FUSION NEUTRON DAMAGE TO A CHARGE COUPLED DEVICE CAMERA

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A charge coupled device (CCD) camera's performance has been degraded by damage produced by 14 MeV neutrons (n) from the Rotating Target Neutron Source. High-energy neutrons produce atomic dislocation in doped silicon electronics. This thesis explores changes in Dark Current (J), Charge Transfer Inefficiency (CTI), and Contrast Transfer Function (CTF) as measures of neutron damage.

The camera was irradiated to a fluence, f, of 6.60 x 10^{12} n/cm^2. The camera temperature was lowered from room temperature to 267 K at a fluence of 4.7 X 10^{11} n/cm^2 to preclude saturation of the camera picture. With temperature compensations, J increased linearly with f. Four data points for J, CTF (ideal of 1.0) and CTI (ideal of 0) are:

Fluence (n/$cm^{2)}$	0	4.7x10^{11}	4.7x10^{11}	6.60x10^{12}
Temp (K)	292.1	296.1	276	266.8
J (nAcm^2	0.37	11	0.93	9.8
CTF	0.89	0.37	0.82	0.48
CTI	1.3x10^{-4}	1.2x10^{-3}	2.4x10^{-4}	1.6x10^{-3}

Neutron irradiation significantly degraded CCD camera performance; however, operating the camera at lower temperatures significantly reduces the effects. Damage thresholds for fluences greater than 6.60 x 10^{12} n/cm^2 and for all temperatures can be extrapolated from this work.

THE UTILITY OF HYPERSPECTRAL DATA TO DETECT AND DISCRIMINATE ACTUAL AND DECOY TARGET VEHICLES

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The objective of this work is to evaluate the utility of hyperspectral signature data in satisfying time-sensitive intelligence requirements. This work is conducted in support of the Hyperspectral MASINT Support to Military Operations (HYMSMO) program. Data are used from the Hyperspectral Digital Imaging Collection Experiment (HYDICE) imaging spectrometer using the 0.4 mm to 2.5 mm wavelength range. Operation Forest Radiance I was the third in a series of HYMSMO-sponsored collection and exploitation experiments, and the data set analyzed herein was derived from this effort. The first phase of the Forest Radiance experiment emphasized the collection of spectra from a suite of overtly exposed mobile vehicles, decoys, and target panels. Analysis shown here was conducted to determine if it is possible to detect and discriminate real and decoy vehicles. The Low Probability of Detection (LPD) and Spectral Angle Mapper (SAM) anomaly detection and classification algorithms are applied to the data set being analyzed. The LPD algorithm performs well at detecting residual spectra, but produces a significant number of false alarms. The SAM technique is equally successful at detecting residual spectra and proves to have an advantage over the LPD when it comes to obviating misidentifications. This thesis shows that detection and discrimination of mobile vehicles (HMMWVs) and decoys in a natural grass environment is possible using this technology.

LINE BROADENING ANALYSIS OF MPD THRUSTERS

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Spectroscopic analysis of the cathode jet of a model coaxial magneto-plasma dynamic (MPD) thruster is conducted to determine electron density and temperature downstream from the cathode. H_b line profiles were scanned from an argon-hydrogen plasma generated in the cathode test facility of the NASA Jet Propulsion Laboratory in Pasadena, CA. A computer program was written in DL to determine the profile Doppler- and Stark half widths, which were used to determine temperature and electron density, respectively. Three sets of data from the cathode test facility were taken, while varying operating voltage, current, hydrogen/argon ratio, and pressure. Radial profiles for electron density and temperature were determined within the cathode jet. Generated plasmas ranged in electron density and temperature from approximately $N_e = 2\text{x}10^{14}$ cm^{-3} at 5000 K (0.43 eV) to $4\text{x}10^{14}$ cm^{-3} at 15600 K (1.3 eV). It was determined that radial density and temperature distribution within the cathode jet are essentially uniform.

BORO-SILICATE POLYCAPILLARY LENS FOR COLLIMATION OF X-RAYS

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The purpose of this thesis is to investigate the collimation of x-rays produced by transition radiation using the Naval Postgraduate School (NPS) Electron Linear Accelerator. These measurements support the theory that x-rays can be focused using a boro-silicate array of polycapillaries consisting of 258 bundles with 1387 micro-channels each. A 90 MeV electron beam incident upon a non-resonant mylar stack formed transition radiation spatially distributed in an annular cone. The electron beam was deflected 30 degrees using a rare earth permanent magnet. The diverging x-rays incident upon the lens array were transported through total external reflection and directed out of the array onto a phosphor screen. A digital camera recorded the phosphorescing image of the screen. Pixel intensity was analyzed to determine x-ray intensity as a function of two dimensional spatial distribution.

Column average profiles of the pixel intensity show that the transition radiation intensity retains its Gaussian distribution after being redirected from a diverging beam into a mostly parallel beam. The intensity of the x-rays decreased by a factor of 0.72 due to the obstructed area at the face of the array and to imperfect admittance of the diverging x-ray cone into the polycapillary array.

SIMULATION OF THE DYNAMIC BEHAVIOR OF EXPLOSION GAS BUBBLES IN A COMPRESSIBLE FLUID MEDIUM

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Data from one-dimensional (spherically symmetric) analyses was used to examine the effects of compressibility and gas energy on the dynamic behavior of an explosion gas bubble, by comparing the bubble's behavior with experimental results and with analytical results which neglect these factors. Results from two-dimensional (axially symmetric) analyses were used to investigate the behavior of a deep explosion gas bubble in the vicinity of plane rigid or constant pressure boundaries. Previous analytical research into explosion gas bubbles near such boundaries has primarily led to results of a qualitative nature, owing to a complete breakdown of the assumptions made in the analysis at the critical juncture. In the present investigation, it was found possible to characterize the effect of the boundary surface on both the change in the first oscillation period of the bubble and its location at the end of the first oscillation cycle. For a broad range of bubble-boundary standoff distances, these semi-empirical characterizations have a functional form particularly suitable for extension of the quantitative results of this investigation to other explosive charge types, weights, and depths, as has been done for the Willis formula for the free-field oscillation period of explosion gas bubbles.

INVESTIGATION OF A CONSTRICTED ANNULAR ACOUSTIC RESONATOR

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One topic of current interest in thermoacoustic research is an annular prime mover (LIN et al., *Journal of Acoustical Society of America*, 100, 2846, 1996). The starting point for this research is an investigation of a constricted annular resonator. A literature search of the field resulted in surprisingly few references. The results of analytic, numerical, and experimental investigations are presented. Introducing a constriction into an annular resonator splits each longitudinal duct mode into two modes, one of a higher frequency with a pressure antinode at the constriction and one at a lower frequency with a velocity antinode near the constriction. The lower mode is more sensitive to changes in the length and porosity of the constriction than the higher mode. Overall agreement between measured and predicted mode shapes and resonance frequencies is very good. It was found that it is necessary to include end corrections at the constriction to get accurate agreement between measured and predicted results.

NUMERICAL SIMULATION OF BLOCH OSCILLATIONS IN PERIODIC STRUCTURES

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Felix Bloch's 1928 article made a prediction concerning the dynamical behavior of electrons in a solid, subject to a uniform, static electric field. This aspect of his work, as later clarified by Zener, showed that electrons accelerated by an electric field in a periodic potential, under the right conditions, would oscillate. A theoretical debate as to the existence of this phenomenon has been ongoing since Bloch's proposal. One of the most controversial consequences of this prediction is that an electron undergoing Bloch oscillations would radiate. The controversy on the theoretical analysis was due to the great difficulty in systematically and reliably treating interband transitions by analytical methods based on the time-dependent Schrodinger equation is numerically solved for independent electrons. In this thesis, the time-dependent Schrodinger equation is numerically solved to show that electrons accelerated by an electric field in periodic structures do undergo Bloch oscillations and other dynamic behavior. By accurately modeling this phenomenon a better understanding of it will be gained in hopes of using it in future applications as a stable source of Terahertz (THz) radiation.

NON-ELECTRO-OPTIC METHODS OF HIGH FREQUENCY LASER MODULATION

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Two high frequency, non-electro-optic methods for modulating the intensity of a laser are examined theoretically and experimentally. The first modulation technique makes use of the Zeeman effect. Under an applied DC magnetic field, a splitting into two lines or three lines occurs. Modulation rates of 200 MHz have been proven possible with this technique. In the second technique, the properties of self-phase modulation of a monochromatic light are explored. For a high intensity beam, the optical path of a beam can be altered due the dependence of the phase on intensity. Thus two coherent beams of light of different intensity can be made to constructively or destructively interfere even if the physical paths are identical. In a configuration called a nonlinear-optical loop mirror, the output beam is amplitude modulated by linear variations in time of the total input power. A new design for a variable X-coupler, a key element of the loop mirror, is presented. Applications of high frequency modulators to test a theory of the AM-FM conversion of monochromatic light in fibers, to improve pulse rate control during target acquisition, and to high speed communications are discussed.

CONSTRUCTION OF A CONTINUOUS WAVE FREQUENCY MODULATION SENSITIVE LASER RADAR FOR USE IN TARGET IDENTIFICATION

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This thesis covers the theory, design and construction of a continuous wave (CW) frequency modulation sensitive laser radar. Using a commercially available CO_2 laser, optics and electronics, a CW frequency modulation sensitive laser radar was constructed and tested under laboratory conditions. The theory of each component in the laser radar is covered as well as the configuration and design of the radar. Design of a target that enabled measurement of the laser radar's capabilities was also completed. The laser radar was able to accurately measure a target's vibrational frequency and amplitude for

amplitudes greater than 40 nm. The theoretical range of the designed laser radar is over 6 km. An improved optical design that allows a theoretical range of over 9 km is also presented. Applications of target identification are discussed.

NAVAL INFRARED IMAGERY EXPLOITATION (U)

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Infrared Remote sensors often detect thermal excess energy emanating from naval ships through the discharge of seawater used to cool the equipment in the engineering spaces. Once the thermal energy has been detected, the properties associated with the production of that thermal energy could be simulated using a three-dimensional hydrodynamic model. The parameters of the engineering plant are estimated when the simulated thermal plume provides a good representation to the observed energy discharged into the harbor. The synergy of data obtained remotely combined with hydrodynamic modeling can provide insight to the intentions of the vessels.

VARIATIONS ON AUTOCORRELATION MATCHING AND THE SIFT LOCALIZATION ALGORITHM

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As part of the existing acoustic transient localization program, a feasibility study was performed to apply existing algorithms to signals at higher carrier frequencies. The coherent matching, autocorrelation matching and SIFT algorithms are time domain Matched Field Processing algorithms based on arrival structures for single hydrophone applications. In previous studies, these algorithms were employed only at lower frequencies using ray propagation models to create the replicas with varying success. This study is meant to investigate the performance of the algorithms at higher frequencies, using both the University of Miami Parabolic Equation (UMPE) Model and the Hamiltonian Raytracing Program for the Ocean (HARPO), to give insight into the previously unexplained inconsistent behavior of the algorithms at low frequencies, to improve and optimize existing algorithms, to point out improvements to existing eigenray extraction programs, and to suggest additional signal processing on the signal. Simulations are performed and synthetic signals are generated using both the HARPO and UMPE models. The arrival structures are investigated and the relation between features in the arrival structures for matching and the physical parameters are identified. Some insight into the performance of the SIFT algorithm is gained which relates matching and physical parameters. Simulations lead to improvements and optimization of the algorithms and give insight into the performance at higher frequencies.

DESIGN, CONSTRUCTION AND INSTRUMENTATION OF A THERMOACOUSTIC PRIME MOVER WITHOUT A STACK

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This thesis is written to document the design, construction and instrumentation of a thermoacoustic prime mover without a stack. A thermoacoustic prime mover uses a temperature differential maintained between two heat exchangers to produce sound, i.e., work in a resonator. The no stack design may offer improved efficiencies over current designs which use a stack

by eliminating the thermal and viscous losses associated with the stack. A detailed description of the construction of the experimental components and the instrumentation is provided.

AN ANALYSIS OF THE IIR AND FIR WIENER FILTERS WITH APPLICATIONS TO UNDERWATER ACOUSTICS

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A detailed analysis of the performance the Wiener optimal filter for estimating a signal in additive noise is carried out. A first order AR model is assumed for both the signal and noise. Both IIR and FIR forms of the filter are considered and expressions are derived for the processing gain, mean-square error, and signal distortion. These measures are plotted as a function of the model parameters. This analysis motivates a generalized form of the Wiener filter, which can improve the signal distortion. An analysis of this more general filter is then carried out. A practical noise removal algorithm based on short-time filtering using the generalized filter is also described and results of applying the algorithm to some typical underwater acoustic data are presented.

COMPUTER PROGRAMS SUPPORTING INSTRUCTION IN ACOUSTICS

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Traditionally, the study of mechanical vibration and sound wave propagation has been presented through textbooks, classroom discussion and laboratory experiments. However, in today's academic environment, students have access to high performance computing facilities which can greatly augment the learning process. This thesis provides computer algorithms for examining selected topics drawn from the text, *Fundamentals of Acoustics*, Third Edition, John Wiley & Sons, Inc., by Kinsler, Frey, Coppens, and Sanders, (KFCS). Emphasis is on using the modeling and simulation capability of the programming language, MATLAB, to illustrate and analyze complex physical principles which may seem obscure on the printed page yet are challenging or inconvenient to duplicate in the laboratory. This is not a passive recitation of acoustic phenomena, but complements KFCS with interactive student participation. The usefulness of these programs and any weaknesses in format or content needs to be tested in the classroom.

A SIMULATION OF THE LUNAR PROSPECTOR'S GAMMA RAY SPECTROMETER

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The expected response of the Lunar Prospector's Gamma Ray Spectrometer instrument was predicted using a Monte Carlo simulation. The full lunar spectrum was generated using 90 lines and a continuum gamma ray background taken from Apollo 15 and 16 data. The Monte Carlo program uses the exact dimensions and composition of the Gamma Ray Spectrometer in order to most accurately predict spectral performance, assuming an operating temperature on orbit of-30 0C. The

Gamma Ray Spectrometer will be launched aboard the Lunar Prospector spacecraft on October 24, 1997. The Lunar Prospector will assume a 100 km altitude orbit around the moon, allowing the Gamma Ray Spectrometer to map the elemental composition of the surface. The simulated Gamma Ray Spectrometer response can be used as a comparison for the actual data in order to determine how well the spectrometer is working.

INSTRUMENTATION AND MEASUREMENT OF A THERMOACOUSTICALLY DRIVEN THERMOACOUSTIC REFRIGERATOR

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This thesis is written to document the design, instrumentation and initial operation of a thermoacoustically driven thermoacoustic refrigerator. This design combines a quarter wavelength acoustic motor and a quarter wavelength acoustic refrigerator in a common resonator. Electrically generated heat provides power to the acoustic motor, producing a standing pressure wave, which is used by the refrigerator to produce cooling power. Several techniques are employed in the design to increase the efficiency of both the driver and the refrigerator compared to previous designs. A detailed description of the design and calibration of the required measurement instrumentation is provided. Finally, some initial driver data is presented.

ACOUSTIC CASIMIR EFFECT

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In 1948, Hendrick Brugt Gerhard Casimir predicted that two closely spaced uncharged conducting plates in vacuum would be mutually attracted. This attractive force is an indirect manifestation of the quantum electromagnetic zero point field (ZPF). When the indirect manifestations of the ZPF are interpreted as due to radiation pressure, acoustic noise can provide an excellent analog to investigate the Casimir effect as well as other effects due to the ZPF. Force measurements between two parallel plates are performed in an acoustic chamber with a broadband noise spectrum within a 5-15 kHz band and an intensity of 133 dB (re 20 mPa). When the results are compared with the appropriate theory, very good agreement is obtained. Applications of the acoustic Casimir effect to noise transduction can provide new means to measure background noise. Because attractive or repulsive forces can be obtained by adjusting the noise spectrum or the plate geometry, a non-resonant method of acoustic levitation is also suggested.

NUMERICAL SIMULATIONS OF SHOCKLESS NONLINEAR ACOUSTICS NOISE IN ONE DIMENSION

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The attenuation of a monochromatic signal in the presence of discrete noise in one dimension is investigated numerically. The predicted Gaussian attenuation is verified by the numerical program, which is based on Riemann's implicit solution of the exact equation for the unidirectional propagation of shockless sound. Two new results are also presented. In the first, the transition from Gaussian to Bessel dependence as a function of resolution in the detection of a signal is observed. This results shows that the fundamental property of time reversibility can only be established if the overall system of the waves and the observer is considered. In the second result, the evolution of the amplitude of a signal injected downstream from the noise is investigated. The Gaussian attenuation is also observed in this case. This result explicitly shows that the attenuation length depends on the distance the signal has traveled, thus displaying memory and breakdown of translational invariance.

DESIGN, DEVELOPMENT, AND TESTING OF AN ULTRAVIOLET HYPERSPECTRAL IMAGER

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This research involved the development of an ultraviolet (UV) hyperspectral imager. A hyperspectral image is a three dimensional image in which two of the dimensions provide spatial information and the third provides spectral information. In an effort to minimize the cost of this experiment, the NPS Middle Ultraviolet SpecTrograph for Analysis of Nitrogen Gases (MUSTANG) instrument was modified to function as a hyperspectral imager. This required the design, fabrication, and testing of hardware and software to coordinate the operation of a two dimensional, charge coupled device (CCD) detector with a servo-controlled scanning mirror. Control and synchronization of scanning mirror and image collection was accomplished by software (written in Borland C++) run from an Intel microprocessor based PC. The benefits of a UV hyperspectral imager are primarily in the area of Support to Military Operations (SMO). There are two principal applications: 1) target identification, and 2) battle damage assessment. Additionally, this instrument has dual use applications, namely, 1) redirection of jet aircraft to avoid the foreign object damage (FOD) hazards presented by volcanic ash clouds through analysis of the absorption of solar UV radiation by the sulfur dioxide ($S0_2$) gas associated with volcanic ash, and 2) forest fire detection.

ROBOT WARS SIMULATION

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Naval Postgraduate School (NPS) Combat Systems students learn about robots and autonomous weapons during group design projects in the SE 3015 course sequence. This sequence is designed to provide experience in combat systems development. The capstone project is the Robot Wars Competition, where pairs of student-designed autonomous robots battle each other. This thesis extends this competition into the arena of simulation and modeling. Our motivation is to further

students' understanding of the strengths and weaknesses of computer modeling and simulation in combat systems design and testing.

This thesis creates a simulation foundation of the Robot Wars Competition. The simulation has been designed in two main parts, a C++ program that manipulates the Simbots on the playing field and generates data files of their movements, and a 3D graphical visualization that allows the user to see the Simbots in action. The C++ program uses a Simbot class to instantiate two Simbots which are composed of three basic components: base, optics and weapons. The graphics portion uses data files created in the main simulation and displays in 3D animation. The simulation correctly replicates the logical and physical aspects of the robot competition. Future research on the physical aspects of the component parts and the graphics package can be integrated with this foundation.

THE USE OF NON-PARAMETRIC TRANSFER FUNCTION ESTIMATES TO PREDICT SUBMARINE HULL VIBRATIONS FROM NOISE SOURCE MEASUREMENTS (U)

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Fundamental and practical limitations in the ability of non-parametric transfer function estimates to predict submarine hull vibrations are investigated. In order to assess the prediction performance and to succeed with non-stationary transfer functions, new methods and terminology are developed. An expression is derived for the maximum fractional error due to leakage which can be expected for the prediction of a pure sinusoid. For the data analysis, Bendat and Piersol's techniques for multiple-correlated inputs are used to condition up to eight input signals. Data is analyzed in three stages of complexity. The first data analyzed is from a scale model submarine driven by shakers. The next data is from the *USS Dolphin*, a deep-diving diesel-electric submarine. Measurements were taken on the Dolphin both surfaced running on diesels and submerged running on battery. During the submerged runs a minimal engineering line-up was used to limit the number of active noise sources. The final data analyzed was obtained from the *USS Hartford*, a nuclear attack submarine while in a normal engineering line-up. Results discussed include the percentage of power remaining in the processed hull signals, the lack of sensitivity of the predictions to input order, and the practical limitations encountered.

MODELING THE QUANTUM DOT

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Much of the progress in solid-state microelectronics has come from the continued reduction in size of the transistors that make up integrated circuits (ICs), having dropped by a factor of 10 in the last decade to where minimum device geometries have reached approximately 350 nanometers in mass production. Continued improvements in ICs will require a device technology that can be scaled down to the sub-100 nanometer size regime. There, the quantum mechanical nature of the electron becomes strongly evident, and new design tools are required for a nano-electronic semiconductor technology. The combined scaling and speed advantages of these new devices could portend orders of magnitude increases in the functional performance of future-generation ICs.

Quantum device performance is extremely sensitive to small variations in design parameters. Accurate theoretical modeling is therefore required to guide the technology development. Conventional device design tools are based on classical physics, and do not incorporate quantum effects. New design tools are required to explicitly account for the quantum effects that control charge transport at the nanometer scale. To further understand and develop nanoscale device technology, this thesis will model the potential energy function in a quantum dot, a nanostructure in which electrons are quantum-mechanically confined in all three dimensions and which represents the inevitable result of continued downscaling of semiconductor devices.

EXPERIMENTAL AND NUMERICAL INVESTIGATIONS OF THE GAUSSIAN SUPPRESSION OF SOUND BY SOUND

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In this work we report on experimental and numerical investigations of the attenuation of a small-amplitude signal due to its interaction with high intensity, band limited sound whose spectrum consists of up to four discrete peaks. We probe the “thermodynamic limit” for different configurations of the spectral components. In particular the attenuation of the signal is investigated for both equally and unequally spaced spectral components, as well as different phase relations among them. The possibility of collective modes is also explored by measurements of the phase change in the signal downstream due to the presence of discrete noise.

HARDWARE MODIFICATIONS AND INSTRUMENTATION OF THE THERMOACOUSTICALLY DRIVEN THERMOACOUSTIC REFRIGERATOR

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This thesis describes hardware modifications, instrumentation, and measurements taken with a heat driven refrigerator apparatus. Basic engine operation requires a heat source for the thermoacoustic driver which produces a high amplitude acoustic standing wave in a resonant vessel. Acoustic energy is extracted from the wave by the thermoacoustic refrigerator, located in the same vessel, which produces the cooling power. The engine has no moving parts.

The measurements characterize the performance of the driver half of the engine in terms of amplitude and heat input with respect to changes of the “stack” component, resonator tuning, and gas type. Amplitudes as high as 9.5% (peak/mean pressure) were achieved, and control of onset and amplitude were generally excellent although some amplitude instabilities were observed. Preliminary refrigeration measurements were also made, with substantial amounts of cooling power produced.

AN ANNULAR THERMOACOUSTIC PRIME MOVER

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The dissertation constitutes the first detailed theoretical and experimental investigation of a thermoacoustic prime mover with periodic boundary conditions. There are five significant aspects to this research: (1) using DeltaE to analyze an annular prime mover, (2) developing an entirely new analysis program using MATLAB, (3) designing, building, and experimentally investigating a single stack, annular prime mover, (4) experimentally investigating a constricted, single stack prime mover, and (5) predicting the performance of a two stack annular prime mover. The major conclusions are: (1) A single stack annular prime mover will not reach onset because the eigenmodes of the system do not support thermoacoustic growth, (2) A constricted annular prime mover will reach onset because the constriction forces dominating boundary conditions that alter the eigenmodes, and (3) A two stack prime mover is predicted to reach onset because one of the eigenmodes of the symmetric system does support thermoacoustics.

THE DESIGN OF THE NAVAL POSTGRADUATE SCHOOL'S ULTRAVIOLET IMAGING SPECTROMETER (NUVIS)

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Hyperspectral imaging spectrometers are remote sensing instruments capable of producing an image cube comprised of a two-dimensional scene and the corresponding spectra of each scene element remote sensing is growing in civilian applications and support of military operations. Civilian applications vary from plant species identification, stress measurement, leaf water content and canopy chemistry to geological identification and mapping. Military applications include target identification and classification, bomb damage assessment, terrain or area utilization and rocket plume identification.

This thesis describes the fabrication and alignment of the NPS Ultraviolet Imaging Spectrometer (NUVIS). NUVIS is a hyperspectral imaging spectrometer designed to investigate the added value of the ultraviolet region of the spectrum. The spectrometer is comprised of a telescope assembly using an off-axis parabolic mirror, a slit, a flat-field imaging diffraction grating and a camera assembly. This is the first part of a continuing project to build, test and use this sensor for support of military operations.

OCEAN WAVE DATA ANALYSIS USING HILBERT TRANSFORM TECHNIQUES

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A novel technique to determine the phase velocity of long-wavelength shoaling waves is investigated. Operationally, the technique consists of three steps. First, using the Hilbert transform of a time series, the phase of the analytic signal is

determined. Second, the correlations of the phases of analytic signals between two points in space are calculated and an average time of travel of the wave fronts is obtained. Third, if directional spectra are available or can be determined from time series of large array of buoys, the angular information can be used to determine the true time of travel. The phase velocity is obtained by dividing the distance between buoys by the correlation time. Using the Hilbert transform approach, there is no explicit assumption of the relation between frequency and wavenumber of waves in the wave field, indicating that it may be applicable to arbitrary wave fields, both linear and nonlinear. Limitations of the approach are discussed.

A SIMULATION STUDY OF ACOUSTIC VARIABILITY DUE TO INTERNAL SOLITARY WAVES ON THE MID-ATLANTIC CONTINENTAL SHELF

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During the summer of 1995, a multi-institutional field study called Shallow-Water Acoustic Random Medium (SWARM) was conducted in the Mid-Atlantic Bight continental shelf region off the coast of New Jersey. Environmental and acoustic sensors were deployed as part of SWARM to measure and characterize the internal waves and their impact on the spatial and temporal coherence of the acoustic transmissions. As part of the environmental monitoring network, two bottom-moored, upward-looking acoustic Doppler current profilers (ADCPs) were deployed. Large-amplitude, non-linear, internal soliton wave packets were observed to propagate shoreward from the shelfbreak. Based on the ADCP observations, a kinematic model of the soliton wave packets was developed to synthesize the corresponding temporal and spatial fluctuations in the sound-speed field. Using a coupled normal-mode sound propagation model and the synthesized sound speed variations, the variability of sound pressure and of the modal amplitudes for a 224 Hz CW transmission were simulated. The auto and cross-correlations of sound pressure at different depths, and of the modal amplitudes at a fixed range, were computed in an effort to estimate the vertical and temporal scales of the fluctuating sound field. The simulation method, the simulated acoustic variability as well as the results of the correlation analysis are presented and discussed in this report.

ANALYSIS OF HYPERSPECTRAL DATA USING POLARIMETRIC CHARACTERISTICS

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The utility of polarimetric reflectance characteristics of targets and background surfaces in the analysis of hyperspectral imagery data is investigated. A technique is proposed for filtering a data hypercube of an imaged scene to select targets for subsequent analysis using standard hyperspectral signature matching techniques, thereby reducing image analysis time. An experimental study to measure polarization characteristics of reflected light from various surfaces in order to determine wavelengths for maximum and minimum intensity differences between polarized reflectance values is proposed. A second study is outlined for collection of simulated hyperspectral imagery that would attempt to validate the proposed filtering technique. A research of past studies indicate that useful polarization signature components are present for many targets and target materials. Additionally, backgrounds composed of grass, trees, dirt, and clouds generate very little polarized components making detection of targets using polarization signatures feasible.

SOLAR HEATING EFFECTS ON BALLOON-BORNE MICROTHERMAL PROBES FOR THE AIRBORNE LASER PROGRAM

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Atmospheric optical turbulence induces phase fluctuations in a propagating electromagnetic wave. The resulting degradation in coherence limits the capability of any laser, target acquisition, or surveillance system. Past data collection methods for the parameterization of atmospheric turbulence profiles, in support of critical Theater Ballistic Missile Defense (TBM) systems, from ground level to 30 km, have depended on meteorological balloon-thermosonde systems, probes carried on the U.S. Air Force Argus aircraft, as well as radar and optical measurements. The balloon and aircraft systems measure temperature fluctuations and compute the temperature structure function, C_T^2 and the related index of refraction structure parameter, C_n^2. It has recently become critical to explain why turbulence profiles from daytime thermosonde data consistently show a two order of magnitude increase over that taken during the night, primarily between 12-20 km.

This thesis analyzed the TSI 3.8 µm platinum coated tungsten thermosonde probe used by the USAF Research Laboratory (AFRL) to quantify the magnitude of the solar heating and to investigate other heat transfer mechanisms in the probe. A model of the thin wire probe was developed to identify each of the contributions to the temperature error and its significance. Experimental measurements where collected to verify most aspects of the final model.

We found that the sun induces a temperature rise in the TSI 3.8 µm fine wire probe, during the day, that can vary from near zero to 0.175 K. It is strongly dependent on probe orientation with respect to the sun and on variations in the air flow over the probe. This then causes an apparent increase by two orders of magnitude in the daytime measurements of the optical turbulence parameters C_T^2 and C_n^2.

FREE ELECTRON LASER WEAPONS AND ELECTRON BEAM TRANSPORT

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The Navy is exploring the possibility of using a MW class free electron laser (FEL) as a ship self-defense weapon against anti-ship missiles. The Navy has helped fund the construction of a KW average power FEL and has held workshops to discuss weapons class FELs.

A design workshop resulted in two possible MW FELs which are examined. One of these designs, the MW regenerative amplifier FEL, is looked at further to determine the feasibility of its design parameters. The second design, the MW oscillator FEL, presents a challenge in understanding the electron beam transport phenomena known as coherent synchrotron radiation (CSR). A workshop concluded that CSR is potentially disruptive in the electron beam recovery in the oscillator design. Possible CSR experiments are analyzed to help the Navy's Directed Energy office determine which, if any, CSR experiment will be useful.

ACOUSTIC SOURCE AND DATA ACQUISITION SYSTEM FOR A HELICOPTER ROTOR BLADE-VORTEX INTERACTION (BVI) NOISE REDUCTION EXPERIMENT

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One of the most objectional noises produced by a helicopter is due to interaction of a rotor blade with a previously shed vortex. Various methods have been proposed to reduce this blade-vortex interaction (BVI) noise; this investigation is concerned with BVI noise reduction by rotor blade tip design modifications. Potentially much can be learned regarding the prospect for success of a candidate rotor blade design at greatly reduced time and money by performing acoustic scattering measurements in an anechoic chamber. It is proposed that a rotor blade which scatters acoustic waves less could be expected to produce less BVI noise. This thesis describes the development of the acoustic source and computer controlled data acquisition system for such a scattering experiment.

HIGH-ACCURACY DISTRIBUTED SENSOR TIME-SPACE-POSITION INFORMATION SYSTEM FOR CAPTIVE-CARRY FIELD EXPERIMENTS

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Operational EW test and evaluation experiments require that the position of the aircraft and other moving objects on the range be known precisely as a function of time. Terminal Time-Space-Position Information (TSPI) Systems involve the range platforms interacting at close distances and therefore require precise trajectory information over a restricted volume of space. Terminal TPSI systems are used for tactics evaluation and the evaluation of simulated weapons firings (e.g., captive-carry hardware-in-the loop missile simulators). Distributed sensor TSPI systems consist of two or more measurement sensors located some distance from each other. Each sensor makes a measurement of target angle and range. Distributed sensor systems are more complex than single-point systems involving multiple hardware installations, complex mathematical computations to extract coordinate information, synchronization of multiple measurements and calibration of a number of different stations.

This paper presents a novel distributed sensor TSPI architecture that provides precise positioning information of the target relative to a fixed inertial coordinate system. The architecture efficiently integrates the information from an inertial navigation system (INS), a global positioning system (GPS) and any number of distributed RF sensors which may be located onboard a captive-carry aircraft. The significance of this work is that by knowing the target's position in a fixed inertial frame of reference (derived from the integration process) an evaluation can be made as to the effectiveness of any electronic attack or off-board decoys that might have been launched during the field test scenario. The induced INS, GPS and sensor noise and the corresponding errors due to the integration process are evaluated numerically as a function of the weapons system being used. The accuracy in the targeting information is also quantified and compared wiht the true expected values.

EVOLUTION OF THE TEMPERATURE PROFILE IN A SIMPLE THERMOACOUSTIC STACK

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The purpose of this thesis is to provide data on the evolution of the temperature profile in a simple thermoacoustic stack. These measurements are made to support the development of nonlinear time-dependent models of thermoacoustics. An acoustic resonator and driver is used with a five-plate stainless steel stack. The center plate of the stack is instrumented with nine thermocouples, one in the midpoint and four near each end of the plate. The edge thermocouples are located within an acoustic displacement amplitude of one another at high amplitude drive conditions.

Temperature evolution data is recorded for both argon and helium gases at several mean pressures and several drive ratios with the stack located between a pressure node and antinode. This data showed a deviation from linear theory at drive ratios above 1.5%. A crossover of gradient magnitudes is evident during gradient formation with edge thermocouple pairs initially forming larger gradients but dropping in magnitude to less than those of the inner thermocouple pairs after 25-56 seconds. As the gradients approached steady state conditions, they split into two groups of gradient pairs that appeared independent of displacement amplitude. Measurements are also made with the stack positioned in the vicinity of a pressure node and a pressure anti node. This data will be used for future study.

INTERACTION OF LASER BEAMS WITH RELATIVISTIC ELECTRONS

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Motivated by the desire to put a free electron laser (FEL) weapon on a ship, the FEL and the related process of Compton backscattering are studied. The theme of the majority of this work is the interaction of the Gaussian optical mode with a beam of relativistic electrons.

Classical FEL theory is reviewed in Chapter II. Simulations based on the classical theory are used in Chapter III to study a proposed 1 kW (kilowatt) infrared FEL. In Chapter IV, simulation is used to study the problem of electron beam/optical mode overlap in an ultraviolet (UV) FEL. A new concept, the FEL with a short Rayleigh length, is studied in Chapter V. The idea is tested on the UV FEL, then used to design and simulate a megawatt-class FEL for ship self-defense.

An analytical calculation of the Compton backscattering of laser light is performed in Chapter VI. A quantum electrodynamics (QED) formalism is used to find the spectrum and angular distribution of photons scattered out of a Gaussian optical mode by relativistic electrons.

ANALYSIS OF MODAL TRAVEL TIME VARIABILITY DUE TO MESOSCALE OCEAN STRUCTURE

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This dissertation examines the effects of ocean mesoscale variability on acoustic arrival time patterns for two separate ocean environments. First, for an open ocean environment away from strong boundary currents, the effects of randomly phased linear baroclinic Rossby waves on acoustic travel time are shown to produce a variable overall spreading in the arrival pattern, primarily producing a delay in the later, axial arrivals. Second, using the state-of-the-art Semtner-Chervin eddy resolving global ocean circulation model coupled with the University of Miami Parabolic Equation (UMPE) acoustic propagation model, the effects of a fluctuating frontal region created by the California Current on the temporal, spatial and seasonal variability in the individual modal arrivals of the first thirty modes over a one-model-year time span is assessed. The mesoscale bias variability is also examined by comparing the various peak arrival times for the range-averaged environment to that of the range-dependent environment. To support this work, approximate "wide angle PE mode functions" were newly developed which form a different basis set for modal expansion from that obtained using standard normal mode theory. These new mode functions provide the proper basis set for modal expansion of the field computed by wide-angle PE models.

BATHYMETRY FROM HYPERSPECTRAL IMAGERY

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This work used hyperspectral imagery to derive shallow water depth estimates. A technique to classify substrates and estimate reflectance values for the substrate types is the major contributions of this work. This was accomplished by masking different bottom types based on spectra, effects that were not included in previous methods. HYDICE data was taken over Lake Tahoe on June 22, 1995. The high altitude of the lake provided a low aerosol content within the atmosphere. This allowed for relatively straightforward atmospheric corrections. This was substantially easier than in an oceanic environment. The atmospheric radiative transfer code MODTRAN3.0 was used to model the atmospheric conditions at the time of the experiment. The radiative transfer code HYDROLIGHT3.5 was used to model the attenuation coefficients of the relatively clear water of the lake. Minimal river input and low chlorophyll concentrations made it simpler to determine these values. Making use of the full spectral content of data within the optical range, multiple substrates were differentiated and masked off. This allowed for an estimation on wet substrate reflectance and a straightforward calculation of bottom depth.

CASIMIR ACOUSTICS

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When the indirect manifestations of the electromagnetic ZPF are interpreted as due to radiation pressure, acoustic noise can render an excellent analog to probe previous as well as recently proposed behavior. An acoustic chamber for isotropic and homogeneous acoustic noise of controllable spectral shape has been built. The noise can be driven up to levels of 130dB (re 20 mPa) in a band of frequencies up to 50 kHz wide. When driving the system with broadband noise, it will be used: (i) to test the Galilean invariance of a spectral shape proportional to the square of the frequency, (ii) the force of attraction between parallel plates (analog to Casimir force), (iii) the acoustic radiation emitted by a cavity that is made to oscillate at high frequencies (analog to the proposed Casimir radiation), (iv) the change in the frequency of oscillation of a pendulum as the noise intensity is varied (analog to the proposed origin of inertia), and (v) the force of attraction between two spheres due to the acoustic shadow that each one casts onto the other (analog to van der Waals force and the proposed origin of gravitation).

FRAGMENT IMPACT ON A CHEMICAL WARHEAD (U)

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Current U.S. strategic policy has placed significant emphasis on Theater Missile Defense (TMD); problems associated with high-altitude intercept and destruction of threat missile Systems are extensive. The actual missile-to-missile encounter is anticipated to occur anywhere from exoatmospheric altitudes to very low endoatmospheric altitudes. Conduct of experiments to simulate these conditions at these altitudes is hampered by the inability to produce, at ground level, the velocity and atmospheric conditions associated with actual missile-to-missile encounters. However, experiments have been conducted at a reduced scale, for velocity and atmospheric conditions, for both the interceptor and target.

The objective of this thesis is to evaluate the role target obliquity and hole size have on fragment lethality of TMD interceptors. Also, the ability of the fragment model within the Parametric Endo/Exoatmospheric Lethality Simulation (PEELS) is evaluated for representation of the above parameters. In order to evaluate the significance of obliquity on a fragment intercept and the ability of PEELS to accurately represent that intercept, this thesis will first examine the intercept conditions of two different fragmenting warhead missiles, one directional and one aimable, against a threat chemical payload ballistic missile. Aimable warheads focus the fragment spray directly on the target, thereby increasing the probability of hit and the probability of kill given a hit on the target. Directional warheads have charges placed around the warhead to direct the blast through the timing of the charges, thereby increasing the hit probability. Experiments relevant to the intercept conditions are analyzed to better understand the phenomeno- logy of fragment impact that occurs at these conditions. Next, the current Parametric Endo/Exothermic Lethality Simulation (PEELS) fragmentation methodology, produced by Kaman Sciences Corporation, is compared to the intercept conditions and experimental data. Finally, hole size in the aeroshell, produced by interceptor fragments will be examined to determine if enhanced lethality is obtained for the aimable fragmenting warheads.

HIGH FREQUENCY CHARACTERIZATION OF THE GSANGER LM0202P ELECTRO-OPTIC MODULATOR

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This thesis documents experiments conducted with the Gsanger LM0202P electro-optic modulator to achieve a high percentage modulation at 125MHz of an argon-ion laser. The laser was tuned to produce a single mode, linearly polarized light at 514.5 nm. The laser light was first passed through the electro-optic crystal modulator with no external electric field applied, and the frequency spectrum was observed to be the same as the frequency spectrum of the source laser. When an AC voltage with a frequency of 125 MHz was applied to the modulator sidebands were observed by using a Fabry-Perot interferometer. Further measurements were taken to determine the suitability of the LM0202P modulator over a large frequency range.

ALTERNATIVE PATHWAYS TO NUCLEAR WEAPONS PRODUCTION (U)

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CLASSIFIED ABSTRACT