith, M. B., Cizewski, J. A., Carpenter, M. P., Kondev, F. G., Khoo, T. L., Lauritsen, T., Janssens, R. V. F., Abu Saleem, K., Ahmad, I., Amro, H., Danchev, M., Davids, C. N., HARTLEY, D. J., Assistant Professor, Heinz, A., Lister, C. J., Ma, W. C., Poli, G. L., Ressler, J. J., Reviol, F. W., Riedinger, L. L., Seweryniak, D., and Wiedenhover, I., "Limits of the Energy-Spin Phase Space beyond the Proton Drip Line: Entry Distributions of Pt and Au Isobars," Physics Letters, B 551 (2003) p. 262.

Entry distributions in angular momentum and excitation energy have been measured for several very proton-rich isotopes of Pt and Au. This is the first systematic study of the energy-spin phase space for nuclei near and beyond the proton drip line. Comparisons are made between the distributions associated with proton-unbound Au nuclei and more stable Pt isobars. In ^{173}Au the first evidence is seen for the limits of excitation energy and angular momentum which a nucleus beyond the proton drip line can sustain.

Tomm, Jens W., Gerhardt, Axel, Müller, Roland, BIERMANN, Mark L., Assistant Professor, HOLLAND, Joseph P., Midshipman 1/C (USN), Lorenzen, Dirk, and Kaulfersch, Eberhard, "Quantitative Strain Analysis in AlGaAs-Based Devices," *Applied Physics Letters*, 82 (2003) p. 4193.

We present a strategy for quantitative spectroscopic analysis of packaging-induced strain using both finite element analysis and bandstructure calculations. This approach holds for a wide class of AlGaAs-based, and related, devices, among them high-power 'cm-bars'. The influence on the results of particular device structure properties, such as intrinsic strain and QW geometry, is analyzed. We compare theoretical results based on a uniaxial stress model with PC data obtained from an externally strained 'cm-bar' and obtain better agreement than from alternative strain models. The general approach is also applicable to the analysis of all data that refer to changes of the electronic bandstructure such as absorption, PL and micro-PL.

TUCHOLSKI, Edward J., Commander (USN), Assistant Professor, White, J. E., and Green, Robert E. Jr., "Nondestructive Evaluation of Aircraft and Spacecraft Wiring," *Materials Evaluation*, accepted for publication.

Spacecraft, and especially aircraft, often fly well past their original design lives and, therefore, the need to develop nondestructive evaluation procedures for inspection of vital structures in these craft is extremely important. One of the more recent problems is the degradation of wiring and wiring insulation. The present paper describes several nondestructive characterization methods which afford the possibility to detect wiring and insulation degradation in-situ prior to major problems with the safety of aircraft and spacecraft.

Young, A., Rudnick, L., KATZ-stone, Debora M., Associate Professor, and O'Donoghue, A. A., "Electron Population Aging Models for Wide-Angle Tails," *New Astronomy Reviews*, 46 (2002) p. 105.

Color-color diagrams have been useful in studying the spectral shapes in radio galaxies. At the workshop we presented color-color diagrams for two wide-angle tails, 1231+674 and 1433+553, and found that the standard aging models do not adequately represent the observed data. Although the JP and KP models can explain some of the observed points in the color-color diagram, they do not account for those found near the power-law line. This difficulty may be attributable to several causes. Spectral tomography has been previously used to discern two separate electron populations in these sources. The combination spectra from two such overlying components can easily resemble a range of power-laws. In addition, any non-uniformity in the magnetic field strength can also create a power-law-like spectrum. We will also discuss the effects that angular resolution has on the shape of the spectrum.

Zeidan, O., HARTLEY, D.J., Riedinger, L.L., Reviol, W., Weintraub, W.D., Sun, Y., Zhang, Jing-ye, Galindo-Uribarri, A., Paul, S.D., Sarantities, D.G., Devlin, M., Carpenter, M.P., Janssens, R. V. F., and Seweryniak, D., "Yrast Spectroscopy of ^{128}Nd and Systematics of the $\nu h_{11/2}$ Crossing in A~130 nuclei," *Physical Review*, C 66 (2002) p. 044311.

High-spin states in ^{128N}d were populated with the ^{92}Mo (^{40}Ca, 2p2n) reaction at a beam energy of 184 MeV. The previously known ground-state band has been extended to $I^{\pi} = (34^{+})$ and four sidebands were observed. Configuration assignments for these sidebands are discussed based on their alignment behavior. A significant delay of the $\nu h_{11/2}$ crossing frequency is observed in the A~130 region, with the largest delays occurring consistently at N = 70. Cranked shell model calculations were performed in order to investigate whether a variation of deformation and/or pairing parameters can account for this phenomenon.

Conference Proceedings

Batchelder, J. C., Bingham, C. R., Gross, C. J., Grzywacz, R., Hamilton, J. H., HARTLEY, D. J., Assistant Professor, Hagino, K., Karny, M., Krolas, W., Larochelle, Y., McConnell, J. W., Piechaczek, A., Rykaczewski, K. P., Rykaczewski, K., Semmes, P. A., Tantawy, M. N., Winger, J. A., Yu, C. H., and Zganjar, E. F., "Recent Results of Proton Drip-Line Studies at the HRIBF Recoil Mass Spectrometer," *Proceedings from the Frontiers of Nuclear Structure Conference*, Berkeley, CA, July 2002, P. Fallon and R. Clark, Eds., AIP Conference Proceeding 656, (2003) p. 77.

The observation of fine structure in proton emission allows one to measure the composition of the parent state's wavefunction and the deformation of the daughter state. A systematic study of proton-unbound nuclei in the rare earth region is ongoing at the HRIBF. Newly discovered fine structure in the decays of ^{145}Tm and ^{141}Ho are discussed, as well as advances in our experimental equipment.

BIERMANN, Mark L., Assistant Professor, HOLLAND, Joseph P., Midshipman 1/C (USN), Tomm, Jens W., Gerhardt, Axel, and Lorenzen, Dirk, "Modeling of Packaging-Induced Strains in Quantum-Well Laser," *OSA Trends in Optics and Photonics (TOPS) 59, Conference on Lasers and Electro-Optics (CLEO 2003),* Baltimore, MD, June 2003. (CD-ROM)

Interband energy shifts due to strain that arises via a combination of diode-laser, device-packaging effects and lattice-mismatch are theoretically modeled and used to interpret the strain situation in commercial devices. Packaging of optoelectronic devices, such as high power diode lasers, substantially impacts total device costs and

device lifetime. Thus, the development of stress-reduced packaging techniques is an important goal. This goal requires reliable stress or strain measurement techniques, applicable to packaged devices. One such technique is the analysis of the strain-induced changes in the bandstructure of the semiconductor materials employed in the optoelectronic device. Raman and photoluminescence spectroscopy are applied to the substrates of these devices. However, it is highly desirable to use the optically active layer, especially the quantum-wells (QW) themselves, as 'strain sensors,' as is done in electroluminescence and photocurrent (PC) experiments. Such an approach requires a theory describing the strain condition in the QWs of a packaged device. We demonstrate how strain-induced QW energy shifts serve as a 'strain sensor' for analysis of packaging-induced strain in high-power laser devices. This technique is available to crosscheck strain data obtained from the waveguide, or the substrate.

CHURCHILL, T. H., Midshipman 1/C (USN), VANHOY, J. R., Professor, and Hicks, S.F., "Investigation of Tellurium-130 Nuclear Structure Using Inelastic Neutron Scattering," *Proceedings: 13th National Conference on Undergraduate Research 2003*, Salt Lake City, NV, March 2003, R.D. Yearout, Ed., Asheville: University of North Carolina at Asheville Press (2003).

The excited states of tellurium-130 have been identified from gamma ray spectra measured following inelastic neutron scattering. The energy level scheme has been constructed and spectroscopic information such as excitation energies, lifetimes, level spins and parities, decay branching ratios, and multipole-mixing ratios have been extracted. The behavior of the 130Te nucleus is examined from the viewpoint of previously existing particle-core coupling model calculations. The level scheme can be reproduced, but agreement with transition rate data is lacking.

ENGLE, I.M., Professor, "Incorporation of an Enhanced Magnetotail into the Model of the Global Saturnian Magnetosphere," *Meeting book of the Magnetospheres of the Outer Planets,* Laurel, MD, July 2002.

An extension to the global Saturnian magnetosphere model can be developed by adding a realistic magnetotail, which heretofore, the model has lacked. The magnetotail structure provides a mechanism for the rejoining of deflected solar wind particles after they have traveled beyond the planet, following the deflection from their original paths as a result of interaction with the magnetospheric field. These particles generate a dawn-to-duskward crosscurrent as they re-merge to eventually form a neutral plasma streaming outwards. The cross-tail current sheet with its associated return currents generates a magnetotail magnetic field, an additional contribution to the overall Saturnian magnetospheric field. The incorporation of a magnetotail that fills the tail region space out to the magnetopause boundary into Saturn's magnetosphere has enhanced the range wherein the model may be said to be applicable. This paper incorporates an enhanced magnetotail into previous global Saturnian magnetospheric models of Maurice and Engle, Maurice, Engle, Blanc, and Skubis, and the work done by Mr. Jeremy Bruch (Trident Scholar, Class of 1999).

HARTLEY, D. J., Assistant Professor, Djongolov, M., Riedinger, L. L., Kondev, F. G., Janssens, R. V. F., Abu, Saleem, K., Ahmad, I., Balabanski, D. L., Carpenter, M. P., Chowdhury, P., Cullen, D. M., Danchev, M., Dracoulis, G. D., El-Masri, H., Goon, J., Heinz, A., Kaye, R. A., Khoo, T. L., Lauritsen, T., Lister, C. J., Moore, E. F., Riley, M. A., Seweryniak, D., Shestakova, I., Sletten, G., Walker, P. M., Wheldon, C., Wiedenhover, I., Zeidan, O., and Zhang, J.-Y., "Possible Triaxial Superdeformation in ^{174}Hf," *Proceedings from the Frontiers of Nuclear Structure Conference*, Berkeley, CA, July 2002, P. Fallon and R. Clark, Eds., AIP Conference Proceeding 656, (2003), p. 177.

Three, possibly four, regularly spaced rotational bands with large dynamic moments of inertia have been identified in ^{174}Hf. Their properties are consistent with known triaxial superdeformed bands of the Lu/Hf region. Calculations predict substantial triaxial deformation ($\gamma \sim \pm 17^\circ$) for ^{174}Hf structures with deformation $\varepsilon_2 \sim 0.45$, despite the fact that ^{174}Hf is eight neutrons away from the previously established N = 94 triaxial superdeformed gap. Shell gaps at N = 100 and 106 with $\gamma \geq 15^\circ$ are predicted for $\varepsilon_2 \sim 0.45$, and are most likely responsible for the calculated TSD minima in ^{174}Hf.

KORMAN, M. S., Professor, and Sabatier, James M., "Nonlinear Tuning Curve Vibration Response of a Buried Landmine," Proceedings of SPIE - The International Society for Optical Engineering, Detection and Remediation Technologies for Mines and Minelike Targets VIII, Orlando, FL, April 2003, Russell S. Harmon, John H. Holloway and J. Thomas Broach, Eds., Volume 5089, paper No. 57 (2003).

Measurements of the acoustic impedance of a VS 2.2 anti-tank plastic landmine reveal significant resonances in the frequency range between 80 and 650 Hz. The top surface resonances are due to its complicated mechanical structure vibrating in air. The lowest mode of the landmine results in a high Q simple harmonic oscillator resonance of the top surface, which behaves like a rigid mass. At higher frequencies the top surface behaves like thin circular plate acoustic modes. When these landmines are buried in soils, the modes are mass loaded. Resonances from measurements of the normal component of the acoustically induced soil surface particle velocity (due to sufficient acoustic-to-seismic coupling) are used for 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. Here, the structure of a family of resonant tuning curves for relatively low amplitude, but nonlinear drive levels, reveals the "nonclassical" nonlinear resonant behavior of the soil-landmine oscillator.

KORMAN, M. S., Professor, and Sabatier, James M., "Nonlinear Acoustic Techniques for Land Mine Detection," *Proceedings of the 16th International Symposium on Nonlinear Acoustics*, Moscow, Russia, August 2002, O. V. Rudenko, Ed., AIP Press, (2002).

Donskoy [SPIE Proceedings 3392, 211-217 (1998); 3710, 239-246 (1999)] has suggested a nonlinear technique that can detect an acoustically compliant buried mine that is insensitive to relatively noncompliant targets. Airborne sound at two primary frequencies f_1 and f_2 undergoes acoustic-to-seismic coupling and a superimposed seismic wave interacts with the compliant mine and soil to generate a difference frequency component that can effect the vibration velocity at the surface. Geophone measurements scanning the soil surface at the difference frequency (chosen at a resonance) profile the mine with more relative sensitivity than the linear profiles - but off the mine some nonlinearity exists. Amplitude dependent frequency response curves for a harmonically driven mass-soil oscillator are used to find the parameter of nonlinearity of the soil acting as a "soft" spring. Donskoy's nonlinear mechanism (over the mine) involves the top surface of the mine-soil planar surface. During the compression phase of the wave, the surfaces stay together and then separate under the tensile phase due to a relatively high compliance of the mine. This effect is thought to be a bi-modular oscillator that is inherently nonlinear.

Tucker, J. E., Reintjes, J., TANKERSLEY, L. L., Professor, Sebok, T., Thoresen, H., Fjerdinstad, S., and Howard, P. L., "On Line Operation of LaserNet Fines with Accurate Sampling," *Proceedings of American Society of Naval Engineers Intelligent Ships Symposium V*, Philadelphia, PA, May 2003. (CD-ROM)

Debris analysis of oil-wetted machinery can provide fault-specific information to support diagnostics and prognostics for machinery maintenance. Common practice is to draw an oil sample from an access point and have that sample analyzed on site or at a remote laboratory. Effective monitoring of machinery health requires both accurate sampling of the lubrication system and effective analysis of the debris in the sample. Inaccurate or inconsistent sampling can easily lead to erratic trending results, while ineffective sample analysis can miss critical faults. This paper describes the combination of a batch bottle sampler LaserNet Fines imaging optical debris monitor with FRAS AS's DynaSamp™ on-line fluid sampler to create an on-line, accurate, and automatic particle analyzer. Results of this analyzer combination operating directly on a fluid line in an oil flow test stand are reported.

VanLehn, Kurt, Lynch, Collin, Taylor, Linwood, SHELBY, Robert N., Professor, SCHULZE, Kay G., Professor, TREACY, Donald J., Professor, and WINTERSGILL, Mary C., Professor, "Minimally Invasive Tutoring of Complex Physics Problem Solving," Proceedings of the 6th International Conference on Intelligent Tutoring Systems, Biarritz, France and San Sebastian, Spain, (S. Cerri, G. Gouarderes, and F. Paraguacu, Eds.) (2002) p. 367.

Solving complex physics problems requires some kind of knowledge for selecting appropriate applications of physics principles. This knowledge is tacit, in that it is not explicitly taught in textbooks, existing tutoring systems or anywhere else. Experts seem to have acquired it via implicit learning and may not be aware of it. Andes is a coach for physics problem solving that has good evaluations, but still does not teach complex problem solving as

well as we would like. The conventional ITS approach to increasing its effectiveness requires teaching the tacit knowledge explicitly, and yet this would cause Andes to be more invasive. In particular, the textbooks and instructors would have to make space in an already packed curriculum for teaching the tacit knowledge. This paper discusses our attempts to teach the tacit knowledge without making Andes more invasive.

WATHEN Jeremiah J. (Trident Scholar, Class of 2002), BUTLER, James J., Assistant Professor, and Shirk, J.S., "Transmission Properties of Nonlinear Multimode Waveguides," *OSA Trends in Optics and Photonics (TOPS) 59, Conference on Lasers and Electro-Optics (CLEO 2003),* Baltimore, MD, June 2003.

Multimode capillary waveguides containing reverse-saturable absorbers demonstrate an unexpected enhancement of the nonlinear response. It is shown that this result stems from partial mode filling within the cores of such waveguides.

Books

Tipler, Paul A. and MOSCA, Eugene P., Professor, "Physics for Scientists and Engineers", Vol. 1, 5th ed., New York: W.H. Freeman (2003).

This is the first volume of a three-volume calculus-based physics textbook that has been used at the Naval Academy for the introductory physics sequence for physics majors since the 1970s. The volume consists of 20 chapters that cover kinematics, mechanics, oscillations and waves, and thermodynamics. New features include context-rich problems and a new chapter of special relativity.

Book Chapters

BENDLER, J. T., Associate Professor, and FONTANELLA, J. J., Professor, "Why Conductivity Decreases with Pressure in Ion-Doped Polymers," International Workshop and collection of articles honoring Professor Antonio Coniglio on the occasion of his 60th Birthday, Scaling and Disordered Systems, Singapore, World Scientific (2002) pages 93 to 97.

The relaxation time scale in glassy materials is derived within a model of anomalous defect diffusion. The effect of the defects on ion-doped polymeric glasses is to produce a stretched exponential waiting time distribution for ion jumps. The characteristic time scale for ion jumps is connected to the temperature and pressure dependent concentration of mobile defects. The resultant expression for ionic conductivity is compared with experimental results for the polymer electrolytes poly(ethylene glycol) (PEG) and poly(propylene glycol) (PPG) containing $LiCF_3SO_3$.

MIKULSKI, Paul T., Assistant Professor, "The Friction of Model Self-Assembled Monolayers (SAMs)", in Encyclopedia of Nanoscience and Nanotechnology, H. S. Nalwa, Ed., American Scientific Publishers, Los Angeles (2003).

Molecular dynamics (MD) simulation is a useful tool that can be used to model atomic-scale probes in sliding contact with SAMs, providing information that would otherwise be unavailable. Like Atomic Force Microprobe (AFM) experiments, MD experiments are faced with a number of difficult challenges, most notably problems of scale. Despite the exponential growth in computing power, it will be quite some time before the time and length scales of laboratory experiments can be approached. Computational groups that have undertaken MD investigations of the tribology of SAMs have often taken very different approaches. Broadly, the differences can be addressed by a number of basic questions: How are atomic-interactions modeled? How are the initial SAMs and the initial probing tips designed? How are external forces used to control load and temperature? How are the challenges of length and time scales handled? These questions are not independent of one another. However, they do provide a useful framework within which the work in this field can be understood. This review focuses on work by groups

that have undertaken computational studies aimed at complementing AFM or surface force apparatus (SFA) tribology experiments with SAMs.

Technical Reports

BENDLER, J. T., Associate Professor, and FONTANELLA, J. J., Professor, "A New Vogel-Like Law: Ionic Conductivity, Dielectric Relaxation, and Viscosity near the Glass Transition," Office of Naval Research Technical Report #29, 1 July 2002.

A model, based on defect diffusion, is developed that describes temperature and pressure dependence of dielectric relaxation, ionic conductivity and viscosity of glass-forming liquids near the glass transition temperature. The resultant expressions for ionic conductivity are compared with experimental results for the polymer electrolytes poly(ethylene glycol) (PEG) and poly(propylene glycol) (PPG) containing $LiCF_3SO_3$. Those for dielectric relaxation are compared with experimental results for poly(propylene oxide) (PPO) and poly(vinyl acetate). The theoretical viscosity law is compared to experiments on propylene carbonate (PC).

BENDLER, J. T., Associate Professor, FONTANELLA, J. J., Professor, and WINTERSGILL, M. C., Professor, "The Need to Reconsider Traditional Free Volume Theory for Polymer Electrolytes, "Office of Naval Research Technical Report #30, 1 July 2002.

Pressure-temperature-volume (PVT) data have been obtained for poly(propylene glycol) of molecular weight 10^{25} 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 = 296 K, 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.

Trident Scholar Reports

CHURCHILL, Tyler H., Midshipman 1/C (USN), "Investigation of Tellurium-130 Nuclear Structure Using Inelastic Neutron Scattering," *U. S. Naval Academy Trident Scholar Report,* No. 303 (2003).

The excited states of ^{130}Te below 3.3 MeV in excitation energy were studied at the University of Kentucky Nuclear Structure Laboratory utilizing inelastic neutron scattering techniques (n,n'γ). The level scheme was constructed from gamma-ray excitation function and gamma-gamma coincidence data. The level scheme is comprised of approximately 100 energy levels and 170 gamma-ray transitions. Spectroscopic information about each level (lifetimes, electromagnetic transition rates, multipole mixing ratios, branching ratios, and level spins and parities) was deduced from measured gamma-ray angular distributions and Doppler shift data. These spectroscopic results contribute to the understanding of the behavior of vibrations in slightly deformed potential wells and the interplay of particle and collective structures in the tellurium isotopic chain. The behavior of the ^{130}Te nucleus was examined from the viewpoints of the General Collective Model (GCM) and the Particle-Core Coupling Model (PCM). The GCM has difficulty reproducing the level scheme as an admixture of vibrational and rotational motion. Many of the low-lying states are severely misplaced. Using the PCM, the level scheme can be reproduced, but the agreement with transition rate data is lacking. In contrast to the lighter tellurium nuclei, the low-lying states of the ^{130}Te nucleus appear to be severe admixtures of the anticipated structures.

DUNDON, Luke R., Midshipman 1/C (USN), "Physical Properties of Near-Earth Objects: Optical and Infrared Astronomical Observations," U. S. Naval Academy Trident Scholar Report, No. 306 (2003).

The goal of this project was to determine the intrinsic characteristics of a sample of recently discovered Near-Earth Objects (NEOs). The sample was carefully chosen based on the NEOs' proper motion, magnitude, and position.

Two weeks in Arizona were spent making thorough optical and infrared ground-based observations on the sample. Four telescopes were used: 1) the Kitt Peak National Observatory's 84-inch telescope with the Simultaneous Quad Infrared Imaging Device, 2) the University of Arizona's 90-inch Steward optical observatory, 3) Spacewatch's 72-inch optical telescope, and 4) the 16-inch Super Livermore Optical Transient Imaging System automatic telescope. These data were used to measure color photometry in six different bandpasses, and to make optical and infrared lightcurves. These results were utilized to constrain the physical properties of the sample. The optical and infrared lightcurves were analyzed to determine the rotational properties and, where possible, the shape of the object. The taxonomic classification was constrained from three-color optical photometry, three-color infrared photometry, broadband spectra and albedo. From these taxonomic classifications, a chemical composition was assigned to each object. The combination of infrared and optical observations made in this Trident Project provides unique information about the physical characteristics of this sample of NEOs.

Newsletters

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 8 (Aug 2002) p. 18.
On partial phase photography with colored filters, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 8 (Aug 2002) p. 19.
A further comment on partial phase photography with colored filters, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 8 (Aug 2002) p. 44.
Observation sites for the transit of Venus, 8 June 2004, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 8 (Aug 2002) p. 49.
On the uses of eclipse glasses, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 10 (Oct 2002) p. 33.
Travel in Africa for the 4 December 2002 Total Solar Eclipse, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 10 (Oct 2002) p. 33.
Further comment on Travel in Africa, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 10 (Oct 2002) p. 52.
Comment on observing eclipses from aircraft in flight, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 11 (Nov 2002) p. 23.
Solar filters for digital cameras, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 11 (Nov 2002) p. 24.
Further comment on solar filters for digital cameras, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 11 (Nov 2002) p. 62.
Educational value of eclipses to children, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 11 (Nov 2002) p. 67.
A thought on communicating with the media about eclipses, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 11 (Nov 2002) p. 81.
Sources for safe solar filters for eclipse use, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 12 (Dec 2002) p. 21.
"Black Polymer" vs. "Polymer Plus" solar filters for eclipse photography, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 12 (Dec 2002) p. 24. Observation report on the penumbral lunar eclipse of 19 November 2002, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 12 (Dec 2002) p. 53. Power for portable astronomical equipment, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 12 (Dec 2002) p. 56. Further comment on power for portable astronomical equipment http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 8, No. 2 (Feb 2003) p. 75. Possible observing sites for the 29 March 2006 total solar eclipse, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 8, No. 4 (Apr 2003) p. 26. On the scientific value of transit timings, http://www.mreclipse.com/SENL/SENLinde.htm.

HUDDLE, James R., Associate Professor, "Dance of the Planets #11: Leonid Meteors 2002 and a Penumbral Lunar Eclipse," Monograph written for the Naval Academy community and published by e-mail on 14 Nov 2002.

HUDDLE, James R., Associate Professor, "Dance of the Planets #12: Eclipses" Monograph written for the Naval Academy community and published by e-mail on 7 May 2003.

Presentations at Professional Meetings and Conferences

Batchelder, J. C., Carter, H. K., Spejewski, E. H., Bilheux, J.-C., Grzywacz, R., Rykaczewski, K. P., D. Stracener, W., Bingham, C. R., HARTLEY, D. J., Assistant Professor, Larochelle, Y., Tantawy, M. N., Fong, D., Hamilton, J. H., Hwang, J. K., Krolas, W., Ramayya, A. V., Garrett, P. E., Kulp, D., Wood, J., Piechaczek, A., Zganjar, E. F., and Winger, J. A., "Decay of ^{116}Ag," Division of Nuclear Physics Meeting, East Lansing, MI, 9-12 October 2002.

Batchelder, J. C., Bilheux, J. -C., Bingham, C. R., Carter, H. K., Cole, J. D., Fong, D., Garrett, P. E., Grzywacz, R., Hamilton, J. H., HARTLEY, D. J., Assistant Professor, Hwang, J. K., Krolas, W., Kulp, D., Larochelle, Y., Piechaczek, A., Ramayya, A. V., Rykaczewski, K. P., Spejewski, E. H., Stracener, D. W., Tantawy, M. N., Winger, J. A., Wood, J., Zgabjar, E. F., Casares, A., Radford, D., and Wollink, H., "Decay of the Neutron-Rich Nucleus ^{116}Ag, " The 3rd International Conference on Fission and Properties of Neutron-Rich Nuclei, Sanibel Island, FL, 3-9 November 2002.

BENDLER, J. T., Associate Professor, FONTANELLA, J. J., Professor, and WINTERSGILL, M. C., Professor, "Generalized Vogel Relation and the Pressure, Volume and Temperature Variation of Dielectric Relaxation in Glass-Forming Liquids," 2nd International Conference on Broadband Dielectric Spectroscopy and its Applications, Leipzig, Germany, 2-6 September 2002.

BENDLER, J. T., Associate Professor, and FONTANELLA, J. J., Professor, "Physical Basis of Fragility," 2003 Meeting of the American Physical Society, Austin, TX, 3 - 7 March 2003.

BENDLER, J. T., Associate Professor, "Synthesis of 4,4'-bisphenolformal," 225th American Chemical Society National Meeting, New Orleans, LA, 23-27 March 2003.

BENDLER, J. T., Associate Professor and SCHROEDER, Maria J., Associate Professor (Chemistry Department), "Synthesis of bis[4-(4-hydroxyphenyl)phenyl]propane and Novel Polycarbonates Prepared Therefrom," 225th American Chemical Society National Meeting, New Orleans, LA, 23-27 March 2003.

BENDLER, J. T., Associate Professor and SCHROEDER, Maria J., Associate Professor (Chemistry Department, "Synthesis of 1,1-dichloro-2,2-bis[4'-(4-hydroxyphenyl)phenyl ethylene and its Incorporation into Homo- and Heteropolymers," 225th American Chemical Society National Meeting, New Orleans, LA, 23-27 March 2003. (Invited presentation)

BENDLER, J. T., Associate Professor, "High-Heat Polycarbonates Containing Bisaryl Units: Theory and Modeling," 225th American Chemical Society National Meeting, New Orleans, LA, 23-27 March 2003. (Invited presentation)

BIERMANN, Mark L., Assistant Professor, and KATZ, Debora. M., Associate Professor, "Wein's Law and the Temperature of the Sun," National Conference of the Council on Undergraduate Research, Connecticut College, New London, CT, 19-22 June 2002.

BIERMANN, Mark L., Assistant Professor, KATZ, Debora M., Associate Professor, Wesseman, Jodi L., Sudhakaran, Gubbi R., and Kolehmaninen, Karen, "Getting a Tenure-Track Position at a Primarily Undergraduate Institution," National Conference of the Council on Undergraduate Research, Connecticut College, New London, CT, 19-22 June 2002.

BIERMANN, Mark L., Assistant Professor, DIAZ-BARRIGA, James, Midshipman 1/C (USN), and Rabinovich, W. S., "Nonlinear Behavior of Subbands in Quantum Wells Under Tensile, Uniaxial, In-Plane Strain," Laser Science Conference XVIII, Orlando, FL, September, 2002.

BIERMANN, Mark L., Assistant Professor, HOLLAND, Joseph P., Midshipman 1/C (USN) and DURAN, Stephen, Midshipman 1/C (USN), "Computer Modeling of Strained Quantum Wells Used in Opto-Electronic Devices," Undergraduate Research Poster Session on Capitol Hill 2003, Washington, DC, 1 April 2003.

BIERMANN, Mark L., Assistant Professor, HOLLAND, Joseph P., Midshipman 1/C (USN), Tomm, Jens W., Gerhardt, Axel, and Lorenzen, Dirk, "Modeling of Packaging-Induced Strains in Quantum-Well Laser," poster presentation at Conference on Lasers and Electro-Optics 2003, Baltimore, MD, 1-6 June, 2003.

BIERMANN, Mark L., Assistant Professor, "Strain and Optical Polarization Anisotropies in III-V Quantum Wells," Department of Physics and Astronomy, Florida Institute of Technology, Melbourne, FL, 2 October 2002. (Invited presentation)

BIERMANN, Mark L., Assistant Professor, "Strain and Optical Polarization Anisotropies in III-V Quantum Wells," Department of Physics, University of Maryland, Baltimore County, 23 October 2002. (Invited presentation)

BIERMANN, Mark L., Assistant Professor, "Using Applied Stress to Model Strain in Quantum-Well Lasers," Max Born Institute for Nonlinear Optics and Short-Pulse Spectroscopy, Berlin, Germany, 16 December 2002. (Invited presentation)

BIERMANN, Mark L., Assistant Professor, "Science as a Vocation," Sigma Zeta Science Honor Society Induction Ceremony, Houghton College, Houghton, NY, 13 March 2003. (Invited keynote address)

Bingham, C. R., HARTLEY, D. J., Assistant Professor, Larochelle, Y., Nazarewicz, W., Tantawy, M. N., Batchelder, J. C., Grzywacz, R. K., Gross, C. J., Lewis, T. A., Rykaczewski, K. P., Shapira, D., Yu, C.-H., Fong, D., Hamilton, J. H., Hwang, J. K., Ramayya, A. V., Królas, W., Kruppa, A. T., Maier, K. H., McConnell, J. W., Vertse, T., Piechaczek, A., Zganjar, E. F., Winger, J. A., Hagino, K., "Study of Dripline Nuclei via Proton Radioactivity Fine Structure," American Physical Society April Meeting, Philadelphia, PA, 5-8 April 2003.

CHATEAUNEUF, G., Postdoctoral Researcher (Chemistry Department), GAO, G., Postdoctoral Researcher (Chemistry Department), HARRISON, Judith A., Associate Professor (Chemistry Department), and MIKULSKI, Paul T., Assistant Professor, "Analysis of Compression- and Shear-Induced Polymerization in Model SAMs," 225th American Chemical Society National Meeting, New Orleans, LA, 23-27 March 2003.

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ENGLE, Irene M., Professor, "Incorporation of an Enhanced Magnetotail into the Model of the Global Saturnian Magnetosphere," Magnetospheres of the Outer Planets (MOP) Meeting, Laurel, MD, 30 July 2002.

FONTANELLA, J. J., Professor, and EDMONDSON, C. A., Associate Professor, "Fuel Cell and Battery Material Properties," Office of Naval Research – Air Force Office of Scientific Research (ONR-AFOSR) Electrochemistry Program Review, Annapolis, MD, 3-5 March 2003.

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KATZ, Debora M., Associate Professor, "Mines, Fossils and Bombs," Gettysburg College, Gettysburg, PA, 24 January 2003. (Invited presentation)

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MUNGAN, C. E., Assistant Professor, "Laser Cooling in the Solid State," Photonics North/Canadian Association of Physicists Annual Congress, Quebec City, Canada, 2–5 June 2002. (Invited presentation)

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TUCHOLSKI, Edward J., Commander (USN), Assistant Professor, "The Effect of Temperature on the Speed of Sound in Water using the Sing Around Method," Education in Acoustics, Physical Acoustics and Noise: Demonstrations for all Ages Session, 145th Meeting of the Acoustical Society of America, Nashville, TN, 30 April 2003. (Invited presentation)

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