Physics Department

Professor Francis David Correll
Chair

Physics Department faculty members were vigorously engaged in research and scholarly activity during the 2001-2002 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, the Naval Research Laboratory (NRL), the Naval Surface Warfare Center (NSWC), and the National Center for Physical Acoustics. 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 members published 12 articles in refereed journals, 7 articles in conference proceedings, one letter in a pedagogical journal, and 31 articles on the Internet. In addition, they issued 3 faculty technical reports and 2 midshipman/faculty publications/technical reports. Finally, faculty and midshipmen made 32 presentations at conferences, including some at international meetings in Australia, Austria, England, Greece, and Zimbabwe.

The scholarly relationship between our faculty and our students was close and productive. One Trident Scholar studied optical limiting in capillary waveguides. He won the annual Office of Naval Intelligence Harry E. Ward Trident Scholar prize. Another Trident Scholar investigated the environmental thermal neutron flux and its effects on electronic reliability. Two midshipmen developed successful new Trident Scholar proposals, one in astronomy and one in nuclear physics, which they will carry out during the next academic year. Ten midshipmen participated in research projects in acoustics, 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 is 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 has been identified, containing bisaryl units separated by small, flexible organic units such as ethers, carbonates, and isopropylidenes. Force fields appropriate to these new structures are being developed and molecular dynamics simulations of stress strain responses will be 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 Tgs and molecular weights Mw using GPC.

Efforts will continue this summer to scale up the synthesis to obtain sufficient amounts of each polymer to mold and test parts for mechanical strength and toughness studies and comparisons to theory.

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

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

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 faceshields, 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 current 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.

Testing this summer will enable these new materials to be screened for potential military use and also provide important feedback regarding the theoretical and computational algorithms employed. Comparisons of theory with measurement will enable refinements and improvements in the model.

Description and Tolerancing of an Optical System Design

Researcher: Assistant Professor Mark L. Biermann
Sponsor: Naval Research Laboratory (NRL)

After the completion of an initial design for a Cat's Eye Retroreflector in 2000-2001, the original design needed to be readied for production. Key aspects of this project included the tolerancing of the optical design so that fabrication could be carried out, and the revision of the design to meet specific performance and manufacturing demands. The design was successfully prepared for fabrication and manufacturing was started in December of 2001. Key improvements were made in the original design, including the possible use of an ellipsoidal asphere to maximize system performance. Also, it was determined that the optimal location for a single asphere in the system is at the first physics surface. Additionally, oversight of the initial manufacturing process was required, and guidance as to acceptable alterations for the purposes of manufacturing was provided.

Modeling Optical Properties of III - V Quantum Well Structures

Researcher: Assistant Professor Mark L. Biermann
Sponsor: Naval Research Laboratory (NRL)

Quantum well structures provide excellent performance in a variety of electro-optical applications. The further characterization of these complex systems is beneficial to a greater understanding of the systems on a fundamental level and to gaining insight into additional device applications. The goal of this research is to provide a robust numerical model of a variety of quantum-well systems that can been applied to motivate and analyze experimental work related to quantum wells and their applications.

A full computer model for quantum wells has now been implemented. The computer model allows for a variety of materials to be incorporated in the quantum well structure and allows for an arbitrary number of material layers in the structure. The flexibility of the formalism makes it particularly appealing for the modeling of complicated quantum well structures of the type that could be used in micro-electro-mechanical machines, or MEMS. The formalism has been applied to a variety of quantum well structures under a variety of strain conditions. The formalism is also being used to model quantum well systems that show potential for device applications. Key results related to the characteristics of subband energies and wave functions in quantum wells under uniaxial, tensile strain have been found.

Nonlinear Optics in Capillaries and Capillary Arrays

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

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

Optically Active Photonic Crystal and Holey Fibers

Researcher: Assistant Professor James J. Butler
Sponsor: Naval Research Laboratory (NRL)

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.

Nonlinear Optics in Capillary Waveguides

Researcher: Assistant Professor James J. Butler
Sponsor: Naval Research Laboratory (NRL)

This research involves the study of optical limiting in highly nonlinear capillary waveguides. 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. Highly nonlinear capillary waveguides will provide low threshold optical limiting and will extend the wavelength range at which optical limiting in fiber optic systems can be achieved.

The plan of procedure for this research project is divided into two sequential steps: (i) preparation and characterization of glass capillaries with a linear core material and (ii) testing of the optical properties of glass capillaries with nonlinear core materials. Preliminary work on both of these steps began in the summer of 2000. This investigation is a continuation of that work.

Percolation in S-SEBS and Fluorocarbon Proton Conducting Membranes

Researchers: Professor John J. Fontanella and 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. The resulting electricity can be used as a power source for a wide variety of applications. Unlike a battery, which is a closed system and consequently has a limited amount of energy, the fuel cell may run indefinitely with the continuous addition of fuel and oxygen. The fuel cell offers a significantly higher theoretical efficiency than systems which combust the fuel for thermal energy. The 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, typically in the form of protons, from one electrode to the other while keeping the constituents separated. This transport is required to sustain the chemical reaction.

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 in the development of fuel cells. Extensive studies of Nafion, a Teflon based membrane, have shown that the transport mechanism at low water content is related to the motion of polymer side chains which are terminated with a sulfonate group. Recent work has

focused on similar membranes such as sulfonated styrene/ethylene-butylene/styrene (S-SEBS) and sulfonated styrene/ethylene (S-SE), which are sulfonated copolymer membranes developed by Wnek and co-workers at Virginia Commonwealth University. The primary objective of this work is to gain insight into ion motion in the ion exchange membranes via complex impedance measurements. Detailed studies of the complex impedance as a function of water content and pressure are on going.

Optical Observations of Near-Earth Asteroids

Researcher: Associate Professor Debora M. Katz
Sponsor: 2001 Kinnear Fellowship

A team of eight researchers (four in high school, three midshipmen and one ensign) used the 20-inch reflecting telescope on the roof of Michelson Hall to observe Near-Earth Asteroids. We tracked approximately two-dozen asteroids over the course of the year. These data were then submitted to the Minor Planet Center in order to calculate their orbits. Once orbits have been established it is possible to determine if they pose a threat to the Earth.

In addition, we collaborated with Dr. Richmond at the Rochester Institute of Technology to perform simultaneous observations of four especially close asteroids. With these data, we were able to directly measure the distance to these asteroids using the parallax method.

Nonlinear Acoustic Techniques for Land Mine Detection: Experiments and Theory, Part I

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

A nonlinear acoustic technique for detecting buried land mines has been suggested by Donskoy [SPIE Proceedings 3392, 211 (1998); 3710, 239 (1999)]. Airborne sound at two primary frequencies f1 and f2 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 bimodular oscillator that is inherently nonlinear. Geophone measurements scanning the soil’s surface (at the difference frequency) profile the mine, but off the mine some nonlinearity exists. Amplitude-dependent frequency response curves for a harmonically driven mass-soil oscillator are used to find the nonlinearity of the soil acting as a “soft” spring. Finally, a layer of soil in a large tube, terminated by a thin elastic plate, is used to model the bimodular nonlinearity. This work is supported by the United States Army Communications-Electronics Command Night Vision and Electronic Sensors Directorate.

Comparison of Linear and Nonlinear Experiments for Land Mine Detection

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

When airborne sound couples into the ground, so-called “slow” compressional waves can interact with a target buried in the soil and effect the vibration velocity of the surface. Donskoy [SPIE Proceedings 3392, 211 (1998); 3710, 239 (1999)] has suggested a nonlinear technique that can detect an acoustically compliant buried mine that is insensitive to relatively noncompliant targets. A VS 1.6 inert antitank mine (23 cm diameter) was buried in the natural loess soil at the test site. In the linear experiment, a pair of subwoofers were sinusoidally swept from 70 to 600 Hz. The geophone’s response was measured along a 1 m scan segment across the mine. A 107 Hz resonance was chosen and the nonlinear experiment was performed by driving the woofers at f1 = 300 Hz and f2 = 407 Hz and detecting at the difference frequency. Nonlinear scan profiles over the mine have more relative sensitivity than the linear profiles. When a 30-cm diameter, 4-cm thick concrete disk was buried, it could be detected “linearly” but not “nonlinearly” in agreement with Donskoy. Nonlinear theories will be discussed. This work is supported by the United States Army Communications-Electronics Command Night Vision and Electronic Sensors Directorate.

Nonlinear Acoustic Techniques for Land Mine Detection: Experiments and Theory, Part II

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

A nonlinear acoustic technique for detecting buried land mines has been suggested by Donskoy [SPIE Proceedings 3392, 211 (1998); 3710, 239 (1999)] and verified in a number of experiments by Sabatier et. al. [J. Acoust. Soc. Am., 110, No. 5, Pt. 2, 2757; 2758 (2001)]. Airborne sound involving two primary frequencies f1 and f2 undergo acoustic-to-seismic coupling which interacts with the compliant mine and soil to generate a difference frequency component that can effect the vibration velocity at the surface. A Laser Doppler Velocemeter (LDV) profile across a buried mine at the difference frequency (chosen at a resonance), showed more relative sensitivity than a linear profile. A layer of soil in a large tube, terminated by an air backed clamped thin elastic plate is used to model nonlinear effects including Donskoy's "bouncing" soil-mine interface. The frequency spectrum of modes of the plate's response are investigated vs. the amount of soil mass loading. In particular, the lowest mode frequency first decreases with loading and then increases. Linear response curves near resonance compare well with the difference frequency response as one primary is varied. This work is supported by the United States Army Communications-Electronics Command Night Vision and Electronic Sensors Directorate.

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

Researcher: Assistant Professor Kevin L. McIlhany
Sponsors: Office of Naval Research (ONR) and 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 2001 NARC grant allowed Professor McIlhany to travel to Bates to continue efforts towards installing the Helium-3 internal gas target. Several basic goals were laid out at the beginning of the summer and all were subsequently achieved by the end. The first goal was to survey and set up a 100-meter-long fiber-optic conduit from the Engineering Building to the experimental area in the South Hall, terminating at the future location of the helium-3 target. The second goal was to construct several glass target cells and fill them with helium-3. The third goal was to design and implement a remote control system for the laser mirrors in the optical pumping apparatus that polarizes the helium-3 gas. The fourth and final goal was to assemble and test a second target polarimeter.

Solid-State Laser Cooling of Organic Dyes in Modified Polymers

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

The key idea behind laser cooling of bulk materials is anti-Stokes fluorescence. That is, the sample emits fluorescence photons of higher mean energy than those it absorbs from a long-wavelength pump laser. The energy balance comes from thermal absorption. For example, Yb^{3}+:ZBLANP has two inhomogeneously broadened manifolds separated from each other by an energy gap of 1 μm. The wavelength corresponding to the mean emission energy at room temperature is 995 nm. Since the fluorescence quantum efficiency is at least 99.7%, heat-generating nonradiative relaxation is extremely rare. This is due to the large energy gap and high sample purity. But the intramanifold equilibration times are much shorter than the 2-ms intermanifold relaxation lifetime. Consequently, the sample cools as the Boltzmann population distributions are restored in the two manifolds following optical absorption and emission.

Work is in progress to achieve cooling of an inexpensive polymer. Recently, other researchers have demonstrated remarkably high fluorescence efficiencies for pyrromethene dyes in advanced polymers. Poly(methyl methacrylate) has been modified using suitable additives and by copolymerization to achieve damage-resistant hosts which retain excellent dye compatibility and minimal scattering loss.

Photothermal deflection spectroscopy measures the refraction of a probe laser beam by a thermal gradient following optical absorption in a sample. This technique was originally developed to characterize thin films and was later used to measure the fluorescence quantum efficiency of Yb^{3}+:ZBLANP. As the pump is tuned across the mean fluorescence wavelength, the deflection angle changes sign. The amplitude of the signal, normalized by the pump power and sample absorptance, is proportional to the cooling efficiency.

Optical Refrigerators and Self-Cooled Lasers: New Paradigms in Solid-State Spectroscopy

Researcher: Assistant Professor Carl E. Mungan

Sponsors: Office of Naval Research (ONR) and Naval Academy Research Council (NARC)

Optimal performance criteria have been derived for steady-state radiation-balanced lasing. A spectral analysis of selected ytterbium-doped materials reveals potassium gadolinium tungstate (KGW) to be the most promising. This crystal has figures-of-merit an order of magnitude higher than those of yttrium aluminum garnet (YAG), the most widely used 1-µm laser material. Optical pumping experiments in collaboration with researchers at the Naval Research Laboratory and Los Alamos National Laboratory confirm the potential of this tungstate host. Anti-Stokes cooling has been discovered at room temperature in 3.5% Yb-doped KGW crystals. This is the first report of optical cooling in a crystal and the first step towards the demonstration of a new class of very high power solid-state lasers.

Models of Hysteresis in Polycrystalline Magnets

Researcher: Professor Carl S. Schneider

Sponsors: Office of Naval Research (ONR) and Naval Surface Warfare Center (NSWC)

An equation of state based upon saturation magnetization, M_s, coercive field, H_c, and the reversible susceptibility function of magnetization is proposed for ferromagnetic hysteresis. Reversible susceptibility divided by the initial susceptibility is the anisotropy function of magnetization, X_r, ranging from one in the demagnetized state to zero at saturation, and varying with magnetic history. Its dependence on scaled magnetization, $m = M/M_s$ on the interval (-1,1) varies with material, allowing characterization of anisotropy classes. Precise measurements have been made of reversible susceptibility, initial and saturate magnetization curves, and loops for Orthonol™, annealed three per cent nickel steel and as-received 1018 steel, representing crystals, isotropic polycrystals and composite ferromagnets, respectively. Magnetization change is the product of the reversible susceptibility, change in the applied field and the cooperative function due to domain interactions. This function is $1 + \beta m$ for the virgin curve with half this slope from any reversal, where $\beta = M_s / X_i H_c$ is the hysteresis coefficient. Variation of β for 1018 steel is due to distributed coercivities, and causes sigmoid $B(H)$ curves. In the scaled field representation, where $h = H / H_c$, the cooperative function is $1 / (1 - hX_r)$, a hyperbolic field dependence smeared by the anisotropy function. Constant anisotropy causes closed hysteresis loops, while variable anisotropy causes creeping of cycled asymmetric loops. In ferromagnetism, $1 / X = 1 / X_r - h$, normal scaled reluctivity is reduced from its reversible value by the scaled field.

Andes: An Active Learning, Intelligent Tutoring System for Newtonian Physics

Researchers: Professor Robert N. Shelby,
Professor Kay G. Schulze (USNA Computer Science Department),
Professor Donald J. Treacy, Professor Mary C. Wintersgill,
and Dr. Kurt VanLehn (University of Pittsburgh)

Sponsor: Office of Naval Research (ONR)

The Andes Project is developing an intelligent tutoring system for teaching physics to students at the U.S. Naval Academy. It is based on three key ideas: (1) 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) principle based dialog between the 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 continuing to expand 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. ANDES was cast in a new form to allow the tutor to give better diagnostic advice to the student. This new version, Andes2, was given its first trial in fall 2001. The analysis of this trial is being is still underway and corrections and additions for the fall 2002 trial are being incorporated into the system.

Applied Studies of the Imaging and Pattern Recognition

Researcher: Professor Larry L. Tankersley
Sponsor: Naval Research Laboratory (NRL)

All the studies listed are in support of an ongoing effort at the Naval Research Laboratory in Code 5614. The current studies include optical detection and analysis of debris in turbine engine lubrication fluids, imaging through turbid media. The emphasis on monitoring operational systems is to be increased. Theoretical background areas including quantum optical effects are to be studied to understand fundamental limitations on approaches to noise reduction in optical imaging schemes. Some of the program elements are:

1. Collect field samples data and compare evaluation schemes
2. Optical evaluation of lubricating fluids using partial-volume sampling
3. Optical studies of small wear particles in lubricants
4. Real-time evaluation of debris in turbine engine lubricants
5. Software development for system integration
6. Development of support electronics
7. Signal to Noise effects due to amplification and attenuation.
8. Theoretical investigation of non-linear effects involving longitudinal fields

Nuclear Structure of Tellurium–128

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

Tellurium has a wide range of abundant stable isotopes. Three different types of structure are thought 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. Emphasis centers on understanding the interplay between particle and collective features and on the aspects of the nuclear forces that determine the relative importance.

Excited levels in ^{128}Te below 3.3 MeV were studied at the University of Kentucky Nuclear Structure Laboratory utilizing inelastic neutron scattering techniques. Electromagnetic transition rates, multipole mixing and branching ratios, and level spins and parities will be deduced from measured gamma-ray excitation functions, $\gamma\gamma$ coincidences, angular distributions, and Doppler shifts.

Recoil-Distance Lifetime Measurements in Tellurium–120

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

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

Lifetimes in the picosecond range are measured using the recoil-distance Doppler-shift technique and associated gamma-ray detector array at the University of Cologne. Tellurium-120 nuclei are generated using the ^{13}C reactions on a ^{110}Pd target. By examining the fraction of ^{120}Te nuclei decaying in flight after being knocked out of the target foil, the lifetimes may be extracted.

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 studies of light curves of CV stars are planned with the CCD photometric camera system on the 20" telescope on Michelson Hall. The goal is to determine the characteristics of these systems.

Wien's Law and the Temperature of the Sun

Researchers: Assistant Professor Mark L. Biermann, Associate Professor Debora M. Katz, Midshipman 1/C Robert Aho, USN, Midshipman 1/C James Diaz-Barriga, USN, and Midshipman 1/C Jerome Petron, USN

Based on preliminary work carried out by the SP324 class in the spring of 2001, a detailed study of Wien's Law as a means to measure the temperature of the sun was conducted. The spectrum of the sun was collected by means of a fiber optic spectrometer on a sunny day, a hazy day, and a cloudy day. After analysis of the collected data, it was found that Wien's Law cannot be applied in a simple manner to a solar spectrum collected at sea level to determine the temperature of the sun. An additional key result was that clouds make little difference in the overall spectrum of the sun as measured at sea level. That is, while the atmosphere significantly absorbs and scatters light from the sun, most of the effect arises from the total mass of the atmosphere, and intervening clouds play only a small role in determining the overall shape of the sea-level solar spectrum. Finally, key attributes of the spectrometer were characterized, including the spectral responsivity of the device and the collection angle of light for the device.

U.S. Naval Academy Photonics and Information Sciences Center (PHAIS)

Researcher: Assistant Professor James J. Butler

This effort is to establish an interdisciplinary center dedicated to the development of photonics research and related research in information technologies at the U.S. Naval Academy (USNA). The creation of this center will: 1) ensure that the Naval Academy will continue to attract and develop the highest quality students and faculty in the rapidly developing fields of photonics and dependent information technologies; 2) provide personnel with the expertise to meet the Navy's increasing needs in photonics and related areas; 3) enhance coordination and cooperation across departments and divisions in photonics related research; 4) increase the profile of photonics research conducted at USNA both on and off the Yard.

Weekly meetings have been ongoing to discuss interdisciplinary research proposals. The first of these proposals is planned for fall 2002.

Optical Properties of Birefringent Volume Gratings

Researcher: Assistant Professor James J. Butler

An optical beam steering element is a device that is used to control the direction in which a beam of light travels. I have investigated the optical properties of a class of beam steering elements that utilize the fact that the amount of light diffracted by a hologram imbibed with a nematic liquid crystal can be controlled by the application of an electric field. By a careful comparison of experimental data and theoretical predictions, it has been shown that the birefringence of the liquid crystal must be included in order to correctly model these devices. This ongoing work will also provide evidence of the orientation of the liquid crystal within the diffraction grating thereby leading to a better understanding of the physics of these structures.

Refinement of Global Planetary Magnetosphere Models

Researcher: Professor Irene M. Engle

The objective of this work is to incorporate a more realistic magnetotail model into the full range of global magnetospheric models of the Saturnian magnetosphere, in preparation for the Cassini spacecraft entry into polar orbits about Saturn.

Mr. Jeremy Bruch (Trident Scholar, 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 model during his 1998-99 Trident Scholar year. Engle has expanded upon that initial work to having a full range of models for the total range of possible incident solar wind directions. A crucial next step was to modify the magnetotail models in such a way that their outer boundaries would meld with the boundaries computed from applying the magnetohydrodynamic principle of balancing the incident solar wind pressure on the boundary with the combined internal magnetic field pressure (plus some plasma pressure) inside the boundary. Many postulated modifications have been mathematically modeled and the resulting magnetospheric characteristics studied, and subsequently rejected. Much progress has been made, and the results will be presented at an international meeting during summer 2002. Consultation with the Cassini mission experimenters regarding the incorporation of these results into the working model for the encounter will also take place during the meeting.

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 are traced that are "footed" on the planet surface. None of the lines will go beyond what is known as the magnetopause, the boundary to the local magnetosphere. Unfortunately, in general, a mathematical model will also readily permit the tracing of field lines started at points outside the model, but these lines, and the magnitudes and directions of the magnetic fields at locations along them are entirely irrelevant. When a position $r(\theta,\phi)$ or, alternatively (x, y, z) is specified, it is helpful to know whether that spatial location is inside or outside the magnetopause boundary. The goal is to be able to specify an $R(\theta,\phi)$ representing 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 (*e.g.*, $R = R_0$ would represent a sphere). Although the near-planet magnetosphere can be in some cases considered to be a misshapen sphere with dimples on the side facing the solar wind, the extended magnetotail on the side away from the solar wind is more closely approximated by a elliptical cone which expands as one is further away from the planet. Sufficiently accurately representing the boundaries is an ongoing challenge for assorted 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 Joseph W. Dickey (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

Principal Researcher: Associate Professor James R. Huddle
Associate Researchers: Francis Podmore, University of Zimbabwe, Harare, Zimbabwe;
Simon Walsh, St. John's College, Harare, Zimbabwe; Richard Mugara, University of Zambia, Lusaka, Zambia;
James R. Dire, U. S. Coast Guard Academy, New London, CT, USA;
Edward Hanna, University of Plinth, Devon, UK; and Marcos Penaloza, University of the Andes, Venezuela.
Student Investigator: Jennifer Imbres, Cadet First Class, U. S. Coast Guard Academy, New London, CT.

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. Approximately $12,000 worth of donated and loaned equipment has been secured from Texas Instruments and Vernier Software. This equipment was shipped to three schools in Zimbabwe and Zambia to be used during the 21 June 2001 and 4 December 2002 eclipses, both of which will be visible from southern Africa. Students there measured several meteorological phenomena during the 2001 eclipse, and will continue this work during the 2002 eclipse. A paper describing this work is in preparation.

Calibration of Accelerator Energy by Optical Spectroscopy

Researcher: Associate Professor James R. Huddle

Direct measurement of the energy of a beam of particles from an accelerator usually involves observing the results of the interactions of those particles with a target. Occasionally, beams of excited ions emit visible light as their electrons decay in flight from higher to lower energy levels. The wavelength of such light is Doppler shifted according to the angle of observation. We propose to measure the Doppler shift using an Ocean Optics fiber optic spectrometer. This will allow the speed of the ions to be determined, from which the ions' kinetic energy can be calculated. A simple calculation shows that for a beam energy of 3 MeV, the Balmer alpha wavelength of 656.28 nm in the rest frame of a hydrogen atom is Doppler shifted to 621.26 nm at 45 degrees to the beam, and to 695.49 nm at 135 degrees. Since the Ocean Optics spectrometer currently in use has a resolution of about 15 nm, this shift will be readily observable. Once the technique is demonstrated, the resolution of the spectrometer can be increased by an order of magnitude to increase the precision of the technique. At this point, we have not been able to produce ion beams of sufficient intensity for their visible spectra to be recorded.

Jet-Intracluster Medium Interactions of the Radio Galaxy 3C 129

Researcher: Associate Professor Debora M. Katz

New observations using the Very Large Array have begun. Our observations of 3C 129 will address two questions. First we will estimate the non-thermal pressure for various radio components and thereby derive values of the internal energy densities. Second by making a detailed comparison between high quality radio data and forthcoming x-ray data to be obtained by CHANDRA (space-based observatory) in the near future, we will study the signatures of hydrodynamic interactions between radio plasmas and the ambient cluster gas. 3C 129 provides a uniquely endowed source for this endeavor: it is nearby, it lies relatively far from the cluster center, its long tail suggests that it lies mostly in the plane of the sky, and ram pressure is likely to be important only near the head.

Experiments on the Nonlinearity of Mississippi Loess Soil

Researcher: Professor Murray S. Korman

An apparatus called a soil/mass oscillator is used to measure the parameter of nonlinearity of the soil. The oscillator involves a layer of soil that is placed in a rigid rectangular frame along with a "rigid" concrete plate that rests freely on the soil's surface. The entire apparatus rests on a large concrete block that is buried flush with the surface. A subwoofer located 1 m above the concrete plate is driven with a swept sinusoidal tone near the fundamental resonance of the system. A family of tuning curves is measured from the acceleration of the concrete plate using an accelerometer that is attached to the surface. For increasing acoustic drive level the tuning curve resonant frequency shifts to an increasingly lower resonant frequency - indicating that the soil is acting as a "soft" spring. The parameter of nonlinearity involves an analysis of the tuning curves and yields an estimate of $B/A \sim 30$, where the restoring force is modeled as $f = -A(x/L) - B(x/L)^2$. Here L is the thickness of the soil layer and x is the displacement from equilibrium of the top of the soil. It is expected that effects of hysteresis and a more complicated restoring force model will be needed in a future experiment and analysis.

Molecular Dynamics Simulations of the Bending of Filled Carbon Nanotubes

Researchers: Assistant Professor Paul Mikulski,
Dr. Susan Sinnott and Dr. Boris Ni (University of Florida),
and Associate Professor Judith A. Harrison (USNA Chemistry Department)

The overall goal of this project is to examine the mechanical properties of carbon nanotubes. Nanotubes are filled with CH_4, C_{60}, and Ne. Mechanical properties as a function of filling gas, tube length, and temperature have been examined. This collaboration just resulted in a publication in *Physical Review Letters*.

Complex Impedance Studies of Optically Stimulated SBN

Researcher: Associate Professor Steve 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 is probably due to the slight heating of the crystal induced by the laser.

Research Course Projects

Design, Fabrication and Calibration of a Biaxial Magnetoelastic Sample

Researcher: Midshipman 1/C Robert Aho, USN
Adviser: Professor Carl S. Schneider

The effects of stress on the magnetic hysteresis of steel are an element of physics and naval architecture that has not been fully realized. It was the goal of this project to develop an apparatus capable of creating a model of these effects as studied from a physics perspective. The apparatus was tuned and calibrated and all reasonable sources of error were minimized and corrected for. The experiment used an arbor press to compress a tube of Navy hull steel enclosed within a solenoid. When a second coil around the entire apparatus was turned on and an external magnetic field was created, it induced a magnetic field that was measurable by the current in the primary solenoid. The changes in current based on the stress and external field were used to construct a model. This model is be able to predict how other magnetic materials' hysteresis react to stress as well. Sample design and apparatus calibration was the aim of this research.

The Common Household AA Battery: A Study of Energy Output and Cost Efficiency

Researcher: Midshipman 3/C Christopher K. Brown, USN
Adviser: Associate Professor James R. Huddle

The power output of different brands of AA batteries was monitored as a function of time, so that the energy content of the different brands of batteries could be compared. The name brand batteries from Duracell, Eveready and Radio Shack, packed the most energy, about 8000 to 8500 Joules per battery. Generics contained a little less, 7200 to 7800 Joules per battery. Special-purpose batteries, like the Energizer Lithium, held more energy but cost more. One Joule of energy from a typical name-brand AA battery cost about 0.01 cents. By comparison, one Joule of electrical energy from the local power company, BGE, costs about 0.000002 cents.

Characterization of New High-Performance Polycarbonates for Transparent Armor Applications

Researcher: Midshipman 2/C Colin Browning, USN (Chemistry major)
Advisers: Associate Professor Maria J. Schroeder (USNA Chemistry Department)
and Associate Professor John T. Bendler

Midshipman Browning conducted Differential Scanning Calorimetry (DSC) and Gel Permeation Chromatography (GPC) studies under the direction of Associate Professor Schroeder in the Chemistry Department on three novel polycarbonates synthesized in connection with the Army Research Office project in Physics studying high-performance polycarbonates. These new polymers were synthesized for the first time by Professor David Boyles at South Dakota School of Mines & Technology, and were sent to Associate Professor Bendler of the Naval Academy Physics Department in February 2002. The experimental resins were designed using molecular modeling methods. Polycarbonate GPC standards were also obtained as well as commercial high molecular weight polycarbonate resin from General Electric Company's Plastic Division so that comparisons could be made with known polymers.

Midshipman Browning traveled in April to Aberdeen Proving Grounds to visit with Dr. Alex Hsieh of the Polymers Research Branch to consult on the project. Dr. Hsieh also explained how the Army planned to use the new polymer materials when they become available.

Midshipman Browning gave a presentation and poster on his work to the Chemistry Department. He found that the early polymers were too low in molecular weight to be useful, and also appeared to be contaminated with monomer and unreacted catalyst. New synthetic procedures have been adopted in South Dakota and new samples will be studied in late summer.

Analyzing the Movement of Near-Earth Asteroids with Visual Astronomy

Researcher: Midshipman 1/C Cecelia L. Crannell, USN
Adviser: Associate Professor Debora M. Katz

Observations of eight asteroids during the course of seven months are presented in this research effort. Tracking done on these eight asteroids and data collected and submitted to the Minor Planet Center allowed orbital information to be calculated. Simultaneous observations with New York state observatories, Rochester Institute of Technology and Union College, allowed parallax measurements to be made and from this an exact position of the asteroid can be calculated.

Computer Analysis of Isolated Quantum Wells Under Anisotropic, In-Plane Strain

Researcher: Midshipman 1/C James Diaz-Barriga, USN
Adviser: Assistant Professor Mark L. Biermann

A computer model was used to study $Ga_{1-x}In_xAs/Al_{1-y}In_yAs$ quantum wells under uniaxial, in-plane strain. The computer model allows for full band mixing, properly describes the nature of each constituent material in the quantum well, and simultaneously calculates the valence and conduction subbands. This project focused on the conduction subbands for quantum wells with tensile and compressive strain in the well layer. Zone-center subband energies and envelope functions were calculated and the overall behavior of the conduction subbands as a function of applied strain and well width was characterized. It was found that band mixing plays a much larger role in determining the zone-center subband energies in the case of uniaxial strain as opposed to biaxial strain. Uniaxial, in-plane strain led to changes in the subband energies that are strongly nonlinear with applied strain, especially for larger strains. These results for the conduction subbands can be combined with valence subband results to determine interband transition energies and matrix elements for the quantum well as a whole. Future studies involving asymmetric coupled quantum wells have also been motivated by the research project.

Calibration of Thermochron Temperature Loggers

Researchers: Midshipman 3/C Alexis F. Gonzalez, USN
and Midshipman 3/C Rainel A. Nunez, USN
Adviser: Associate Professor James R. Huddle

Thermochron is the registered name of a product sold by Dallas Semiconductor. About the size of a stack of six dimes, Thermochron contains a temperature sensor, microprocessor with real-time clock, enough memory to hold 2048 temperature readings, and an internal battery. The objective of this work was to calibrate the temperature sensor. This turned out to be more difficult than we expected due to problems keeping the temperature of a water bath constant. Although no reliable calibration was obtained, we were able to determine that the Thermochron agrees with a good mercury thermometer within plus or minus one Celsius degree over the range from zero to 70 degrees Celsius.

Laser Dye Performance in a Polymer Matrix

Researcher: Midshipman 1/C Michael J. Holmes, USN
Adviser: Assistant Professor Carl E. Mungan

Organic dyes have many practical applications in modern technology, especially when doped into a solid polymer matrix. In order to learn how placing a dye into a polymer matrix affects the dye's performance, different dyes were studied in different media. Some dyes were placed into bulk polymer blocks, while others were left in liquid polymer solution or spin coated with polymer onto glass slides. The dyes were excited by a continuous-wave dye laser pumped by an argon-ion laser.

After being optically excited and relaxed many times, an individual dye molecule eventually chemically decomposes. Our main focus during this study was on the stability of various dyes within a polymer, as measured by the decay of the fluorescence during continuous excitation. We also studied the shift of the fluorescence peak to see how the shape of the emission spectrum is affected by the laser dye host. We used poly(methyl methyacrylate), more commonly known as PMMA or plexiglass, for our polymer matrix, ethanol for our solvent in the liquid samples, and two different laser dyes, cresyl violet and styryl 9M.

Updating the NATALY Data Acquisition Codes

Researcher: Midshipman 3/C Joshua Mueller, USN
Adviser: Professor Jeffrey R Vanhoy

Previous data acquisition software used in the Naval Academy Tandem Accelerator Laboratory was written in 1994 to run on 68030 series Macintosh computers. The replacement of these computers and changing data buss standards forced an update of the data acquisition codes. The new data acquisition software takes advantage of the advanced window management capabilities of the current Kmax™ software package and the higher data rate capabilities of buffered CAMAC modules and SCSI data busses.

Nonlinear Acoustic Techniques for Land Mine Detection: Experiments and Theory

Researcher: Midshipman 1/C Mathias K. Roth, USN
Advisers: Professor Murray S. Korman
and Associate Professor David R. Smith (USNA Oceanography Department)

A nonlinear acoustic technique for detecting buried land mines has been suggested by Donskoy [SPIE Proceedings Vol. 3392, 211-217 (1998); Vol. 3710, 239-246 (1999)]. Airborne sound at two primary frequencies f1 and f2 undergo acoustic-to-seismic coupling and a superimposed "slow" compression 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. An apparatus (called the soil/mine oscillator) has been constructed that is thought to be a simple model of a buried land mine. This apparatus, consisting of a layer of homogeneous soil in a large tube that is terminated by a thin elastic plate, is used to model the bi-modular nonlinearity. (1) Using an accelerometer and a microphone both placed under the elastic plate, the acoustic impedance of the unloaded plate is measured over a range of frequencies using a single swept tone. (2) Using a single swept sinusoidal source, the acceleration of the center of the plate is plotted verses frequency and a family of tuning curves are measured for different amounts of soil mass that are placed on the top surface of the plate. (3) Amplitude dependent frequency curves of the top surface of the soil's particle velocity are measured using a geophone and single primary swept sinusoidal acoustical source. (4) Nonlinear experiments using two frequency components f1 and f2 are performed such that tuning curves near the nonlinear generated difference frequency (where f1 is fixed and f2 is swept) can be compared to a tuning curve that is generated linearly using one primary swept source. Here the nonlinearly generated difference frequency tuning curves (from the geophone's response) are studied in the same frequency region as the linearly generated curves (using the same geophone). It is concluded from these studies that it may be possible to study the nonlinear mine detection problem using this model apparatus, provided that the modal structure of an actual mine behaves similarly to a clamped elastic plate.

Parallax Distance Measurements of Near-Earth Asteroids

Researcher: Midshipman 1/C Lee M. Smallwood, USN
Adviser: Associate Professor Debora M. Katz

In this research, positional data for asteroid K01R18B derived through parallax distance calculations for the night of October 29, 2001 were determined. The distance derived correlates well with previous calculations of its orbit, within the margin of error of the data. The derivation required to calculate parallax distance in addition to our data, thus providing a framework to facilitate future parallax calculations, is described.

Trident Scholar Projects

Optical Limiting Within Capillary Waveguides

Researcher: Midshipman 1/C Jeremiah J. Wathen, USN
Adviser: Assistant Professor James J. Butler

Many applications - especially commercial fiber optical systems - demand practical optical limiters. These devices can protect optical sensors that can't handle the intense light many optical systems carry. Optical limiters can be constructed from chemical compounds that display a nonlinear response to incident light. That is, they allow nearly full transmission of low-intensity light but deny the transmission of high-intensity light. The more intense the incident light becomes, the less light a "limiting" compound will transmit. An investigation of nonlinear optical waveguides, which integrate such limiting compounds, is reported.

To achieve an optical limiting element compatible with optical fiber systems, very narrow glass "capillary" tubes were filled with solutions of the nonlinear compound SINC. These filled tubes, called nonlinear capillary waveguides, operated analogously to optical fibers. Capillary waveguides with core diameters ranging from 5 to 200 µm were tested. Prepared waveguides had a linear transmission of 45%. Transmission characteristics of these nonlinear waveguides were measured as a function of incident energy from a pulsed, frequency-doubled Nd:YAG laser that produced 7ns pulses at 532nm. With a 10 µm core, nonlinear effects are observed at input energies as low as 1.0E-10 J. A transmission of 5% or less was observed for input energies as low as 1.0E-7 J, making these waveguides effective optical limiters.

Experimental data was compared with a computer model that simulated the limiting response of SINC. Simulations have proven quite accurate for the larger diameter capillaries. Modifications to the model must be made to compensate for boundary condition effects within the smaller diameter capillaries.

Electronic Reliability and the Environmental Thermal Neutron Flux

Researcher: Midshipman 1/C John D. Dirk, USN
Advisers: Professor Martin E. Nelson (USNA Mechanical Engineering Department)
and Visiting Professor James F. Ziegler

Boron that is used in the manufacturing process of microelectronics is highly sensitive to low energy (thermal) neutrons. When background thermal neutrons originating from cosmic rays interact with the nucleus of certain atoms, ionizing radiation is produced that can change the logic state of a cell on the microchip. This phenomenon is known as Single Event Upset or Soft Error and is an important problem facing computer manufacturers who employ boron-based materials in their microelectronics. The goal of this project was to characterize the environmental thermal neutron flux with respect to environmental reliability.

The detection of thermal neutrons was based on He-3 gas-proportional counters. Two detectors were employed at each field location. One detector was bare while the other was shrouded with boron-impregnated rubber that shielded it from thermal neutrons. Fast neutrons still penetrated the rubber and they were counted. The difference in the response between the detectors yielded the thermal flux. The device was packaged into a single suitcase for portability. The detectors have been calibrated at the National Institute for Standards and Technology (NIST) and the Armed Forces Radiobiology Research Institute (AFRRI).

Measurements of the thermal flux have been completed in various locations at the Naval Academy and in surrounding sites. Prior experimental results had indicated large terrestrial changes in the flux of thermal neutrons (more than 50x at different sea level locations). The current measurements show less than 10x difference in thermal neutrons, and most of this difference can be explained by natural attenuation from building materials.

The observed flux of neutrons has been used to predict the soft-fail rate of modern memory modules in terrestrial locations. The results agree well with published reports of "life-testing" reliability, in which hundreds of chips are tested using natural ambient conditions of cosmic rays. The results obtained in this project were also compared with similar reliability estimates based on previous scientific measurements of the thermal neutron flux.

Publications

Journal (Refereed) Manuscripts

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," *Physical Review Letters*, Volume 87, #19, November 2001, pp. 195503-1 to 195503-4.

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 LiCF3SO3. 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, 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) 337 to 342.

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.

BIERMANN, Mark L., Assistant Professor, Rabinovich, W. S., Mahon, Rita, and Gilbreath, G. Charmaine, "Design and Analysis of a Diffraction-Limited Cat's Eye Retroreflector," *Optical Engineering*, Volume 41, #7, July 2002, pp. 1655-1660**.**

The authors describe a design for a modified, cat's-eye retroreflector. The design is catadioptric, containing a single concave mirror and several lenses. This retroreflector design exhibits a unique combination of performance characteristics. It is diffraction limited over a large field angle while operating with a large aperture and numerical aperture. There is little vignetting of the optical beam, even at large field angles, providing good light return at all angles of incidence. It brings the light beam to a focus and allows access to the light near the focal plane, thus decoupling the size of the aperture from the size of devices used with the retroreflector. This final feature makes the design appealing for use with spatial light modulators, or other optical or electro-optical components.

BIERMANN, Mark L., Assistant Professor, KATZ, Debora M., Associate Professor, AHO, Robert, Midshipman 1/C (USN), DIAZ-BARRIGA, James, Midshipman 1/C (USN), and PETRON, Jerome, Midshipman 1/C (USN), "Wien's Law and the Temperature of the Sun," *The Physics Teacher*, Volume 40, #7, October 2002, pp. 47-49.

An experiment was conducted to test the validity of Wien'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 Wien'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.

BUTLER, J. J., Assistant Professor, Malcuit, M. S., and Rodriguez, M. A., "Diffractive Properties of Highly Birefringent Volume Gratings: Investigation," *Journal of the Optical Society of America B*, Volume 19, #2, February 2002, pp. 183-189.

We have performed a detailed comparison of the predictions of coupled wave theories of isotropic and anisotropic volume gratings. It is shown that material birefringence can dramatically modify the diffractive properties of volume gratings. The predictions of the coupled wave theories have also been compared to the diffractive properties of volume gratings fabricated using polymer-dispersed liquid crystals. It is shown that a coupled wave theory that includes the effects of the birefringence of the liquid crystal must be used to explain the diffraction properties of these highly anisotropic gratings. Information can be obtained about the alignment of the liquid crystal within the composite gratings from comparisons of theory and experiment.

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) 355 to 361.

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 $C \approx 0.035$. 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 $C_A \approx 0.12$ which approaches that expected for continuum percolation. The activation volume results are shown to be consistent with free volume considerations.

MIKULSKI, P. T., Assistant Professor, and HARRISON, J. A., Associate Professor, "Packing-Density Effects on the Friction of n-Alkane Monolayers," *Journal of the American Chemical Society,* Volume 123, #28, 2001, pp. 6873-6881.

The classical molecular dynamics simulations were used to examine the tribology associated with the sliding of a hydrogen-terminated diamond counterface across a monolayer of n-alkane chains that are covalently bound to a diamond substrate. Two systems using chains of fixed length (18 carbon atoms per chain) on diamond (111) were examined: a tightly packed (2 x 2) arrangement and a loosely packed system with approximately 30% fewer chains. Both systems give a similar average friction at low loads. Under high loads, the tightly packed monolayer exhibits significantly lower friction than the loosely packed monolayer. While the movement of chains is greatly restricted in both systems, the tightly packed monolayer under high loads is clearly more uniform in geometry and more constrained with respect to the movement of individual chains than the loosely packed monolayer. This suggests that efficient packing of the chains is responsible for the lower friction for tight packing under high load. This is supported by the fact that sliding initiates larger bond-length fluctuations in the loosely packed systems, which ultimately lead to more energy dissipation via vibration.

MUNGAN, C. E., Assistant Professor, "Acceleration of a Pulled Spool," *The Physics Teacher*, Volume 39, #8, November 2001, pp. 481–485.

The maximum acceleration of a pulled spool that rolls without slipping is analyzed. In addition to the well-known pulling angle at which it cannot roll without slipping, there may be an angle at which it always rolls without slipping.

MUNGAN, C. E., Assistant Professor, "The Satellite Derotator," *The Physics Teacher*, Volume 40, #6, September 2002, pp. 6–10.

The physical principles behind an elastic rotational collision demonstration available on a popular video series are analyzed.

Ni, Boris, Sinnott, Susan, MIKULSKI, Paul T., Assistant Professor, and HARRISON, Judith A., Associate Professor, "Compression of Carbon Nanotubes Filled with C_{60}, CH_4, or Ne: Predictions from Molecular Dynamics Simulations," *Physical Review Letters*, Volume 88, #20, May 2002, pp. 205505-1 to 205505-4.

The effects of filling nanotubes with C_{60}, CH_4, or Ne on the mechanical properties of the nanotubes were examined. The approach was classical molecular dynamics using the reactive empirical bond order (REBO) and the adaptive intermolecular REBO potentials. The simulations predict that the buckling force of filled nanotubes can be larger than that of empty nanotubes, and the magnitude of the increase depends on the density of the filling material. In addition, these simulations demonstrate that the buckling force of empty nanotubes depends on temperature. Filling the nanotube disrupts this temperature effect so that it is no longer present in some cases.

SCHNEIDER, Carl S., Professor, "Role of Reversible Susceptibility in Ferromagnetic Hysteresis," *Journal of Applied Physics*, Volume 91, #11, May 2002, pp. 7637-7639.

An equation of state based upon saturation magnetization, M_s, coercive field, H_c, and the reversible susceptibility function of magnetization is proposed for ferromagnetic hysteresis. Reversible susceptibility divided by the initial susceptibility is the anisotropy function of magnetization, X_r, ranging from one in the demagnetized state to zero at saturation, and varying with magnetic history. Its dependence on scaled magnetization, $m = M/M_s$ on the interval (-1,1) varies with material, allowing characterization of anisotropy classes. Precise measurements have been made of reversible susceptibility, initial and saturate magnetization curves, and loops for Orthonolä, annealed three per cent nickel steel and as-received 1018 steel, representing crystals, isotropic polycrystals and composite ferromagnets, respectively. Magnetization change is the product of the reversible susceptibility, change in the applied field and the cooperative function due to domain interactions. This function is $1 + bm$ for the virgin curve with half this slope from any reversal, where $b = M_s / X_i H_c$ is the hysteresis coefficient. Variation of b for 1018 steel is due to distributed coercivities, and causes sigmoid $B(H)$ curves. In the scaled field representation, where $h = H / H_c$, the cooperative function is $1 / (1 - hX_r)$, a hyperbolic field dependence smeared by the anisotropy function. Constant anisotropy causes closed hysteresis loops, while variable anisotropy causes creeping of cycled asymmetric loops. In ferromagnetism, $1 / X = 1 / X_r - h$, normal scaled reluctivity is reduced from its reversible value by the scaled field.

Young, A., Rudnick, L., KATZ-Stone, D. M., Associate Professor, and O'Donoghue, A. A., "Electron Population Aging Models for Wide-Angle Tails," *New Astronomy Reviews*, Volume 46, #2-7, January 2002, pp. 105-107.

Color-color diagrams have been useful in studying the spectral shapes in radio galaxies. 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 attributed 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 also discuss the effects that angular resolution has on the shape of the spectrum.

Conference Proceedings

BIERMANN, Mark L., Assistant Professor and Rabinovich, W. S., "Valence Subbands in $Ga_{1-x}In_xAs/Ga_{1-y}Al_yAs$ Quantum Wells Under In-Plane Biaxial and Uniaxial Strain," in *OSA Trends in Optics and Photonics (TOPS)*, Volume 74, Quantum Electronics and Laser Science Conference, OSA Technical Digest, Postconference Edition (Optical Society of America, Washington, DC, 2002), pp. 208-209.

A detailed study on the nature of subband energy shifts in quantum wells under applied strains was made. It was seen that, in general, the phenomena that effect subband energies can be divided into two broad classes: effects linear with applied strain, and effects nonlinear in applied strain. Effects linear with applied strain are hydrostatic and shear deformations leading to subband energy shifts. Effects nonlinear with applied strain include quantum confinement within the quantum well, mixing of the heavy- and light-hole subbands with the spin split-off band, and mixing of the heavy- and light-holes due to a uniaxial strain. It was found that the case of uniaxial, in-plane, tensile strain is qualitatively different from the other in-plane strain cases, which are biaxial and uniaxial compression and biaxial tension. The key feature in the uniaxial, in-plane, tensile strain case is a same-parity, same-order anti-crossing that arises between the HH1 and LH1 subbands. It was also found that phenomena that are nonlinear with applied strain are nonlinear with well width, and that phenomena that are linear with applied strain are largely independent of well width.

KORMAN, M. S., Professor and Sabatier, James M., "Linear and Non-linear Acoustic Velocity Profiles Over Buried Land Mines," *Proceedings of SPIE's 16th Annual International Symposium on Aerospace/Defense, Sensing, Simulation, and Controls*, Vol. 4742, pp. 695-700, Orlando, FL, 1-5 April 2002.

Acoustic-to-seismic coupling has proven to be an extremely accurate technology for locating buried land mines. Most of the research to date has focused on linear techniques in which sound couples into the ground, interacts with the buried mine, and causes increased vibration of the ground above the mine. However, Donskoy [SPIE Proceedings Vol. 3392, 211-217 (1998); Vol. 3710, 239-246 (1999)] has suggested nonlinear acoustic techniques may be applicable to acoustic mine detection. This technique has recently been used with success in field tests at the University of Mississippi and US Army mine lanes. In the nonlinear acoustic technique, airborne sound is produced at two primary frequencies which couple into the ground and a superimposed compressional wave interacts with the mine and the soil. Because the mine is compliant, contact between the soil and the mine is maintained during the compression phase of the wave, but they separate during the tensile phase. This creates a bimodular oscillator that is inherently non-linear. This effect has been demonstrated on inert land mines at the University of Mississippi and at US Army test lanes. Results of these tests indicate that nonlinear measurements over buried land mines have more sensitivity than linear measurements. Non-compliant objects such as concrete disks do not exhibit nonlinear phenomena but can be located using linear techniques. This work is supported by the United States Army Communications-Electronics Command Night Vision and Electronic Sensors Directorate.

KORMAN, M. S., Professor, and Sabatier, James M., "Nonlinear Acoustic Techniques for Land Mine Detection," *Proceedings of the 5th International Symposium on Technology and the Mine Problem*, (MINWARA), Naval Postgraduate School, Land Environment, Part III, Chapter 2, pp. 315-321, Monterey, CA, 22-25 April 2002.

When airborne sound couples into the ground seismic waves can interact with a target buried in the soil and effect the vibration velocity of the surface. Acoustic-to-seismic coupling (using linear acoustic techniques) has proven to be an extremely accurate technology for locating buried land mines [J. M. Sabatier and N. Xiang, IEEE Trans. Geoscience and Remote Sensing 39, 1146-1154 (2001)] . 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. (Utilizing both techniques could eliminate certain types of false alarms.) Airborne sound at two primary frequencies f1 and f2 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 nonlinearity of the soil acting as a "soft" spring. Donskoy's nonlinear mechanism (over the mine) 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.

MUNGAN, C. E., Assistant Professor, Bowman, S. R., and Gosnell, T. R., "Solid-state Laser Cooling of Ytterbium-doped Tungstate Crystals," *Lasers 2000*, edited by V.J. Corcoran and T.A. Corcoran, STS Press, McLean, VA, 2001, pp. 819–826.

Anti-Stokes fluorescence can be used to cool a material if its radiative quantum efficiency is nearly unity. Until recently, the only solid which had shown net cooling was an ytterbium-doped heavy metal fluoride glass. Reasons for the lack of success with other materials include energy transfer to unwanted impurities, trapping of the fluorescence by internal reflection and reabsorption, and nonradiative relaxation via low-frequency accepting modes. However, substantial progress has recently been achieved in cooling new classes of rare-earth-doped solids. Photothermal deflection spectroscopy of Yb3+ in the two laser crystals KGd(WO4)2 and KY(WO4)2 demonstrates optical cooling. These materials have high figures of merit for radiation-balanced lasing, in which the Stokes heating by stimulated emission is offset by the anti-Stokes cooling due to spontaneous emission. However, approximately 1.3% of the relaxations from the excited to the ground states are nonradiative via energy transfer to impurities. In addition, about 0.3% of the pump light is absorbed per centimeter of travel by species such as transition-metal ions which dump that energy directly into heat.

Reintjes, J.E., Tucker, Thomas, S.E., Schultz, A., TANKERSLEY, L.L., Professor, Lu, C., Sebok, T., and Holloway, C., "Application of LaserNet Fines to Mechanical Wear and Hydraulic Monitoring," *Proceedings of the International Conference on Condition Monitoring 2001*, Oxford, UK, 2001, pp. 300-311.

LaserNet Fines (LNF) is an optically based debris monitoring technology that determines the existence, type, severity and rate of progression of mechanical faults by measuring the size, distribution, shape characteristics and rate of production of debris particles. LNF measures the size distribution of particles from 5 µm to more than 100 µm, and provides wear classification based on shape features for particles larger than 20 µm. The analysis of particles in this size range is useful for the early detection of mechanical faults in diesel and turbine engines, turbochargers and gearboxes. Additionally, it is useful for measuring particulate and water contamination in hydraulic and fuel systems. We describe the application of LNF to analysis of wear debris in a class survey of 18 medium speed diesel engines. The results show evidence of excess wear that has been identified with a fault mode related to inadequate lubrication. The fault identification has been corroborated by lab analysis of teardown components from a failed system within the class. LNF has also been used for analysis of aircraft and shipboard hydraulic systems. The use of LNF for assessing system cleanliness in terms of various hydraulic standards is demonstrated. The ability of LNF to detect, identify and quantify water concentrations and type of particles such as fiber, abrasive oxide and wear particles allows not only assessment of system cleanliness but also the system health and consequences of specific contamination types. The ability to develop fault signatures directly from LNF results, allowing root cause analysis, estimates of fault severity, recommendation of remedial action and prognostics will be explored.

Reintjes, J.E., Tucker, S. E., Thomas, Schultz, A., TANKERSLEY, L. L., Professor, Lu, C., Howard, P. L., Sebok, T., and Holloway, C., "The Application of LaserNet Fines for the Detection of Mechanical Wear and Hydraulic Contamination for CBM Systems," *Proceedings of the 2001 ASNE Fleet Maintenance Symposium*, San Diego, CA, 2001. (CD-ROM)

Analysis of debris that is present in machinery lubricating systems has long had the potential to provide fault-specific information in a timely manner to support diagnostics and prognosis of machinery maintenance. This capability allows the avoidance of catastrophic failures and enables improved cost-effective asset-management philosophies, especially in the area of timely maintenance and reduction of maintenance induced failures. Essen-

tial to achieving these asset management and condition based maintenance goals, are technologies that can provide reliable early identification of fault or failure mechanisms and the degree of degradation of the machine's performance capability. These technologies must also assess the effect of the performance degradation with its impact on the machine's mission requirements, the system that it supports in a shipboard environment or the affected factory environment. The LaserNet Fines (LNF) instrument delivers a technology which has significant potential in these areas. Results of the LNF batch processor's analysis of a medium speed diesel study and helicopter and shipboard hydraulic systems are presented.

SHELBY, Robert N., Professor, SCHULZE, Kay G., Professor, TREACY, Donald J., Professor, WINTERGILL, Mary C., Professor, VanLehn, Kurt and Weinstein, Anders, "An Assessment of the Andes Tutor," *Proceedings of the 2001 Physics Education Research Conference*, Edited by S. Franklin, J. Marx and K. Cummings, Rochester, NY, 2001, pp. 119-122.

Andes is an intelligent problem-solving tutor for classical physics. It was used in the fall semester of 1999 and 2000 by a group of approximately 150 students. An assessment of its effectiveness was made using: 1) comparative results on a free-response test taken by the Andes group and a control group, 2) portfolios of the students' work and 3) student opinion surveys. The results of the assessment highlight some strengths and weaknesses of Andes.

Letter

MOSCA, Eugene P., Professor, "Figuring Physics" (letter), *The Physics Teacher*, Volume 39, #7 October 2001, p. 389.

The regular item "Figuring Physics," which appeared in a recent issue, claimed that both impulses and momentum changes always occur in equal but opposite pairs. The letter clarified that while impulses do always come in equal but opposite pairs, momentum changes do not.

Internet Publications

ERTEL, John P, Associate Professor, and Dickey, Joe, "The Focusing of Transient Response in Structural Networks: Hot Spots,"accepted (11 June 2002) for publication in *Acoustics Research Letters Online* (ARLO), a refereed electronic letters journal of the Acoustical Society of America. http://ojps.aip.org/ARLO/

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.

Newsletters

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 5, p.54 (May 2001). Report on vaccinations required for entry into Zimbabwe and Zambia. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200105B.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 6, p. 10 (June 2001). An evaluation of viewing a solar eclipse from the centerline vs. the edge of the path. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200106A.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 6, p. 11 (June 2001). About Polaroid Filters. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200106A.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 6, p. 51 (June 2001). On camera obscura. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200106A.pdf

HUDDLE, James R., Associate Professor, "Using a Thermochron to Measure Temperatures during a Solar Eclipse: A Preliminary Assessment", Solar Eclipse Newsletter Vol. 6, No. 6, p. 53 (June 2001). http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200106B.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 6, p. 84 (June 2001). On the accuracy of maps. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200106B.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 7, p. 19 (July 2001). Comment on solar Filters. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200107.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 7, p. 29 (July 2001). More on solar filters. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200107.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 7, p. 30 (April 2001). More on Solar Filters. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200107.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 7, p. 32 (July 2001). More on solar filters. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200107.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 7, p. 33 (July 2001). More on solar filters. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200107.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 7, p. 32 (July 2001). More on solar filters and eclipse photography. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200107.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 7, p. 49 (July 2001). Can camcorder be damaged by taking video of the sun? http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200107.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 7, p. 61 (July 2001). On the cause of shadow bands. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200107B.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 9, p. 38 (September 2001). On Tecumseh's Eclipse. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200109B.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 9, p. 38 (September 2001). Stonehenge was not an eclipse calculator. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200109B.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 9, p. 33 (October 2001). Unusual eclipse geometry for 31 May 2003 Annular Solar Eclipse. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200110.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 11, p. 21 (November 2001). "Sunspotter" telescope. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200111A.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 11, p. 28 (November 2001). On the History of Photography. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200111A.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 11, p. 41 (November 2001). Lunar eclipses in History. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200111B.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 11, p. 50 (November 2001). A webliography on the Transit of Venus. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200111B.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 6, No. 12, p. 13 (December 2001). Kepler's eclipse joke. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200112.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 2, p. 60 (February 2002). Weather along the path of the 4 Dec 2002 solar eclipse. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200202.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 3, p. 35 (March 2002). Seasickness and the Antarctic eclipse of 2003. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200203B.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 4, p. 35 (April 2002). Film and airport security. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200204.pdf

HUDDLE, James R., Associate Professor, "Africlipse Map Error", Solar Eclipse Newsletter Vol. 7, No. 3, p. 41 (April 2002). Error in map showing eclipse path. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200204.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 4, p. 61 (April 2002). Weather forecasts for the 2003 Annular Eclipse. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200204.pdf

HUDDLE, James R., Associate Professor, "Toys for Helioeccentrics", Solar Eclipse Newsletter Vol. 7, No. 5, p. 20 (May 2002). New equipment of interest to eclipse chasers. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200205A.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 5, p. 52 (May 2002). Planning an eclipse observing session. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200205B.pdf

HUDDLE, James R., Associate Professor, Untitled, Solar Eclipse Newsletter Vol. 7, No. 5, p. 57 (May 2002). The history of eclipses observed from Antarctica. http://sunearth.gsfc.nasa.gov/eclipse/SENL/SENL200205B.pdf

Technical Reports

BENDLER, J. T., Associate Professor, EDMONDSON, C. A., Associate Professor, FONTANELLA, J. J., Professor, Sheslinger, M. F., and WINTERSGILL, M. C., Professor, "Electrical Conductivity in Glass-Forming Solid Electrolytes: Theory and Experiment," Office of Naval Research, Technical Report # 26, 1 July 2001.

> 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, Tc, below which single defects do not exist. It is shown how the pressure dependence of the conductivity is controlled by the pressure dependence of Tc. 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, FONTANELLA, J. J., Professor, and Shlesinger, M. F., "Why Conductivity Decreases with Pressure in Ion-Doped Polymers," Office of Naval Research, Technical Report # 27, 1 July 2001.

> 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 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 $LiCF_3SO_3$.

EDMONDSON, C. A., Associate Professor, and FONTANELLA, J. J., Professor, "Free Volume and Percolation in S-SEBS and Fluorocarbon Proton Conducting Membranes," Office of Naval Research, Technical Report # 26, 1 July 2001.

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»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 C_A » 0.12 which approaches that expected for continuum percolation. The activation volume results are shown to be consistent with free volume considerations.

Trident Scholar Reports

DIRK, John D., Midshipman 1/C (USN), "Electronic Reliability and the Environmental Thermal Neutron Flux," Trident Report No. 291, U.S. Naval Academy, May 2002.

Measurements of the thermal flux have been completed in various locations at the Naval Academy and in surrounding sites. Prior experimental results had indicated large terrestrial changes in the flux of thermal neutrons (more than 50x at different sea level locations). The current measurements show less than 10x difference in thermal neutrons, and most of this difference can be explained by natural attenuation from building materials.

The observed flux of neutrons has been used to predict the soft-fail rate of modern memory modules in terrestrial locations. The results agree well with published reports of "life-testing" reliability, in which hundreds of chips are tested using natural ambient conditions of cosmic rays. The results obtained in this project were also compared with similar reliability estimates based on previous scientific measurements of the thermal neutron flux.

WATHEN, Jeremiah J., Midshipman 1/C (USN), "Optical Limiting Within Capillary Waveguides," Trident Report No. 301, U.S. Naval Academy, May 2002.

An investigation of nonlinear optical waveguides is reported. To achieve an optical limiting element compatible with optical fiber systems, very narrow glass "capillary" tubes were filled with solutions of the nonlinear compound SINC. These filled tubes, called nonlinear capillary waveguides, operated analogously to optical fibers. Capillary waveguides with core diameters ranging from 5 to 200 µm were tested. Prepared waveguides had a linear transmission of 45%. Transmission characteristics of these nonlinear waveguides were measured as a function of incident energy from a pulsed, frequency-doubled Nd:YAG laser that produced 7ns pulses at 532nm. With a 10 µm core, nonlinear effects are observed at input energies as low as 1.0E-10 J. A transmission of 5% or less was observed for input energies as low as 1.0E-7 J, making these waveguides effective optical limiters.

Experimental data was compared with a computer model that simulated the limiting response of SINC. Simulations have proven quite accurate for the larger diameter capillaries. Modifications to the model must be made to compensate for boundary condition effects within the smaller diameter capillaries.

Presentations

BENDLER John T., Associate Professor, FONTANELLA, John J., Professor, WINTERSGILL, Mary C., Professor, and Shlesinger, Michael F., "Pressure and Temperature Effects on Dielectric Relaxation Near the Glass Transition," 4th International Discussion Meeting on Relaxations in Complex Systems, Crete, Greece, 18-26 June, 2001.

BENDLER John T., Associate Professor, and FONTANELLA, John J., Professor, "A New Vogel-type Law for Polymer Electrolytes," 4th International Discussion Meeting on Relaxations in Complex Systems, Crete, Greece, 18-26 June, 2001.

BENDLER, John T., Associate Professor, EDMONDSON, Charles A., Associate Professor, FONTANELLA, John J., Professor, Sheslinger, Michael F., and WINTERSGILL, Mary C., Professor, "Electrical Conductivity in Glass-Forming Solid Electrolytes: Theory and Experiment," SSI 2001: International Conference on Sold State Ionics, Materials and Processes for Energy and Environment, Cairns, Australia, 8-12 July, 2001.

BENDLER, John T., Associate Professor, "Influence of Pressure on Ionic Conductivity, Dielectric Relaxation, and Viscosity Near The Glass Transition," 15th Annual Harry C. Allen Symposium Honoring Paul T. Inglefield, Clark University, Worcester, MA, 12 October 2001.

BENDLER, John T., Associate Professor, and FONTANELLA, John J., Professor, "Glass Formation and Pressure Effects," 2002 March Meeting of the American Physical Society, Indianapolis, IN, 19 March 2002.

BENDLER, John T., Associate Professor, FONTANELLA, John J., Professor, and WINTERSGILL, M. C., Professor, "The Need to Reconsider Traditional Free Volume Theory for Polymer Electrolytes," 8th International Symposium on Polymer Electrolytes, Santa Fe, NM, 19-24 May 2002.

BIERMANN, MARK L., Assistant Professor, and Rabinovich, W. S., "Valence Subbands in Ga1-xInxAs/Ga1-yAlyAs Quantum Wells Under In-Plane Biaxial and Uniaxial Strain," Quantum Electronics and Laser Science Conference 2002, Long Beach, CA, May, 2002.

BIERMANN, Assistant Professor, Wessemann, Jodi L., Sudhakaran, Gubbi R., and Kolehmainen, Karen, "Getting a Tenure-Track Position at a Primarily Undergraduate Institution," Council on Undergraduate Research 2002 National Conference, Connecticut College, New London, CT, June, 2002.

BIERMANN, Mark L., Assistant Professor, KATZ, Debora M., Associate Professor, AHO, Robert, Midshipman 1/C (USN), DIAZ-BARRIGA, James, Midshipman 1/C (USN), and PETRON, Jerome, Midshipman 1/C (USN), "Wien's Law and the Temperature of the Sun," Council on Undergraduate Research 2002 National Conference, Connecticut College, New London, CT, June, 2002.

EDMONDSON, C. A., Associate Professor, and FONTANELLA, J. J. Professor, "Percolation and Proton Transport in S-SEBS Block Polymer Proton Conducting Membranes," SSI 2001: International Conference on Sold State Ionics, Materials and Processes for Energy and Environment, Cairns, Australia, 8-12 July, 2001.

EDMONDSON, C. A., Associate Professor, and FONTANELLA, J. J. Professor, "Electrical Conductivity and NMR Studies of Sulfonated Styrene-Ethylene Copolymer Membranes," 8th International Symposium on Polymer Electrolytes, Santa Fe, NM, 19-24 May 2002.

ERTEL, John, Associate Professor, and Dickey, Joe, "Time Reversal in Layered Media and the Development of Hot Spots," 142nd Meeting of the Acoustical Society of America, Fort Lauderdale, FL, 3-7 December 2001.

ERTEL, John, Associate Professor, and Dickey, Joe, "The Focusing of Transient Response in Structural Networks: The Development of Hot Spots," 142nd Meeting of the Acoustical Society of America, Fort Lauderdale, FL, 3-7 December 2001.

FONTANELLA, John J., Professor, EDMONDSON, Charles, A., Associate Professor, BENDLER, John T., Associate Professor, and WINTERSGILL, Mary C., Professor, "Properties of Fuel Cell and Battery Materials," Air Force Office of Sponsored Research / Office of Naval Research (AFOSR/ONR) Electrochemistry Science and Technology Review, Annapolis, MD, 4-6 March 2002.

HUDDLE, James R., Associate Professor, "Observing the Total Solar Eclipse of 21 June 2001," Sheraton Hotel, Harare, Zimbabwe, 19 June 2001.

HUDDLE, James R., Associate Professor, "Experiments for Students during a Total Solar Eclipse," American Association of Physics Teachers Summer Meeting, Rochester, NY, 20-25 July 2001.

HUDDLE, James R., Associate Professor, "Nuclear Weapons for Physics Majors," American Association of Physics Teachers Summer Meeting, Rochester, NY, 20-25 July 2001.

HUDDLE, James R., Associate Professor, "Experiments for Students during a Total Solar Eclipse," Totality Day Conference, Open University, Milton Keynes, England, 11 August 2001.

KATZ, Debora M., Associate Professor, "Active Learning Methods in Basic Physics," Naval Academy Preparatory School Development Program, Newport, RI, 4-8 July 2001.

KATZ, Debora M., Associate Professor and BIERMANN, Mark L., Assistant Professor, "Research Courses in Physics at the U. S. Naval Academy: An Approach to Undergraduate Research," Council on Undergraduate Research 2002 National Conference, Connecticut College, New London, CT, June, 2002.

KORMAN, M. S., Professor, "Nonlinear Acoustic Techniques for Land Mine Detection: Experiments and Theory," 142nd Meeting of the Acoustical Society of America, Fort Lauderdale, FL, 3-7 December 2001.

KORMAN, M. S., Professor, "Comparison of Linear and Nonlinear Experiments for Land Mine Detection," 142nd Meeting of the Acoustical Society of America, Fort Lauderdale, FL, 3-7 December 2001.

MIKULSKI, Paul T., Assistant Professor and HARRISON, Judith A., Associate Professor, "Molecular Dynamics Simulations of the Friction of n-Alkane Monolayers: Tip and Sliding Direction Effects," World Tribology Congress, 3-7 September 2001, Vienna, Austria.

Reintjes, J. E., Tucker, S. E. Thomas, Schultz, A., TANKERSLEY L. L., Professor, Lu, C., Sebok, T. and Holloway, C., "Application of LaserNet Fines to Mechanical Wear and Hydraulic Monitoring," International Conference on Condition Monitoring 2001, 25-27 June, 2001, Oxford UK.

Reintjes, J. E., Tucker, S. E. Thomas, Schultz, A., TANKERSLEY L. L, Professor, Lu, C., Howard, P. L., Sebok, T. and Holloway, C., "The Application of LaserNet Fines for the Detection of Mechanical Wear and Hydraulic Contamination for CBM Systems," 2001 ASNE Fleet Maintenance Symposium, San Diego, CA, 28-31 August, 2001.

SCHNEIDER, Carl S., Professor, "Role of Reversible Susceptibility in Ferromagnetic Hysteresis," 46th Conference on Magnetism and Magnetic Materials, Seattle, WA, 12-15 November, 2001.

SCHNEIDER, Carl S., Professor, "Equation of State for Ferromagnetic Transducers," 9th Annual International Symposium on Smart Structures and Materials, San Diego, CA, 19-21 March, 2002.

SCHNEIDER, Carl S., Professor, "Magnetic Signatures of Ships and Mines," 5th International Symposium on Technology and the Mine Problem, Monterey, CA, 22-26 April, 2002.

SCHNEIDER, Carl S., Professor, " Equation of State for Ferromagnetic Transducers," ONR Workshop on Transduction Materials and Devices, Baltimore, MD, 13-15 May, 2002.

SHELBY, Robert N., Professor, SCHULZE, Kay G., Professor, TREACY, Donald J., Professor, WINTERSGILL, Mary C., Professor, Vanlehn, Kurt, and Weinstein, Anders, "An Assessment of the Andes Tutor," American Association of Physics Teachers National Meeting, Rochester, NY, 21-25 July, 2001.

SHELBY, Robert N., Professor, SCHULZE, Kay G., Professor, TREACY, Donald J., Professor, and WINTERSGILL, Mary C., Professor, "Andes: An Intelligent Tutoring System," Naval Academy Physics Department Colloquium, Annapolis, MD, 21 March, 2002.

TREACY, Donald J., Professor, SHELBY, Robert N., Professor, SCHULZE, Kay G., Professor, WINTERSGILL, Mary C., Professor, and VanLehn, Kurt, "Andes: A Tutoring System for Classical Physics," 123rd AAPT National Meeting, Rochester, NY, 25 July 2001.