MASTER OF SCIENCE
IN
PHYSICS

DESIGN AND CONSTRUCTION OF A ONE METER ELECTROMAGNETIC RAILGUN

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The acceleration of projectiles through the use of electromagnetic forces (Railguns) has many advantages over conventional methods. Foremost are the higher velocities which can be achieved and the reduction in firing platform sensitivity to hits. Projectile velocities on the order of 3-4 kilometers per second allow the use of "kinetic energy kill" projectiles which are effectively inert munitions. Additionally, by using purely electromotive force for the acceleration, the need for explosive propellants is eliminated.

A one meter Electromagnetic Railgun was designed and constructed to serve as a test bed for research into alternative armature materials, rail/armature plasma effects, and current pulse forming techniques. A modular approach was used to allow independent changes in power supply, pulse forming network, bore configuration, and gun augmentation.

BOTTOM BACKSCATTER MAPPING: THE EFFECT OF SECONDARY MULTIPATH INTERACTIONS

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It has been shown that good correlation exists between large-scale, high level signal returns of bottom acoustic reverberation and bathymetric ridge structures. The ultimate goal of this type of analysis would be the removal of propagation effects resulting in a large-scale mapping of scattering strengths. Furthermore, analysis with a quasi-CW propagation model suggests a strong correlation between the small-scale fluctuations in the reverberation signal and the bottom acoustic ensonification, thereby suggesting that uncertainties in the predictions of forward propagation may limit the resolution of such mapping. By employing broadband modeling techniques, a valid representation of the complete time domain forward propagation is provided. Diffuse secondary bottom interactions appear to affect the resolution of the primary, direct-path interaction at ranges beyond a few water depths. Analysis of data recorded by near-bottom vertical line arrays (VLA's) confirms the existence of these secondary, multipath interactions in the forward propagation. The exact, two-way travel times from all bottom interactions are modeled and the influence of the secondary interactions is quantified. Possible ramifications for general sonar system performance are discussed.

EXPERIMENTAL INVESTIGATION OF A HIGH RESOLUTION SONAR

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This thesis investigated a laboratory synthetic aperture sonar designed to test the algorithms and techniques needed to detect, classify and identify mine-like objects. Previous synthetic aperture sonar work at NPS achieved 5 cm range resolution and 1 cm azimuth resolution. This thesis developed a pulsed, frequency modulated, synthetic aperture sonar that achieved range and azimuth resolutions of about 1 cm. The processed images clearly reveal detection of targets with a high degree of certainty. However, the ability to classify and identify mines and rocks is less certain because of speckle and glint effects. The high resolution algorithms improved the detection and overall image quality of targets,

and achieved a signal to noise ratio of 35 dB. The 2:1 frequency spread of the FM chirp increased the signal to noise ratio by 20 dB compared to an unfocused synthetic aperture system. However, a significant finding is that resolution alone is not sufficient to classify and identify mine-like targets in complex backgrounds. Resolution of this problem will require a different approach such as utilizing adaptive acoustic daylight to avoid the speckle and glint problems inherent with coherent illumination. To achieve a classification and identification capability, a completely different approach to acoustic illumination and signal processing is needed.

OPTICAL MODULATOR LM0202 P CHARACTERISTICS: APPLICATION TO AMPLITUDE MODULATION OF ARGON-ION LASER

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The purpose of this thesis is to examine the possibility of using a commercial electro-optic modulator, the LM 0202 P modulator manufactured by Gsanger OptoElektroniks of Germany, to provide an amplitude modulated light source to test a theory of the conversion of amplitude to frequency modulation of light in fiber optics. The main focus of this thesis is to experimentally determine the performance characteristics of the modulator including the frequency response in the frequency range 1 kHz to 150 MHz. The effects of inductive loops, both external and internal to the modulator, are examined and solutions discussed. Amplitude modulation of an Argon-Ion Laser operating at 514.5 nm at twenty-five percent modulation at 125 MHz has been achieved.

LIMIT-CYCLE BEHAVIOR IN FREE ELECTRON LASERS

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Many Free Electron Lasers (FEL) are driven by short electron pulses which create equally short optical pulses. At saturation, the strong optical fields present in the undulator result in the trapped-particle instability which drives the carrier wave unstable and modulates the optical pulse. The trapped-particle instability coupled with the short optical pulses can result in periodic oscillations of the pulse shape. This results in oscillations of the output power even though all input parameters are constant. The effect is known as limit-cycle behavior.

The character of the oscillation is highly nonlinear and is dependent on the physical input parameters of the current density, resonator losses, electron pulse length and desynchronism of the resonator cavity. These power oscillations affect the operation of the FEL, requiring better insight into their cause and control. Using simulations based on a self consistent Maxwell-Lorentz theory of FEL operation, the dependence of the limit-cycle oscillations on these physical parameters is examined.

HIGH ORDER PARAMETRIC X-RADIATION FROM SILICON AND LITHIUM FLUORIDE CRYSTAL MONOCHROMATORS

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This thesis examines parametric x-radiation (PXR) generated by Silicon and Lithium Fluoride monochromators, including the first observation of PXR from Lithium Fluoride. Parametric x-radiation may be described as the Bragg

scattering of virtual photons associated with relativistic electrons as they pass through single crystal monochromators. As the photons interact with the crystal lattice they produce x-rays which meet the Bragg condition nl =2dsinq_B, where q_B is the angle between the electron beam and the crystal plane. PXR data were collected from Silicon and Lithium Fluoride crystals using a SiLi detector. The locations of the energy peaks are compared to the locations predicted by theory and the intensity ratios between the peaks are also compared to the theoretical ratios. The PXR energy observed was as predicted by theory for Silicon and Lithium Fluoride monochromators. The observed peak intensity ratios for Silicon were not in agreement with intensity ratios predicted by theory. Intensity ratios observed from Lithium Fluoride were in agreement with the predicted value.

HIGH SPEED NUMERICAL INTEGRATION OF FERMI DIRAC INTEGRALS

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In this thesis we present an algorithm for the precise determination of Fermi-Dirac (FD) integral functions, $f_\tau(\eta)$, for arbitrary values of the parameter τ and the argument η. The FD integrals are a class of functions that are used extensively in the modeling of semiconductor devices, e.g., when the charge carriers are in a strongly quantum, degenerate regime, such as in heavily doped semiconductors. The determination of FD integrals has a long history. Our approach to evaluating these functions is two-fold. First, we develop exact power series expansions of the integral. These series, however, converge too slowly to be a practical means of evaluating the integral. The second aspect of our approach is to apply numerical series acceleration methods to improve significantly the rate of convergence of these series expansions. The result is a computer program that provides efficient, accurate values of the FD integral.

OPTICAL CHARACTERISTICS OF LEXEL 85 ARGON ION LASER AND GSANGER LM0202P MODULATOR: APPLICATION TO AM-FM LIGHT CONVERSION

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The purpose of this thesis is to examine the possibility of using a commercial electro-optical modulator, the LM0202P modulator, manufactured by Gsanger Opto-Elektroniks of Germany, to amplitude modulate an argon ion laser, the LEXEL model 85, for proving a theory of the conversion of amplitude to frequency modulation of light in fiber optics. The main focus is to analyze the spectral output of the laser both before and after being directed through the modulator. Also to be considered is launching the laser light down a length of optical fiber. It was determined that the laser does not produce a single mode, monochromatic spectral line. Further, it was determined that when the laser is directed through the modulator, the structure on the laser profile tends to blur. This effect increases when DC bias voltage is applied to the modulator. Additionally, when the modulator is driven with an AC modulation superimposed on the DC bias voltage, the resultant optical spectral profile does not correspond to that expected for sinusoidal amplitude modulation.