Physics Department

Professor Francis D. Correll
Chair

Physics Department faculty members were vigorously engaged in research and scholarship during the 1999-2000 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, cosmology, nonlinear optics, nuclear structure physics, and planetary physics. They also relate work in a variety of interdisciplinary fields, including cognitive science, applied electromagnetics, environmental science, geoacoustics, materials science, and medical acoustics. Additionally, they describe a number of important efforts to understand how students learn physics and how to teach it more effectively.

External research sponsors included the National Science Foundation, the Office of Naval Research, the Naval Research Laboratory, the Naval Surface Warfare Center, the Naval Air Warfare Center, the American Astronomical Society, and the Swiss National Science Foundation. Internal support came from the Naval Academy Research Council.

Several of our faculty members received special recognition for their research and scholarship. Professor Elise Albert was named "Volunteer of the Week" by The Evening Capital, in part for her popular talks on Astronomy and Astrophysics. Associate Professor Jeffrey R. Vanhoy was awarded beam time to conduct nuclear structure experiments using accelerators at the Paul Scherrer Institute in Zurich. Assistant Professor Debora Katz-Stone was awarded observing time to conduct astrophysics research using the Very Large Array.

Our faculty shared the results of their research by publishing scholarly articles in journals and presenting talks and posters at conferences. They published twelve refereed articles this year and made 37 presentations, including some at international meetings in England, France, Germany, Greece, Scotland, Turkey, and Zimbabwe.

The relationship between our faculty and our students remained close and productive. One Trident Scholar measured the orbital and rotational motions of several near-earth asteroids, and presented his results at a national meeting of the American Astronomical Society. Another midshipman developed a successful Trident Scholar proposal which he will carry out during the next academic year. Fourteen midshipmen participated in a variety of independent research courses, and several of them gave talks based on their work at professional meetings. Four high-school students, one from Holland, collaborated with Physics Department faculty on research projects in acoustics, atomic physics, and astronomy.

Sponsored Research

Photonic Bandgap Materials for Optical Limiting

RESEARCHER: Assistant Professor James J. Butler
SPONSOR: Naval Research Laboratory (NRL)

Nonlinear photonic bandgap materials have been the focus of intense study recently. In particular, these structures show great promise in applications such as optical power limiting and beam steering. In this investigation, I will construct and characterize two types of optical limiters. The first will utilize a hollow waveguide that has its core filled with a material that has an index of refraction that depends on the intensity of the light that is used. At low intensities, the index of refraction of the core will be large enough for waveguiding to occur. As the intensity increases, the index of refraction of the core will decrease until waveguiding ceases, thereby limiting the amount of light that is transmitted. A similar study will be performed using a 2-D array

of these waveguides. In this structure the waveguides couple light from one to another. As the intensity of the light increases the coupling will increase, thus limiting the amount of light transmitted.

Structure and Composition of Metal Fittings from *H.M.S. DeBraak*

RESEARCHERS: Professor Francis D. Correll and Dr. Charles H. Fithian (Delaware State Museums)
SPONSOR: Delaware State Museums

The goal of this project is to provide new perspectives on 18th-century naval production methods and metallurgy using modern ion-beam analysis techniques.

H.M.S. DeBraak was a 16-gun English warship that sank on May 25, 1798, off Cape Henlopen, near Lewes, Delaware. Apparently, the hull became covered with silt shortly after it sank. After many attempts to locate it, *DeBraak* was finally found and salvaged in 1984. Among the recovered items are a large collection of well-preserved copper-alloy bolts, fasteners, sheathing, and sheathing nails. They constitute a valuable record of the materials and techniques used in the construction of naval vessels in the late 18th century.

We have agreed to be part of a large, multi-disciplinary team that will study *DeBraak's* hull. We will analyze the structure and composition of a representative sample of *DeBraak's* metal fittings in order to determine fabrication techniques and document important phases in the development of alloys for shipboard use. We conducted a series of preliminary measurements in 1998, but lack of funding has delayed the beginning of the full study until this year.

Electrical Properties Of Liquids And Polymer Electrolytes Intended For Use In Fuel Cells

RESEARCHERS: Assistant Professor Charles A. Edmondson, Professor John J. Fontanella,
Professor Mary C. Wintersgill, and Assistant Professor Phillip E. Stallworth
SPONSOR: Office of Naval Research (ONR)

A fuel cell is a device which 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 also 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, a Teflon based material, has undergone significant testing and application in the development of fuel cells. These studies 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 the DOW 800 and DOW 1000 membranes and has been accepted for publication in Solid State Ionics. Current work is focused on sulfonated tri-block 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. A manuscript is in preparation to present the most recent results.

Proposed LWAD99-2 and 99-3 Test Sites Assessment of Preliminary Data and Additional Data Sources for Proposed Test Site Evaluation

RESEARCHER: Professor Douglas W. Edsall
SPONSOR: Naval Research Laboratory (NRL)

Researchers at the Naval Research Laboratory (NRL) who are involved in Littoral Warfare Advanced Development (LWAD) Sea Tests rely upon preliminary data for the selection of a final test site. This data is primarily gleaned from historical data files compiled and supplied by various navy laboratories. An in-depth review was conducted of uncited, yet readily available sources of relevant acoustic, geologic, geophysical, oceanographic and meteorological data for LWAD99-2 and LWAD99-3 sites. Once these additional data sources were identified, accessed and reviewed, a comparison with historical data provided in the preliminary reports was undertaken. Given the greater quantity of more recent data, a re-assessment of the selection criteria was made, which further refined the final selection site of LWAD99-2. The creation of a decision tree for LWAD99-3 was invaluable in the selection of the final site for that test.

The results of my investigation into the processes involved in proceeding from preliminary to final site selection for these LWAD sea test sites and suggestions on how to gather additional and more relevant data for the decision making process is presently under review at code 7140.

Creation of Geoacoustical Maps for Selected Littoral Zone Areas

RESEARCHER: Professor Douglas W. Edsall
SPONSOR: Naval Research Laboratory (NRL)

Utilizing two powerful data manipulation programs, MapGrafix and 4th Dimension, bathymetric data was downloaded from NOAA compact disks to create a Long Island Sound base map. Geologic, physiographic, sedimentologic and bathymetric data from sources such as the USGS Office of Marine Geology were added in layers to the base map. The Long Island Sound sea floor was divided into mapable areas characterized by their geoacoustical properties as defined by differences in the geology, physiography and sediment type, thickness and distribution and the existing marine processes.

Recognition and Differentiation of Acoustic Signatures in Breath Sounds of Thoracic Cavity Trauma Patients in an ER Setting: Applications to Rapid Diagnosis of Battlefield Casualties

RESEARCHER: Professor Douglas W. Edsall
SPONSOR: Office of Naval Research (ONR)

Breath sounds from a cohort of patients in the University of Maryland Shock Trauma Center were collected and subsequently analyzed using a computerized sound analysis program. The data were collected from patients with bullet or knife wounds or chest trauma from automobile accidents. The various frequencies observed were related to the type, severity and location of the wound or injury. The location of the acoustic sensors on the thoracic cavity helps pinpoint the location of the trauma and the findings were consistent with the diagnoses of Emergency Room physicians.

Scattering of Acoustical Power from Unribbed and Regularly Ribbed Panels

RESEARCHERS: Associate Professor John P. Ertel (USNA), Dr. Joseph W. Dickey, and Dr. Gideon Maidanik (NSWC, Carderock)
SPONSOR: Naval Surface Warfare Center, Carderock Division (NSWC,CD)

Research continues on the radiation and partial radiation efficiencies as well as the radiated and partially radiated power from point and line driven panels. Current studies were of the mechanical power dissipated in a point driven fluid loaded panel which were compared to the radiated power. The interdependence of the mechanical and radiated powers was investigated, and

they were related as fractions of the total input power. The dependencies of the mechanical and radiated power on frequency, fluid loading, and mechanical loss were further studied. The mechanical power as well as the radiation efficiency has been shown to increase with increased damping in a panel while the radiated power decreases, as it must. A paper including all of the above together with the most recent results of computer experiments is in production.

Properties of Fuel Cell and Battery Materials

RESEARCHERS: Professor John J. Fontanella, Professor Mary C. Wintersgill,
Assistant Professor Charles A. Edmondson, and Assistant Professor Phillip E. Stallworth
SPONSOR: Office of Naval Research (ONR)

The goal of this project is to determine the ion transport mechanism in materials proposed for use in fuel cells and batteries. The materials of interest include ion-exchange membranes for fuel cells and liquid and polymer electrolytes for batteries. NMR studies of cathode materials will also be carried out. For ion-exchange membranes, studies will be made of the sulfonated block copolymer membranes developed by Wnek and coworkers at Virginia Commonwealth University and the PSSA-PVdF and composite membranes described in the ONR proposal by S. G. Greenbaum. One battery material of interest is a hybrid electrolyte composed of PFdF-HFP copolymer containing fumed silica developed by Bellcore. In addition, liquids such as propylene carbonate (containing a lithium salt), phosphoric acid and room temperature molten salts will also be studied.

Experiments for Students During a Total Solar Eclipse

RESEARCHER: Associate Professor James R. Huddle
SPONSORS: Innovations in Travel, Inc., Annapolis, MD and Texas Instruments

A total solar eclipse presents an exciting opportunity to teach students about science. Experiments first tried in Aruba during the 26 February 1999 total eclipse were modified and improved during the eclipse of 11 August 1999 in Elazig, Turkey. Specifically, the flash spectrum was recorded using a video spectrometer, and environmental data including ambient light levels, temperature, relative humidity and barometric pressure were measured using Texas Instruments Calculator-Based Laboratory equipment. The investigator has learned how to take environmental data of quality sufficient to be useful to the scientific community. Flash spectra recorded with the video spectrometer are not of scientifically useful quality, but they are pedagogically interesting.

Texas Instruments and Vernier Software and Technology provided twenty-four CBL systems with sensors for use by faculty and students at the University of Zambia in Lusaka, and the University of Zimbabwe and St. John's College, both in Harare. This equipment was used to record temperatures and light levels as a function of time during the eclipse of 21 June 2001 at a number of locations in Zimbabwe and Zambia.

Electron Populations and Ages in Radio Galaxies

RESEARCHER: Assistant Professor Debora M. Katz-Stone
SPONSOR: University of Minnesota

Galaxies are large collections of stars and gas. In addition, some galaxies have huge plumes of plasma that stretch far beyond the volume occupied by the stars and gas. These plumes are usually observed in the radio part of the electromagnetic spectrum. Galaxies that have strong radio emission are called "radio galaxies."

Radio galaxies have been classified by morphology. Fanaroff-Riley Type I galaxies show continuous out flowing jets of plasma while Fanaroff-Riley Type II galaxies have jets engulfed by back flowing cocoons. However, I found sheaths in several Fanaroff-Riley Type I galaxies. These had not been previously observed, and are not understood.

As part of an international research group, I was awarded time to observe several radio galaxies with the Very Large Array (VLA) in order to further investigate this discovery. In the summer of 2000, I went to the University of Minnesota for two months to work with my collaborators to analyze these data.

Our initial analysis of three new Fanaroff-Riley Type I galaxies has revealed two more sheath engulfed sources. This has allowed us to speculate on the nature of these structures.

In addition, the third radio source appears to be two interacting radio galaxies. While this source had been previously observed, our new images have the highest signal-to-noise ratio and resolution. Our observations settle several mysteries about this radio source.

Development of an Infrared Ytterbium Vanadate Laser

RESEARCHERS: Assistant Professor Anne-Marie d. Novo-Gradac, Midshipman 1/C Thomas Stone, USN, and Ensign Robert McClure, USN
Dr. William Scharpf, Dr. Frank Narducci and Mr. Alan Laux (NAWC, AD)
SPONSOR: Naval Air Warfare Center, Aircraft Division (NAWC, AD)

Currently there are numerous industrial and military applications for the neodymium doped yttrium aluminum garnet laser (Nd:YAG). This laser operates at 1064 nm with wall plug efficiencies ranging from 3 to 10 percent. The purpose of this research project is to investigate the viability of ytterbium doped vanadate ($Yb^{3+}:YVO_4$) as a competitive laser material to Nd:YAG. It is predicted that $Yb^{3+}:YVO_4$ will produce laser emission around 1010 nm with wall plug efficiencies substantially greater than Nd:YAG. This would significantly reduce the expense and bulk of such laser systems.

Experiments conducted during the summer of 1999 focused on measuring the spectral characteristics of $Yb^{3+}:YVO_4$ and determining whether rare earth contaminants detract from the desired laser process. High resolution absorption spectra for $Yb^{3+}:YVO_4$ were measured for wavelengths ranging from 400 nm to 1100 nm. Most measurements were conducted at cryogenic temperatures (less than 40K) in order to improve spectral clarity. Spectra were also measured at room temperature since that is the planned operating temperature of the laser. Infrared spectra indicate that $Yb^{3+}:YVO_4$ has very strong absorption from approximately 940 nm - 990 nm, with the strongest absorption at 985 nm. This overlaps well with high power laser diodes which can be used as the pump source for the desired laser.

Rate equation models were constructed to simulate the action of a three-level laser system and four-level laser system. Experimental values measured as part of this project were used as input parameters for the model in order to predict the optimum pumping scheme for the laser. Results indicate that $Yb^{3+}:YVO_4$ is best suited to continuous wave (CW) pumping since the laser level is very long lived. The model also predicts that laser action may occur in $Yb^{3+}:YVO_4$ at CW pump powers as low as 100 mW.

It was determined that rare earth contaminants are not present in the $Yb^{3+}:YVO_4$ samples in sufficient concentration to impede the laser process. The ideal pump wavelength was identified spectroscopically to be 985 nm. A suitable pump laser is currently being installed in the laboratory and an attempt to produce laser action in $Yb^{3+}:YVO_4$ is planned for the summer of 2000.

A Cooperative Model of Ferromagnetic Hysteresis

RESEARCHER: Professor Carl S. Schneider
SPONSOR: Office of Naval Research (ONR)

We present a cooperative model of ferromagnetic hysteresis with potential applications in magnetostrictive transducer control, transformer design, magnetoelastic effects and hysteresis in general. For a three percent nickel steel alloy, we measured the major magnetic induction hysteresis curve, return branches from it, and minor loops at several magnetic field and induction values. Modeling variables include coercive and effective fields; saturation, remanent and reversal magnetization; initial, maximum and remanent susceptibility; and flux rate. Magnetization is scaled to its saturation value, magnetic field to its coercive value in the direction of field change, and susceptibility to its reversible function of magnetization. Reversible susceptibility contributions from crystalline anisotropy and wall bending are distinguished. The differential susceptibility increases from its reversible value exponentially with magnetization change from any reversal and inversely with the difference between applied and coercive magnetic field. Rayleigh's hysteresis coefficient is an exponential function of magnetization and Brown's effective field. Its value for the initial curve is predicted to be twice that after reversals. An increase in curvature of hysteresis loops near the coercive field causes them to creep toward the anhysteretic magnetization with cycling, as does magnetic reactance of the sample primary coil.

Magnetic phase change is cooperative alignment when the nonlinear dipole field of a ferromagnetic domain exceeds the threshold coercive field of its neighbors.

ANDES: A Tutoring System For Classical Physics

RESEARCHERS: Professor Robert N. Shelby, Professor Donald J. Treacy,
Professor Mary C. Wintersgill, and Professor Kay G. Schulze (Computer Science Department)
SPONSOR: Office of Naval Research (ONR)

Classical physics is a prerequisite for virtually all university level study of science and technology, yet is a notoriously difficult subject for students to learn. We are building a tutoring system, named ANDES, that will help students learn physics. ANDES is based on the latest research in Cognitive Science as well as input from a team of physics instructors with years of experience in instructional reform. When completed, ANDES will be used at the Naval Academy to enhance the introductory physics course, SP211, which is taken by approximately 900 students per year.

The coding and cognitive science portions of the system are being done by Professor Kurt VanLehn's group at the Learning Research and Development Center at the University of Pittsburgh. The domain knowledge is being developed by Professor Donald Treacy, Professor Mary Wintersgill and Professor Robert Shelby of the USNA Physics Department. Knowledge base construction, coding, and coordination is being done by Professor Kay Schulze of the USNA Computer Science Department.

The project is currently in its fifth year and will include a 6-section trial of the current system in the fall of 2000. Focus of the project is on increasing material coverage, knowledge base expansion, addition of more difficult problems and improving the quality of the help being given by the tutor. These changes are designed to improve acceptance of the system by the students and use of the system by professors.

Optical Physics with Applications to Imaging and Pattern Recognition

RESEARCHER: Professor Lawrence L. Tankersley
SPONSOR: Naval Research Laboratory (NRL)

Research has continued on a variety of subjects in support of ongoing efforts 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, and correlator studies using multiple quantum well devices. Theoretical background areas including quantum optical effects are studied in order to understand fundamental limitations on approaches to noise reduction in optical imaging schemes.

Work performed under this program includes: (1) Theoretical investigation of non-linear effects involving longitudinal fields; (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; and (7) Investigation of signal to Noise effects due to amplification and attenuation.

Coexisting Structures in the Mid-Shell Tellurium Nuclei

RESEARCHERS: Associate Professor Jeffrey R. Vanhoy,
Midshipman 1/C Robert T. Coleman, USN, Midshipman 2/C James A. Tanyi, USN,
Kevin A. Crandell (St John's College Class of 2000), Sally F. Hicks (University of Dallas),
M. Walburn (University of Dallas Class of 1999), B. Sklaney (University of Dallas Class of 1999),
P. E. Garrett, N. V. Warr, S. W. Yates (University of Kentucky), and
F. Corminboeuf, L. Genilloud, J. Jolie, J. Kern, and J. L. Schenker (University of Fribourg)
SPONSORS: National Science Foundation (NSF), Swiss National Science Foundation,
and the Paul Scherrer Institut

Tellurium-120 appears to have many characteristics of a harmonic-vibrational nucleus. It is known, however, that other configurations, such as particle and intruder structures, play an important role in neighboring nuclei. Spectroscopic information such as spins and parities, branching ratios, and transition rates are required to search for both collective and particle-like structures and to examine their interplay. One of the best ways to obtain this information is with in-beam gamma-ray spectroscopy.

The level schemes of the mid-shell tellurium nuclei, with A = 120-124, have been developed utilizing in-beam gamma-ray spectroscopy following the (n,n'γ) and (α,2nγ) reactions and iodine beta decay. Excitation functions, gamma-gamma coincidences, and angular distributions were measured. Spectroscopic information was obtained for many new levels below 4.5 MeV excitation. Low-spin states were found to be a mixture of spherical-vibrational, two-particle, and intruder configurations. The emerging intruder band is identified in ^{120}Te. The situation in ^{122}Te and ^{124}Te is not quite as clear.

Level Scheme of ^{126}Te Using Inelastic Scattering from (n, n' γ) Reaction Studies

RESEARCHERS: Associate Professor Jeffrey R. Vanhoy, Midshipman 2/C James A. Tanyi, USN
Sally F. Hicks (University of Dallas), and
M. C. Burns, N. V. Warr, and S. W. Yates (University of Kentucky)
SPONSOR: National Science Foundation (NSF)

The excited levels of ^{126}Te have been studied using the (n,n'γ) reaction at the University of Kentucky's CN Van de Graaff Laboratory. Gamma-ray excitation functions and angular distributions were measured for transitions from levels up to 3.34 MeV excitation in ^{126}Te. Analysis of the excitation function data has identified 25 excited states of spin 0-6, previously unknown.

Visual Survey for Local Group Dwarf Galaxies

RESEARCHER: Assistant Professor Alan B. Whiting, Commander, USNR
SPONSOR: American Astronomical Society

Dwarf galaxies are central to theories of galaxy formation and shed important light on star formation. In addition, they act as tracers of dark matter. Extremely low-luminosity dwarfs are only detectable at very short distances, in effect in and near the Local Group of galaxies. A visual search of southern sky photographic survey plates has resulted in a list of candidate Local Group low-luminosity dwarf galaxies. Follow-up observations have confirmed two as previously unknown members of the Local Group, four as nearby dwarfs just outside the Group and about forty as more distant low-luminosity galaxies. A search of the northern sky plates has resulted in a list of about one hundred similar candidates.

Independent Research

Intermediate Velocity Clouds

RESEARCHERS: Professor C. Elise Albert and Dr. Laura Danly (University of Denver)

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

Optical Properties of Beam Steering Elements Utilizing Volume Holographic 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, I have 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.

Index-Shifted Bragg Gratings

RESEARCHER: Assistant Professor James J. Butler

Bragg gratings, or distributed feedback structures (DFBS), are regions of material in which the index of refraction is periodic. These structures act as highly reflecting mirrors for light with a wavelength near the Bragg wavelength of the DFBS. By introducing discontinuities in the periodicity of the grating, high transmission regions open for a narrow range of wavelengths that were reflected in the unperturbed structure. The particular wavelength range that is now transmitted can be tuned by careful control of the index of refraction of the structure. I have utilized a transfer matrix method to make theoretical predictions of the transmission properties of a structure composed of an arbitrary number of grating regions, regions of uniform index of refraction, and discontinuities. These predictions were verified experimentally using temperature tuned fiber Bragg gratings.

Theory of Sound Production by Excised Laryngeal Preparations

RESEARCHER: Professor Samuel A. Elder

Previous and continuing studies at USNA of excised laryngeal preparations, driven by warm moist air in an anechoic chamber, have suggested that despite the complexity of laryngeal physiology, a simple physical model may be used to account for major features of the production of sound by the human larynx. An excised laryngeal preparation mounted in an anechoic chamber is projected to radiate as a point source, at frequencies for which its dimensions are small compared to wavelength. For monopole sound, radiated sound pressure is proportional to the time derivative of the volume flow, and this in turn depends on the changing area of the glottal slit. Over much of the open glottal cycle, the glottal jet particle velocity is expected to be relatively independent of the amount of glottal open area, and it should be possible to estimate superglottal sound production by numerical differentiation of the photoglottographic signal. However, near the beginning and end of the open cycle, rapid changes in jet speed must occur, causing peaks in the waveform of the generated sound. This deviation from an otherwise sinusoidal wave is believed to provide the harmonic content needed to excite the head resonances responsible for the formants of the human voice. Subglottal sound, on the other hand, since the excised larynx is mounted on a long air tube, should appear as a plane wave, for

which the sound pressure trace is similar to but out-of-phase with the photoglottographic trace. These assumptions have been verified for a simple rubber laryngeal model by recent measurements of Midshipman 1/C Price Chadwick, USN. Comparison of similar measurements for excised human larynges, using the same instrumentation, are expected to be made later.

Magnetospheric Physics

RESEARCHER: Professor Irene M. Engle

Several topics in magnetospheric physics were studied or worked on intermittently during the past year. These include:

Modeling, from first principles, a representation of the Jovian magnetosphere during a semi-inflated state, as observed during the Voyager II flyby. The expanded version of the Voyager II Era magnetosphere field model was the one most applicable to correct predictions and useful data analysis for the July 1994 Shoemaker-Levy 9 Encounter with the Jovian magnetosphere, (which culminated in the collision with the planet). A floppy magnetodisk to replace a rigid magnetodisk is currently being explored, but some fundamental problems have arisen. The mathematical forms used to fit the disk are Euler potentials whose behavior in the neighborhoods outside the regions where the parameters fits were made is bizarre. This discovery was combined with similar difficulties encountered by other investigators into a generalized work on the hazards of such modeling approaches.

A new look at the Mercury magnetospheric field, in response to a published review on Mercury which contains some conclusions which are not supported by this investigator's experience. In addition, there is new interest in obtaining time dependent configuration modeling for analyzing recently observed photo-ionization of heavy ions (especially sodium) near the disc of Mercury. The researcher presented her work at the European Space Agency Workshop for planning a new mission to Mercury and her model was formally requested and supplied for use in mission planning. The associated paper has been published in a special issue of Planetary and Space Science (January 1997). Ensign Jacob Scott undertook as a special project the mapping of the boundaries of the magnetospheric models being used by ESA investigators for mission planning and made a favorably-received presentation of results. An associated manuscript was submitted to a referred journal. The referees said that, although the project was useful to the teams using the model, it would not be useful for the paper to be published in the Journal of Planetary and Space Science, as the necessary details would occupy too many journal pages. The results in terms of a 3-dimensional surface grid and an interpolation were delivered to investigators at Imperial College, London, and are being used, but a concise analytical description appropriate for publication and having sufficient accuracy to be useful to investigators has yet to be achieved.

Modeling, either from first principles or by scaling from a function set, self-consistent, three-dimensional global magnetospheres of Uranus and Neptune.

Adapting alternate sets of orthogonal functions for three-dimensional representation of magnetospheres for earth and other planets with intrinsic planetary magnetic fields.

Investigations of the relationship of observed temporal variations of magnetospheric configurations to the proximate causes and consequential phenomena; investigations of the mechanisms for transport of particles, momenta, and energy related to the aforesaid phenomena. Attempts are being made to model upstream shock waves attributable to diurnal variations of Jovian magnetopause position.

Modeling, from first principles, a representation of the Saturnian magnetosphere as observed during the Pioneer 11 and Voyager I and II flybys. An expanded (from original version) paper written jointly with Sylvestre Maurice was published in the Journal of Geophysical Research. Midshipman Mark Skubis (USNA Class of 1996) worked on an "upgrade" of the model by incorporating a non-equatorial plane incidence of the solar wind as his 1995-96 Trident Scholar Project. A follow-up paper on details of possible size and shape configurations for a plausible range of direction of incident solar wind and solar wind pressure was published (December, 1996), with co-authors Mark Skubis, Sylvestre Maurice and Michel Blanc. The model was adopted by the CASSINI mission investigators as their basic magnetic field model for planning purposes for the now-launched mission to Saturn. Several presentations based upon the work have been made in Europe. Midshipman Jeremy J. Bruch (USNA Class of 1999) produced an "upgrade" to the model by incorporating a realistic representation of a magnetotail for his 1998-99 Trident Scholar Project. The researcher has been thinking about and working on some additional refinements inspired by comments made by colleagues during the discussion following Ensign Bruch's oral presentation at the Magnetospheres of the Outer Planets meeting.

New Experiments for SP324/425 and Demonstrations for SP301

RESEARCHER: Associate Professor James R. Huddle

Several new experiments have been developed for the Physics of the Atom courses (SP324 and SP425), and new demonstrations have been developed for the Modern Physics course (SP301). These are briefly described below.

Measurement of Planck's constant. Characteristic curves of current vs. voltage are measured for six different light-emitting diodes (LEDs). From these curves, the turn-on voltage for each LED can be determined. A plot of the turn-on voltage vs. the LED's peak frequency is a straight line. The value of Planck's constant can be determined from the slope of the line. This method returns a much more accurate value for Planck's constant than can be determined from a study of the photoelectric effect.

Aristarchus's Experiment. Some 2500 years ago, Aristarchus showed how the size of the moon and its distance from Earth can be determined from simple observations made during a lunar eclipse. We repeated Aristarchus's experiment during the total lunar eclipse of 20 January 2000, and achieved measurements of the moon' size and distance that are accurate to within 10 percent.

Modern Physics Demonstrations. Topics covered in SP301 include special relativity, the Old Quantum Theory, quantum mechanics and nuclear physics, and many of the students struggle with the more abstract concepts. There is no laboratory associated with the course, and it is very difficult to demonstrate these concepts in the classroom. Nevertheless, there are some phenomena that can be demonstrated, and I've worked up demonstrations of blackbody radiation, electron diffraction and atomic spectra. The most successful of these is a demonstration of atomic spectra using a video spectrometer. The others need further development.

Demonstration Of Doppler Effects And Sound Speed Measurement Using An Analog Frequency-To-Voltage (FM) Detection Circuit

RESEARCHERS: Professor Murray S. Korman,
Anne Arundel County High School mentorship students Angela K. Huegel and Michael S. Naff

An audio frequency FM detector has been designed and built to measure very small Doppler shifts for classroom demonstrations. This detector uses a limiter, a series L-C phase-shift network, two sine-to-square wave circuits, a multiplier and low pass filter. Using this detector, one can easily measure a deviation of 1/20 Hz in a 4000 Hz carrier. The complete apparatus consists of a stationary piezo-tweeter radiating a tone near a microphone that translates with periodic motion, using a motorized disk and linkage mechanism, which drives a translation stage. The output of the microphone goes to the FM detector, which outputs to a digital oscilloscope or meter for display. Calibration is extremely linear and is performed using the digital frequency readout on the generator. From a measure of the peak to peak Doppler shift Δf (from the periodic Doppler shift signal vs time), the source frequency f, the radius R of the disk and the period T, one can predict the sound speed to be $C = (f/ \Delta f) (4\pi R/T)$. Here, an approximation involving the linear velocity has been made. Results for C are typically within 1% of the expected value for air at room temperature.

Optical Spectroscopy of Upconversion Processes in Rare Earth Doped Crystalline Solids

RESEARCHERS: Assistant Professor Anne-Marie d. Novo-Gradac and
Mr. J. Derleth (St. John's College Class of 2000)

Upconversion is a process which results in the emission of light from a material that is being optically pumped by light lower in frequency than the emission. This is achieved by converting two or more low frequency input photons into a single high frequency output photon. As a result, it is possible to produce blue emission from a crystal that is being pumped by an infrared diode laser. The upconverting crystal can be coupled with the diode pump laser into a compact package to produce a visible light laser. Such systems have immediate applications in the optical data storage industry. Lasers of this nature have been constructed, but are not yet commercially viable due to limitations in performance of known upconverting materials. It is the purpose of this ongoing project to identify new upconverting materials, determine the particulars of the upconversion process itself, and identify the conditions necessary to optimize the process sufficiently to produce laser emission.

Theory of the Cosmological Least-Action Problem

RESEARCHER: Assistant Professor Alan B. Whiting, Commander, USNR

Formulating the equations of motion for cosmological bodies (such as galaxies) in an integral, rather than differential, form has several advantages. Using an integral, the mathematical instability at early times is avoided and the boundary conditions of the integral correspond closely with available data. Here it is shown that such a least-action calculation for a number of bodies interacting by gravity has a finite number of solutions, possibly only one. Characteristics of the different possible solutions are explored. The results are extended to cover the motion of a continuous fluid. A method to generalize an action to use velocities, instead of positions, in boundary conditions, is given. The velocity boundary condition is shown to have no effect on the number of solutions.

The Hubble Tensor: Velocity Anisotropy in the Local Volume

RESEARCHER: Assistant Professor Alan B. Whiting, Commander, USNR

Within the Local Volume of about 10 megaparsecs (Mpc) the galaxy distribution is strongly anisotropic. One would therefore expect the distribution of radial velocities to conform, showing a smaller increase with distance (component of the Hubble tensor) in the most flattened direction, to a degree which depends on the concentration of dark matter on this scale. A least-squares fit to data for 67 galaxies within this volume does indeed show anisotropic flow, with the largest Hubble component roughly four times the smallest. However, further analysis shows that this effect is largely or entirely due to the anisotropic distribution of the galaxies themselves, along with noise in the data. A set of 25 galaxies chosen for better quality data shows a similar effect. A list of galaxies is constructed for which good distance determinations would help the situation greatly.

Research Course Projects

Determining the Motions of Near-Earth Asteroids

RESEARCHER: Midshipman 1/C Douglas T. Campbell, USN (Trident Scholar AY 1999-2000)
ADVISER: Assistant Professor Debora M. Katz-Stone

An Earth impact with an asteroid has potentially devastating consequences. In order to avoid global destruction, astronomers have been attempting to map out the orbits of all possibly hazardous Near-Earth Asteroids (NEAs) for the past two decades. Although there are a number of astronomers devoted to discovering new NEAs, there are very few who are tracking these discoveries. Therefore many recently identified NEAs are routinely lost.

This Trident Scholar Project had two main objectives. The scientific goal of this project focused upon tracking several NEAs in order to determine their orbits. In addition, lightcurves were observed for a subset of these NEAs in order to find their rotational periods and their general shapes. This was done by taking observations of each asteroid for at least one full night and then plotting light intensity versus time.

The second objective was to refurbish and upgrade the observatory at the U.S. Naval Academy. Astronomical research at the U.S. Naval Academy hinges on the successful operation of a 20" Cassegrain telescope with a Photometrics 1024x1024 Charge Coupled Device (camera), as well as several computers to control these devices and process the data. As a result of this Trident Scholar Project, the U.S. Naval Academy now boasts a fully functioning, state-of-the-art observatory, including newly acquired and developed software for tracking NEAs and analyzing astronomical observations in general.

This Trident Scholar Project added to the body of knowledge of NEAs by determining the orbits of eleven asteroids, as well as the rotational periods and rough shapes of four asteroids. In addition, this Trident Scholar Project will benefit both midshipmen and faculty who wish to either continue tracking NEAs or begin a new field of astronomical research using the now completely established observatory at the U.S. Naval Academy.

Optical and Electrical Characterization of Photorefractive Crystals

RESEARCHER: Midshipman 2/C Peter G. Brereton, USN (Trident Scholar AY 2000-2001)
ADVISERS: Associate Professor Steven R. Montgomery and Assistant Professor Charles A. Edmondson

This research topic was developed in the spring of 2000 and approved by the Academic Dean for the 2001 academic year. Photorefractive ferroelectric crystals have generated significant scientific interest because of their potential application in optical devices. Through a process which includes the application of DC electric fields and illumination with a focused source, it is possible to "write" a pattern of change in the index of refraction. This pattern remains when the field and illumination are removed. Subsequent applications of light result in an interaction with the altered index of refraction. The patterns may be used in applications such as wave-guides, optical junctions or solid state holograms. One day they may serve as the foundation for optical computing. Since these patterns may be erased and rewritten it may be possible to reconfigure an optical computer while it processes. The change in the index of refraction is accompanied by a change in the dielectric constant of the material. While a great deal of literature exists about optical properties, significantly less is known the changes in the electrical properties. The intent of this basic research is to apply complex impedance measurement techniques to observe the changes in the electrical properties of these photorefractive, ferroelectric crystals.

Electromagnetic Launch

RESEARCHER: Midshipman 1/C Rebecca E. Bowen, USN (SP495 Project)
ADVISERS: Professor Carl S. Schneider and Associate Professor John P. Ertel

The topic of electromagnetic lunch is currently of great interest to the Navy for the "quieter and more efficient launch" of aircraft and the "quieter firing" of torpedoes. In this SP495 project, we reviewed the physics of AC electromagnetic launch following the recently published paper "A Classroom Jumping Ring" by the advisers. Further studies were done on the numerical simulator developed for that paper in order to begin the process of revising the jump/launch process from AC launch to DC. The review included Maxwell's Equations, the phenomenon of demagnetization, AC circuits, symmetry, and time averaging. The studies of the numerical simulator included a cell-by-cell review of the algorithms and their output to check for accuracy and computational instabilities. A new data base of theoretically determined parameters for the DC electromagnetic launch were developed including spatially dependent transient responses to step function driving input. This yielded the data required for a computationally stable simulation of a single stage DC electromagnetic lunch process. These results were described in a Physics Department capstone paper entitled "The Classroom Jumping Ring- A DC Alternative?"

Interferometric Profiling of Index Variations in a Photorefractive Crystal

RESEARCHER: Midshipman 1/C Karl E. Brown, USN (SP495 Project)
ADVISER: Associate Professor Steven R. Montgomery

In recent years researchers have discovered that an optical waveguide, which is very similar to a fiber optic waveguide, can be written in a photorefractive crystal. This is called photorefractive soliton. The variation in index of refraction that traps the light beam is usually inferred from the change observed in the laser beam that produced it. It can be difficult to know what is happening to the crystal just outside the waveguide using this method, because the light traveling through it does not extend outside its confines. Also, information about the dynamics of the index change during waveguide formation could be useful, as well as information about the index change when a waveguide is attempted but fails to form. Thus, a need exists in our lab to map the index variation in a photorefractive crystal that is independent of the focused beam used to write the waveguide. The aim of this project was to detect the spatial extent and magnitude of the change in the index of refraction of a photorefractive crystal when a focused beam passes through it. A Mach-Zehnder interferometer was been constructed and interferograms observed with a CCD camera. The initial stage of a Mathematica algorithm for extracting the change in index profile from data was developed.

Modeling the Larynx

RESEARCHER: Midshipman 1/C Price Chadwick, USN (SP496 Project)
ADVISER: Professor Samuel A. Elder

A rubber model of the human larynx has been developed to provide a way of testing theoretical assumptions about the formation of sound waves by excised human laryngeal preparations. Using an apparatus similar to that currently being employed to study excised larynges, a 1 cm diameter rubber tube was equipped with adjustable mass loading and adjustable tension sutures to simulate the dynamical situations presented by actual human vocal folds. The section of the tubing at which horizontal tension was applied acted as glottal opening, while mass loading pads glued to the outsides of the tube just below were used to simulated vocal folds. The model was mounted vertically on an air tube with volume flow adjustable up to about 1.5 liter/s and driven at oscillation frequencies up to about 1000 Hz. Measurements were made of subglottal and superglottal sound pressure, using calibrated sound pressure probes. A photoglottographic device for measuring glottal area function was constructed by means of a tiny intense light source, mounted below the glottis and a photodiode in the air above. The measurements were performed in the Naval Academy Anechoic Chamber facility in Michelson Hall. Preliminary results are in good agreement with a current theoretical model by Elder.

A Comparison of Laboratory Spectrometers

RESEARCHER: Midshipman 1/C Thomas E. Stone, III, USN (SP494 Project)
ADVISER: Associate Professor James R. Huddle

Operating characteristics including accuracy, precision, resolution and spectral range were measured for four different spectrometric techniques, including a rudimentary spectrometer assembled from a diffraction grating and a meter stick, a commercial student spectrometer, and spectrometers made by fixing diffraction gratings to a megapixel digital camera and a Hi-8 video camera. Each technique has its advantages. The grating and meter stick are inexpensive; the commercial spectrometer has the best resolution; the digital camera is expensive, but provides a sharp digital image that can be analyzed fairly simply; and the video camera can be used to capture the chromospheric flash spectrum during a total solar eclipse.

Level Scheme of ^{126}Te Using Inelastic Scattering from (n, n' γ) Reaction Studies

RESEARCHER: Midshipman 2/C James A. Tanyi, USN (SP496 Project)
ADVISER: Associate Professor Jeffrey R. Vanhoy

The excited levels of ^{126}Te have been studied using the (n,n'γ) reaction at the University of Kentucky's CN Van de Graaff Laboratory. Gamma-ray excitation functions and angular distributions were measured for transitions from levels up to 3.34 MeV excitation in ^{126}Te. Analysis of the excitation function data has identified 25 excited states of spin 0-6, previously unknown.

(1) New Discovered Triple Junction in the Scotia Sea
(2) Distribution and Significance of Methane Hydrates
(3) Trace Element Concentration Variations in Ocean Floor Basalt Due to Weathering
(4) Changes in Sedimentation Regimes in the Chesapeake Bay Meteor Impact Crater

RESEARCHERS: Midshipman 1/C Robert Lang, USN, Midshipman 1/C Tara Refo, USN,
Midshipman 1/C Zachary Herzberger, USN, Midshipman 1/C Daniel Pointkowski, USN
and Midshipman 1/C Amy Heck, USN (Oceanography Capstone Course Projects)
ADVISERS: Professor Douglas W. Edsall and Associate Professor Jeffrey R. Vanhoy

Midshipman Lang hopes to continue work on this project this summer and will submit for publication an article on his findings. The co-authors will be Dr. Norman Z. Cherkis (NRL) and Professor Douglas W. Edsall

Midshipmen Refo and Herzberger submitted their results in an Oceanography Department capstone paper. No further work is anticipated.

Midshipman Pointkowski used PIXE to determine variations in elemental concentration of basalt samples provided by WHOI. Midshipman Pointkowski submitted his results in an Oceanography Department capstone paper. Additional analysis is needed, but there are no immediate plans to continue this effort.

Midshipman Heck will be at USNA this summer and if additional sediment samples can be obtained from the USGS, she will use PIXE to further refine our knowledge of the trace element variations in fluvial and littoral sediments from the impact crater site. This data will lead to a better understanding of the development of the Chesapeake Bay over the past 35 MY.

Aristarchus's Experiment

RESEARCHERS: Midshipman 1/C Evelyn A. Melo, USN
and Midshipman 1/C Jacob P. Venema, USN (SM485B Project)
ADVISER: Associate Professor James R. Huddle

About 2500 years ago, Aristarchus of Samos demonstrated how one can measure the size and distance of the moon during a lunar eclipse. Midshipmen Melo and Venema did this experiment and reported their work to their History of Mathematics (SM485B) class.

Nonlinear Scattering Of Crossed Ultrasonic Beams In The Presence Of Turbulence: Multiple Scattering Effects

RESEARCHER: Midshipman 2/C Rebecca A. Manry, USN
ADVISER: Professor Murray S. Korman

The nonlinear scattering of two finite-amplitude mutually perpendicular crossed ultrasonic beams - interacting in the presence of turbulence - generates a scattered sum frequency component that radiates outside the interaction region. In the absence of turbulence, virtually no scattering, at the sum frequency, is observed Here, two primary CW (f_1=2.05 MHz and f_2=1.95 MHz) beams are generated by 2.54 cm diameter circular plane array piston transducer units (T_1 and T_2). A 4 MHz receiving unit (R) is of similar construction. All beam axes form a common plane and overlap region with the axis of a submerged circular water jet, which generates the turbulence. With R fixed, T_1 and T_2 rotate on radius arms - always keeping the beams perpendicular. Symmetry suggests an angle θ_*, where $\theta_* = 0^o$ defines forward scattering. This geometry allows a nonlinear forward scattering intensity component to exist without concern for a coherent component. Here, multiple scattering effects are needed to predict their results. Supplemental scattering experiments will be presented in an attempt to identify a transition from single (Born approximation) to multiple scattering.

Determination of Turbulent Vorticity by The Nonlinear Scattering of Crossed Ultrasonic Beams

RESEARCHER: Midshipman 2/C Rebecca A. Manry, USN
ADVISER: Professor Murray S. Korman

The nonlinear interaction of two, mutually perpendicular crossed ultrasonic beams, overlapping in the presence of turbulence, generates a scattered sum frequency component that radiates outside the interaction region. In the absence of turbulence, virtually no scattered sum frequency component exists (outside the interaction region). A theoretical investigation is reported which relates the scattering angular dependence of the time-dependent Doppler shift (of the sum frequency) to the time-dependent velocity fluctuations of the turbulent eddies. When a second set of focused crossed beams is operated with an overlap region slightly displaced from the first set, one can measure the vorticity using Doppler shift information from four distinct combination frequencies obtained simultaneously at two different scattering angles (180° apart). Experimental results are presented using continuous wave focused primary beams of frequencies f_1=1.8, f_2=2.0, f_3=2.2 and f_4=2.3 MHz (generated by concave transducer units with 15.2 cm focal lengths). The turbulence is generated by a

submergedwater jet with nozzle diameter D=0.635 cm and exit velocity ≈ 7 m/s. Here, the interaction region is located 30D from the nozzle exit and the two receiving transducers are 4 MHz circular plane elements.

Laboratory Experiments as Demos and Projects in the Underwater Acoustics and Sonar Course

RESEARCHER: Midshipman 2/C Elizabeth L. Simmons, USN
ADVISER: Professor Murray S. Korman

Underwater Acoustics and Sonar is a 3-hour course that is typically offered to midshipmen in their senior year. General science majors take the course in the fall while the oceanography majors enroll in the spring. A sprinkling of physics majors, electrical engineers, ocean engineers and systems majors also populate the course (totaling ~110 students per year). Since this course is offered without a lab, the classroom experience has been enhanced with the development (over many years) of demo carts which surround the classroom. Although Friday is our major demo day, demos are performed throughout the week. They motivate the students' out-of-class experimental projects. Demos include: (a) waves on slinkies, (b) Fourier analysis of tones in noise, homemade musical instruments, (c) harmonic synthesis, (d) receiver operating characteristics from processed signals in noise, (e) two-element and loud speaker beam patterns, (f) sound speed vs temperature in water, (g) target strength vs angle of a model submarine, (h) reflection coefficient from an Al/water interface, (i) PC-IMAT (interactive multisensor analysis training) simulations of array steering, ray tracing, active sonar, propagation loss, and (j) FM detection and Doppler effects. Students get involved with the measurements, have fun, and their understanding of underwater sound is greatly enhanced.

The Effect of Chemiluminescence vs. Laser-Induced Fluorescence on the Color Spectrum of Lightsticks

RESEARCHER: Matthew Greene (Ocean Lakes High School, Virginia Beach, VA)
ADVISER: Associate Professor James R. Huddle

The purpose of this experiment was to compare the color spectrum of the chemiluminescent reaction of a lightstick to the laser-induced fluorescence. The hypothesis was that the color spectrum produced by the chemiluminescent reaction and the spectrum produced by laser-induced fluorescence would peak at the same wavelength. A helium-cadmium laser, spectrometer, a Monospec 50 computer program and three green lightsticks were used. Each lightstick was "snapped" and placed in front of two lenses, which focused the light to one point in front of the slit of a spectrometer. Readings were taken at two angstroms per minute, ten angstroms at a time, 500 readings per ten angstroms, and one data point per 500 readings. There were 45 data points, which lead to 22,500 readings total. The mean color for the chemiluminescent portion was 520 nm with a reading of 1.540 mV. The mean color for the laser-induced fluorescence portion was 500 nm with a reading of 4.573 mV. A chi-square test was used to test the research hypothesis at the .05 level of significance. The calculated chi-square value was 6.000 and the p was 0.050. The data supported the research hypothesis. When the dye molecules in the lightsticks became excited, either by chemiluminescence or laser-induced fluorescence, light was emitted as they returned to the ground state. Since the laser provided a steady source of energy to excite the dye molecules, the intensity of the color peak was higher than that of the chemiluminescent reaction peak. However, the color spectra for both reactions showed similarities regardless of the source of energy.

Light and Temperature During a Total Solar Eclipse

RESEARCHERS: Petra van Boeckel
ADVISERS: Associate Professor James R. Huddle and Robert Weilinga (Holland)

Petra van Boeckel is a high-school-aged student in the Netherlands. She sent me e-mail asking for advice on how to carry out measurements of light and temperature as a function of the sun's obscuration during a solar eclipse. We had perhaps half a dozen e-mail exchanges, and she later sent me a very nice e-mail letting me know that her experiment had turned out satisfactorily.

Publications

BUTLER, J. J., Assistant Professor, and Malcuit, M. S., "Diffraction Properties of Highly Birefringent Liquid-Crystal Composite Gratings," *Optics Letters* 25 (2000) 420-422.

We have fabricated electrically switchable, holographic gratings using Polaroid Corporation's DMP-128 photopolymer filled with the nematic liquid crystal E7. 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 anisotropic volume gratings. Furthermore, a detailed comparison of theory and experiment provides information about the alignment of the liquid crystal within the polymer host.

BUTLER, J. J., Assistant Professor, Rodriguez, M. A., and Malcuit, M. S., "Transmission Properties of Refractive Index-Shifted Bragg Gratings," *Optics Communications* 177 (2000) 251-257.

We present an analysis of the transmission properties of index-shifted Bragg gratings. Theoretical predictions of the transmission properties of these gratings are obtained using a generalized transfer matrix method. Our theoretical predictions show that a precise modification of the average refractive index of Bragg gratings can lead to the generation of narrow band transmission windows within a broad low transmission band. The theoretical predictions are compared to experimental results obtained with fiber Bragg gratings.

BUTLER, J. J., Assistant Professor, Rodriguez, M. A., and Malcuit, M. S., "Index-Shifted Bragg Gratings," *SPIE (International Society for Optical Engineering) Proceedings* 3847 (1999) 48-54.

We present an analysis of the transmission properties of index-shifted Bragg gratings. Theoretical predictions of the transmission properties of these gratings are obtained using a generalized transfer matrix method. The predictions show that a precise modification of the refractive index profile of Bragg gratings can lead to the generation of narrow band transmission windows within a low transmission band.

ERTEL, J. P., Associate Professor, and Burt, P. E., *Core Physics Laboratory Manual, 1999-2000*, a laboratory manual for all of Introductory Physics at the United States Naval Academy, Harcourt-Brace Custom Publishing, ISBN # 0-03-045969-9 and 0-03-075748-7.

FONTANELLA, J. J., Professor, "Pressure and Temperature Variation of the Electrical Conductivity of Poly(Propylene Glycol) Containing $LiCF_3SO_3$," *Journal of Chemical Physics* 111 (1999) 7103-7109.

Complex impedance and DSC studies have been carried out on poly(propylene glycol) with average molecular weight 1025 (PPG) and PPG containing $LiCF_3SO_3$. The impedance studies were made at frequencies from about 1 mHz to 100 MHz at pressures up to 0.3 GPa (3 kbar) over the temperature range 215-365K. Both the impedance and DSC studies were carried out in vacuum or at atmospheric pressure over a temperature range of about 100-375K. As a consequence, the impedance studies overlap the DSC glass transition temperature. The inadequacy of the widely used Vogel Tammann Fulcher (VTF) or Williams Landel Ferry (WLF) equations to describe the temperature variation of the vacuum electrical conductivity data is discussed. It is shown that the Bendler-Shlesinger (BENSH) formalism is a better representation of the data, particularly in the region close to the glass transition. The first pressure derivative of the electrical conductivity, and hence apparent activation volume, decreases strongly as temperature increases. In addition, the activation volume is larger for the low molecular weight liquids than for previously reported values for related, high molecular weight rubbery electrolytes. Next, there appears to be an exponential relationship between the activation volume and the electrical conductivity. Finally, the pressure variation of the electrical conductance exhibits negative curvature which shows that the activation volume increases as pressure increases. A *qualitative* explanation of each of these results concerning the relationship between conductivity, temperature and pressure is given in terms of free volume.

HUDDLE, James R., Associate Professor, "Effects of a Solar Eclipse on a Pendulum," *Solar Eclipse Newsletter*, 30 June 1999, archived electronically at www.mreclipse.com.

A review, with comment, of seven papers written by three experimental groups about their attempts to measure effects of solar eclipse on the motions of pendula.

HUDDLE, James R., Associate Professor, "Observation of the 1999 November 15 Transit of Mercury," *Solar Eclipse Newsletter*, 7 January 2000, archived electronically at www.mreclipse.com.

A review of experiences of the author, members of his expedition, and members of other expeditions to observe the transit of Mercury, focussing on minimum specifications of optical devices needed to observe and record such phenomena.

KATZ-STONE, D. M., Assistant Professor, Kassim, N., Lazio, J. and O'Donnell, R., "Spatial Variations of the Synchrotron Spectrum within Tycho's Supernova Remnant (3C 10): A Spectral Tomography Analysis of Radio Observations at $\lambda\lambda$ 20 and 90 cm," *Astrophysical Journal*, 529 (2000) 453-462.

We present subarcminute-resolution (≈10"), high-dynamic range radio observations of Tycho's supernova remnant (3C 10) at λ = 20 cm and λ = 90 cm with the Very Large Array (VLA). The thermal-noise-limited 90 cm image has been compensated properly for the noncoplanar characteristics of the VLA and is the most sensitive low-frequency image of this source presently available. We use these images to search for spatial variations in the continuum radio spectral index within the remnant. Such spatial variations should be related to the electron acceleration processes associated with the evolution of the blast wave. We have also utilized, for the first time in an analysis of a supernova remnant, spectral tomography to search for localized regions within which the spectral index is different from the surroundings. We have identified 13 filaments, ranging in size from ≈40" to ≈260", embedded in a smoother background component. The average spectral index of the filaments ($\langle\alpha\rangle = -0.52 \pm 0.02$) is consistent with that of the background component ($\langle\alpha\rangle = -0.500 \pm 0.007$). However, the filaments in the outer rim show a trend such that brighter filaments have a flatter spectral index. This trend may be due to either supernova remnant (SNR) blast wave-ambient medium interactions or internal inhomogeneities of the magnetic field within the remnant. These hypotheses could be tested by an image at comparable resolution and fidelity at a third frequency.

KORMAN, Murray S., Professor, "Determination of Turbulent Vorticity by the Nonlinear Scattering of Crossed Ultrasonic Beams," in W. Lauterborn and T. Kurz (editors) *Nonlinear Acoustics at the Turn of the Millennium*, AIP Conference Proceedings, 524 (2000) 155-158.

The nonlinear interaction of two, mutually perpendicular crossed ultrasonic beams, overlapping in the presence of turbulence, generates a scattered sum frequency component that radiates outside the interaction region. In the absence of turbulence, virtually no scattered sum frequency component exists (outside the interaction region). A theoretical investigation is reported which relates the scattering angular dependence of the time-dependent Doppler shift (of the sum frequency) to the time-dependent velocity fluctuations of the turbulent eddies. When a second set of focused crossed beams is operated with an overlap region slightly displaced from the first set(by 1.27 mm), one can measure the vorticity using Doppler shift information from four distinct combination frequencies obtained at two different scattering angles. Experimental results are presented using continuous wave (CW) focused primary beams of frequencies $f_1 = 1.8$, $f_2 = 2.0$, $f_3 = 2.2$ and $f_4 = 2.3$ MHz (generated by concave transducer units with 15 cm focal lengths). The turbulence is generated by a submerged water jet with nozzle diameter $D = 0.635$ cm and exit velocity ≈ 7 m/s. Here the interaction region is located 37D from the nozzle exit. A 4 MHz circular plane array receiving transducer detects four distinct scattered sum frequency components (at specific angles) using a spectrum analyzer to demonstrate the effect. The receiver is located 14D from the interaction region.

KORMAN, Murray S., Professor, Huegel, Angela K., and Naff, Michael S., "Demonstration of Doppler Effects and Sound-speed Measurement using an Analog Frequency-to-Voltage (FM) Detection Circuit," *Journal of the Acoustical Society of America,* 106 (1999) 2140(A).

An audio frequency FM detector has been designed and built to measure very small Doppler shifts for classroom demonstrations. This detector uses a limiter, a series L–C phase-shift network, two sine-to-square wave circuits, a multiplier and low-pass filter. One can easily measure a deviation of 1/20 Hz in a 4000-Hz carrier. The apparatus consists of a stationary piezo-tweeter radiating a tone near a microphone that translates with periodic motion, using a motorized disk and linkage mechanism, which drives a translation stage. The output of the microphone goes to the FM detector which outputs to a digital oscilloscope or meter for display. Calibration is extremely linear and is performed using the digital frequency readout on the generator. From a measure of the peak to peak Doppler shift Δf (from the periodic Doppler shift signal versus time), the source frequency f, the radius R of the disk, and the period T, one can predict the sound speed to be $C=(\Delta f/f)(4\pi R/T)$. Here, an approximation involving the linear velocity has been made. Results for C are typically within 1% of the expected value for air at room temperature.

KORMAN, Murray S., Professor, and MANRY, Rebecca A., Midshipman 2/C, USN, "Nonlinear Scattering of Crossed Ultrasonic Beams in the Presence of Turbulence: Multiple Scattering Effects," *Journal of the Acoustical Society of America,* 106 (1999) 2158(A).

The nonlinear scattering of two finite-amplitude mutually perpendicular crossed ultrasonic beams—interacting in the presence of turbulence—generates a scattered sum frequency component that radiates outside the interaction region. In the absence of turbulence, virtually no scattering, at the sum frequency, is observed. Here, two primary cw (f_1=2.05 MHz and f_2=1.95 MHz) beams are generated by 2.54-cm-diam circular plane array piston transducer units (T_1 and T_2). A 4-MHz receiving unit (R) is of similar construction. All beam axes form a common plane and overlap region with the axis of a submerged circular water jet, which generates the turbulence. With R fixed, T_1 and T_2 rotate on radius arms—always keeping the beams perpendicular. Symmetry suggests an angle θ_*, where $\theta_*=0°$ defines forward scattering. This geometry allows a nonlinear forward scattering intensity component to exist without concern for a coherent component. Here, multiple scattering effects are needed to predict their results. Supplemental scattering experiments will be presented in an attempt to identify a transition from single (Born approximation) to multiple scattering.

KORMAN, Murray S., Professor, and SIMMONS, Elizabeth L., Midshipman 1/C, USN, "Laboratory Experiments as Demos and Projects in the Underwater Acoustics and Sonar Course," *Journal of the Acoustical Society of America,* 106 (1999) 2139(A).

Underwater Acoustics and Sonar (SP411) is a 3-h course that is typically offered to Midshipmen in their senior year. General science majors take the course in the fall while the oceanography majors enroll in the spring. A sprinkling of physics, electrical engineers, ocean engineers, and systems majors also populate the course (totaling ~110 students per year). Since this course is offered without a lab, the "in-class" experience has been enhanced with the development (over many years) of our demo carts which surround the classroom. Although Friday is our major demo day, demos are performed throughout the week. They motivate the students' out-of-class experimental projects. Demos include: (a) waves on slinkies; (b) Fourier analysis of tones in noise, homemade musical instruments; (c) harmonic synthesis; (d) receiver operating characteristics from processed signals in noise; (e) two-element and loudspeaker beam patterns; (f) sound speed versus temperature in water; (g) target strength versus angle of a model sub; (h) reflection coefficient from an Al/water interface; (i) PC-IMAT (interactive multisensor analysis training) simulations of array steering, ray tracing, active sonar, propagation loss; and (j) FM detection and Doppler effects. Students get involved with the measurements, have fun, and their understanding of underwater sound is greatly enhanced.

SCHULZE, Kay G., Professor, SHELBY, Robert N., Professor, TREACY, Donald J., Professor and WINTERSGILL, Mary C., Professor, "ANDES: A Coached Learning Environment for Classical Newtonian Physics," in J. Chambers (editor) *Proceedings of the 11th International Conference on Teaching and Learning,* (2000) 151-162.

ANDES is a coached, intelligent tutor for classical Newtonian physics. It provides the student with a learning environment in which to solve physics problems in several areas found in a traditional Physics I course. The system encourages the student to draw free body diagrams and enter the equations necessary to solve the problem. It provides immediate feedback to the student and allows the student to ask for hints, both in terms of what he has done incorrectly as well as

when he has reached an impasse and does not know how to proceed. ANDES has been used with a limited number of students as the United States Naval Academy with statistically significant results.

STALLWORTH, P. E., Assistant Professor, FONTANELLA, J. J., Professor, WINTERSGILL, M.C., Professor, Scheidler, C. D., and Immel, J. J., "NMR, DSC and High Pressure Electrical Conductivity Studies of Liquid and Hybrid Electrolytes," *Journal of Power Sources*, 81-82 (1999) 739-747.

Electrical conductivity, DSC and ^{7}Li NMR studies have been carried out on liquid electrolytes such as EC:PC and EC:DMC containing $LiPF_6$ (and $LiCF_3SO_3$ for NMR) and films plasticized using the same liquid electrolytes. The films are based on poly(vinylidene fluoride) copolymerized with hexafluoropropylene and contain fumed silica. All measurements were carried out at atmospheric pressure from room temperature to about -150°C and the electrical conductivity studies were performed at room temperature at pressures up to 0.3 GPa. The liquids and hybrid electrolytes are similar in that the electrical conductivity of the EC:PC based substances exhibits VTF behavior while that for the EC:DMC based substances does not. Part of the deviation from VTF behavior for the EC:DMC based materials is attributed to crystallization. Further, the glass transition temperatures as determined from NMR, DSC and electrical conductivity measurements are about the same for the liquids and hybrid electrolytes. However, substantial differences are found. The electrical conductivity of the hybrid electrolytes at room temperature is lower than expected and, more importantly, the relative change of conductivity with pressure is larger than for the liquids. In addition, above the glass transition temperature, the NMR T_1 values are smaller and the NMR line widths are larger for the hybrid electrolytes than for the liquids while at both low and high temperature the NMR line widths are larger. Consequently, it is concluded that significant solid matrix-lithium ion interactions take place.

TANKERSLEY, L. L., Professor, Tucker, J. E., Reintjes, J., Schultz, A., Lu, C., Howard, P. L., Sebok, T., and Holloway, C., "Lasernet Fines Optical Wear Debris Monitor," *Proceedings of the 2000 JOAP International Condition Monitoring Conference*, (2000) 180-188.

The analysis of debris particles in machinery lubricating oil has long been used to detect the onset of wear and failure of oil wetted components. Morphological analysis by human experts using optical microscopy is a time-intensive laboratory technique used to identify the mechanical fault type. Lasernet Fines (LNF) identifies the type, rate of production and severity of mechanical faults by measuring the size distributions, rate of progression and morphological analysis of wear debris in flowing fluids. Under an advanced condition based monitoring program sponsored by the Office of Naval Research, several prototype batch processor Lasernet Fines instruments were developed with the capability to analyze common shipboard hydraulic and lubrication fluids. These instruments are undergoing test and evaluation at several sites. The program's goals are to baseline high value equipment, monitor for mechanical faults and improve the capabilities of the instruments. The status and results from these test and evaluation sites and progress towards online implementation of the LNF technology is presented.

TANKERSLEY, L. L., Professor, Tucker, J. E., Reintjes, J., Galie, T. R., Schultz, A., Lu, C., Howard, P. L., Sebok, T., and Holloway, C., "Lasernet Fines Optical Wear Debris Monitor: A Navy Shipboard Evaluation of CBM Enabling Technology," *Proceedings of the 54th Meeting of the Society for Machinery Failure Prevention Technology*, (2000) 191-299.

Online or in-situ analysis of wear debris in machinery lubricating systems has the potential to provide fault-specific information in a timely manner to support CBM diagnostics and prognosis. This analysis can avoid catastrophic failures and enables improved cost-effective asset-management philosophies, especially in the area of timely maintenance and reduction of maintenance induced failures. Essential to achieving these goals are technologies that can provide reliable early identification of mechanical faults and the degree of machinery performance degradation. The Lasernet Fines instrument delivers a technology that has significant potential in these areas. This instrument determines the type, severity and rate of progression of mechanical faults by measuring the size distributions, rate of production and the morphological characteristics of debris particles in fluids. Although the system is in advanced development, useful information can be gained by in-situ shipboard evaluation of the technology. This evaluation is to assess its capabilities and suitability for shipboard operation and baselining operational equipment which will provide a basis for future fault detection and diagnosis. Within this context, the Amphibious SMARTSHIP community has supported the installation and use of the prototype Lasernet Fines batch instrument aboard the USS RUSHMORE. The ship introduction, test and demonstration process is described, as well as preliminary shipboard measurements.

WHITING, Alan, Commander (USN) and Assistant Professor, Hau, George K.T., and Irwin, Mike, "A New Local Group Galaxy in Cetus," *Astronomical Journal*, 118 (1999) 2767-2774.

We report the discovery of a previously uncatalogued Local Group galaxy in the constellation Cetus. Faintly visible on UKST survey plates, it has a smooth, diffuse appearance and appears to be a dwarf spheroidal of type dE3.5. A color-magnitude diagram in V, V-I shows a clear giant branch but no sign of recent star formation. From the position of the tip of the giant branch, we derive a reddening-corrected distance modulus of 24.45 ± 0.15 and a metallicity of -1.9 ± 0.2. With an implied heliocentric distance of 775 ± 50 kpc, and a corresponding Local Group barycentric distance of 615 kpc, the Cetus dwarf lies well within the boundaries of the Local Group, and although it currently lacks a radial velocity measurement, it is undoubtedly a member of the Local Group. The nearest Local Group galaxies are WLM and IC 1613 at angular separations of 73 and 163 and roughly 175 and 230 kpc total distance, respectively. Although the Cetus dwarf is unlikely to be directly associated with any other Local Group galaxy, it does lie in the general direction of the extension of the Local Group toward the Sculptor Group.

WHITING, Alan, Commander (USN) and Assistant Professor, "The Least-Action Principle: Theory of Cosmological Solutions and the Radial-Velocity Action," *Astrophysical Journal*, 533 (2000) 50-61.

Formulating the equations of motion for cosmological bodies (such as galaxies) in an integral, rather than differential, form has several advantages. Using an integral, the mathematical instability at early times is avoided, and the boundary conditions of the integral correspond closely with available data. Here it is shown that such a least-action calculation for a number of bodies interacting through gravity has a finite number of solutions, possibly only one. Characteristics of the different possible solutions are explored. The results are extended to cover the motion of a continuous fluid. We give a method for generalizing an action so as to use velocities, instead of positions, in boundary conditions, which reduces in particular cases to those given by Giavalisco et al. and Schmoldt & Saha. The velocity boundary condition is shown to have no effect on the number of solutions.

Presentations

BUTLER, James J., Assistant Professor, "Index-Shifted Bragg Gratings," SPIE Photonics East Meeting, Boston, MA, 19-22 September 1999. (Presented by M. A. Rodriguez.)

EDSALL, Douglas W., Professor, "Runoff Induced Hazardous Algal Blooms," Coastal Zone 99, San Diego, CA, 24-30 July 1999. (Presented by Professor John W. Foerster, Oceanography Department)

ENGLE, Irene M., Professor, "Pros and Cons of Various Approaches to Global Magnetospheric Modeling," Meeting of the Magnetospheres of the Outer Planets, Paris, France, 9 August 1999.

ENGLE, Irene M., Professor, "Incorporation of a Magnetotail into the Model of the Global Saturnian Magnetosphere," Meeting of the Magnetospheres of the Outer Planets, Paris, France, 10 August 1999. (Presented by Ensign Jeremy J. Bruch, USN.)

ERTEL, John P., Associate Professor, "Interactive Physics III and Its Use in the Undergraduate Classroom/ Laboratory," Summer Meeting of the American Association of Physics Teachers, San Antonio, TX, 3 August 1999.

ERTEL, John P., Associate Professor, "Recent Advances Interactive Physics III and Its Use in the Undergraduate Classroom/ Laboratory, Winter Meeting of the American Association of Physics Teachers, Kissimmee, FL, 16 January 2000.

FONTANELLA, John J., Professor, WINTERSGILL, Mary C., Professor, and EDMONDSON, Charles A., Assistant Professor, "Complex Impedance and NMR studies of Proton Conducting Dow Membranes," International Conference on Solid State Ionics, Thessaloniki, Greece, 6-12 June 1999.

FONTANELLA, John J., Professor, WINTERSGILL, Mary C., Professor, and EDMONDSON, Charles A., Assistant Professor, "Electrical Conductivity and NMR studies of PEG and PPG Containing Lithium Salts," International Conference on Solid State Ionics, Thessaloniki, Greece, 6-12 June 1999.

FONTANELLA, John J., Professor, WINTERSGILL, Mary C., Professor, and EDMONDSON, Charles A., Assistant Professor, "Properties of Fuel Cell and Battery Materials," AFOSR/ONR Electrochemistry Science & Technology Review, Alexandria, VA, 14-16 February 2000.

HUDDLE, James R., Associate Professor, "Simple Experiments for Students During a Total Solar Eclipse," 18th European Symposium on Occultation Projects, Stuttgart, Germany, 5-11 August 1999.

HUDDLE, James R., Associate Professor, "Observing The Total Solar Eclipse of 11 August 1999 from Elazig, Turkey," a presentation to eclipse enthusiasts gathered for the event in Malatya, Turkey, 10 August 1999.

HUDDLE, James R., Associate Professor, "Experiments During the Total Solar Eclipse of 11 August 1999," Northern Virginia Astronomy Club, Fairfax, VA, 12 September 1999.

HUDDLE, James R., Associate Professor, "Simple Spectral Experiments During a Total Solar Eclipse," Winter Meeting of the American Association of Physics Teachers, Kissimmee, FL, 15-19 January 2000.

HUDDLE, James R., Associate Professor, "Experiments for Students During a Total Solar Eclipse," Invited colloquium hosted by the Physics Department, University of Zimbabwe, Harare, Zimbabwe, 14 March 2000.

KATZ-STONE, Debora M., Assistant Professor, "Tracking Near-Earth Asteroids: A Trident Scholar Project," 196th Meeting of the American Astronomical Society, Rochester, NY, 4-8 June 2000. (Presented by Second Lieutenant Douglas T. Campbell, USMC.)

KATZ-STONE, Debora M., Assistant Professor, "The Trident Scholar Program: Year-Long Undergraduate Research Projects at the United States Naval Academy," 196th Meeting of the American Astronomical Society, Rochester, NY, 4-8 June 2000. (Presented by Second Lieutenant Douglas T. Campbell, USMC.)

KORMAN, Murray S., Professor, "Laboratory Experiments as Demos and Projects in the Underwater Acoustics and Sonar Course," 138th Meeting of the Acoustical Society of America, Columbus, OH, 1-5 November 1999.

KORMAN, Murray S., Professor, "Demonstration of Doppler Effects and Sound-speed Measurement Using an Analog Frequency-to-voltage (FM) Detection Circuit," 138th Meeting of the Acoustical Society of America, Columbus, OH, 1-5 November 1999.

KORMAN, Murray S., Professor, "Nonlinear Scattering of Crossed Ultrasonic Beams in the Presence of Turbulence: Multiple Scattering Effects," 138th Meeting of the Acoustical Society of America, Columbus, OH, 1-5 November 1999.

KORMAN, Murray S., Professor, "Determination of Turbulent Vorticity by the Nonlinear Scattering of Crossed Ultrasonic Beams," 15th International Symposium on Nonlinear Acoustics, Gottingen, Germany, 1-4 September 1999.

SCHNEIDER, Carl S., Professor, "A Cooperative Model of Ferromagnetic Hysteresis," Spring Meeting of the American Physical Society, Minneapolis, MN, 25 March 2000.

SHELBY, Robert N., Professor, TREACY, Donald J., Professor, WINTERSGILL, Mary C., Professor, and CORRELL, Francis D., Professor, "ANDES: An Intelligent Physics Tutor," Summer Meeting of the American Association of Physics Teachers, San Antonio, TX, 2 – 7 August 1999.

SHELBY, Robert N., Professor, TREACY, Donald J., Professor, and WINTERSGILL, Mary C., Professor, "Naval Academy Physics Tutor," ONR Cognitive Architectures Meeting, Pittsburgh, PA, 30 March – 1 April, 2000.

TANKERSLEY, Lawrence L., Professor, "Lasernet Fines Optical Wear Debris Monitor," JOAP International Condition Monitoring Conference, Mobile, AL, April 2000. (Presented by J. E. Tucker.)

TANKERSLEY, Lawrence L., Professor, "Lasernet Fines Optical Wear Debris Monitor A Navy Shipboard Evaluation Of CBM Enabling Technology," 54th Meeting of the Society for Machinery Failure Prevention Technology, Virginia Beach, VA, May 2000. (Presented by J. E. Tucker.)

VANHOY, Jeffrey R., Professor, "Gamma Ray Spectroscopy of the 120-130Te Nuclei," ENS2000 Conference, Hungarian Academy of Sciences, Debrecen, Hungary, 15-20 May 2000.

VANHOY, Jeffrey R., Professor, "Levels of ^{120}Te Using the ^{120}Sn(a,2ng) Reactions and ^{120}I beta-decay," Meeting of the APS Division of Nuclear Physics, Asilomar, CA, 21-23 October 1999.

VANHOY, Jeffrey R., Professor, "Decay Characteristics of ^{122}Te Levels Below 3.3 MeV Excitation," Meeting of the APS Division of Nuclear Physics, Asilomar, CA, 21-23 October 1999.

VANHOY, Jeffrey R., Professor, "Coincidence Spectroscopy of the ^{186}W reaction using the KEGS array at LANSCE/WNR," 10th Conference on Gamma-Ray Spectroscopy and Related Topics, Santa Fe, NM, 30 September- 03 October 1999. (Presented by T.B. Brown.)

VANHOY, Jeffrey R., Professor, "Nuclear Structure of the Cd and Te Nuclei: Akin to Tin or a Breed Apart," 10th Conference on Gamma-Ray Spectroscopy and Related Topics, Santa Fe, NM, 30 September- 03 October 1999. (Presented by N. Warr.)

WHITING, Alan B., Commander (USN) and Assistant Professor, "Dwarf-Hunting in the Chilean Andes: New Local Group Galaxies," Royal Observatory, Edinburgh, 23 November 1999.

WHITING, Alan B., Commander (USN) and Assistant Professor, "How Many Needles in the Haystack: Theory of the Cosmological Least-Action Calculation," Queen Mary-Westfield College, London, 17 December 1999.

WHITING, Alan B., Commander (USN) and Assistant Professor, "The Hubble Tensor: Velocity Anisotropy in the Local Volume," Meeting of the American Astronomical Society, Rochester, New York, 6 June 2000.

WINTERSGILL, Mary C., Professor, SHELBY, Robert N., Professor, and TREACY, Donald J., Professor, "ANDES: A Coached Learning Environment For Classical Newtonian Physics," 11th International Conference on Teaching and Learning, Jacksonville, FL, 19 - 22 April 2000.

WINTERSGILL, Mary C., Professor, SHELBY, Robert N., Professor, and TREACY, Donald J., Professor, "ANDES: An Intelligent Tutor for Classical Physics," New Information Technologies and Beral Education, Furman University, Greenville, SC, 5 - 8 May 2000.