DEPARTMENT SUMMARY

During CY 1997, 13 Physics Department faculty members participated in approximately 33 different research projects. Although the scope of these projects is quite broad, the research in the Physics Department can be grouped, for the purposes of this summary, into six general areas: (1) Electromagnetic Radiation and Propagation Phenomena; (2) Remote Sensing; (3) Weapons/Shipboard Systems Technologies; (4) Ocean Acoustics and Air/Sea Interactions; (5) Combat Systems Technology and Policy; and (6) Solid State Physics and Fundamental Processes. An overview of research activities in each of these areas follows.

Electromagnetic Radiation and Propagation Phenomena

Associate Professor Donald Walters continued work on atmospheric optical turbulence in support of the U.S. Air Force Airborne Laser Program. He served as the Air Force's technical representative on a number of occasions. In addition, ten years of atmospheric coherence length and isoplanatic angle measurements were collated and compared. This study showed how solar illumination introduced a factor of ten errors in daytime balloon measurements, and how the problem could be eliminated. Understanding the atmospheric turbulence parameters is a key part determining the viability of optical communication systems for multi Giga bit communication links. To this end Professor Walters initiated a project to evaluate and assess large weather models such as the COAMPS and MM5 Mesoscale Weather models to predict atmospheric turbulence and cloud formation. He is comparing post-processed model results with existing atmospheric optical data and to assessing the desirability and direction for further work.

Associate Professor Scott Davis continued a multi-year project, which has as its primary goal the development of a proof-of-concept prototype instrument capable of recording fully multiplexed images and multispectral images at long infrared wavelengths, where efficient focal plane array technology is not available. The task completed during this research was the design of the prototype opto-mechanical and opto-electronic servo system which will be responsible for spatial positioning of the instrument's Walsh encoding masks to very fine (micron-tolerance) precision.

Professor William Colson continued work in the area of free electron laser (FEL) simulations. His areas of interest include simulation of new and existing FELs for ship self-defense, and FEL simulation for industry partners. His involvement included investigation of wavelength modulation and limit cycle behavior in FELs, atmospheric propagation simulations of high average power FEL, and ultraviolet FELs.

Professor Alf Cooper continued work in a number of areas related to the application of infrared technology to the Navy in support of Naval Sea Systems Command and Space and Naval Warfare Systems Center-San Diego. One project involves the development of a split-field Long Wave Infra Red (LWIR) polarimeter. Another involves analysis of IR ship signatures from the PREOS92 experiment.

Remote Sensing

Associate Professors David Cleary and Chris Olsen continued work in the area of hyperspectral remote sensing. Professor Cleary is conducting experimental work in this field. He has completed the construction of an ultraviolet hyperspectral imager and a hyperspectral polarimeter. Initial testing of these devices has begun and will continue in 1998. Professor Olsen is working on the phenomenology and algorithm development of hyperspectral imaging. His concentration is on littoral and near-shore environments.

Associate Professor Robert Harney developed laser and lidar technologies. During 1996 a laser/lidar laboratory was established. During 1997 the assembly of a breadboard, cw Doppler lidar (including laser, detector, acousto-optic modulator, optics, and radio frequency electronics) was completed. The performance of this lidar in detecting vibrations was verified in the laboratory using a special calibration source assembled during 1996 under this task. Conceptual design of wavelength-tunable and ultraviolet laser sources as upgrades to this aerosol-profiling lidar was also conducted.

Weapons/Shipboard Systems Technologies

Associate Professor Thomas Hofler worked in the area of thermoacoustics. Thermoacoustics is an emerging technology that represents a feasible, non-CFC, non-global warmer cooling alternative. Previously, a laboratory prototype cooling engine of a new design was modeled numerically, partially optimized, and constructed. The prototype has produced much data in 1997 on a variety of thermoacoustic stacks and resonator tuning combinations. Audible noise from the engine is significant at about 70 dBA. Recently, the analysis and design of the engine has been modified to achieve vibration cancellation. The hope is for a noise reduction of 20 dB or more when the new modifications are tested.

Associate Professor Harney worked to integrate the electromagnetic engineering (EMENG) suite of tools and top-side design principles being developed by the Combat Systems Design and Engineering Group (03K) of NAVSEA into NPS Total Ship Systems Engineering (TSSE) program. The intent is to educate the TSSE students concerning the need and techniques for improving the electromagnetic characteristics and performance of a surface combatant, and to serve as a beta test site for proving out the evolving EMENG suite of computer-aided design tools. During 1997 the new Windows NT-compatible version of the EMENG suite of computer-aided design and analysis tools was obtained from NAVSEA. Necessary additional database, X-windows, Fortran compiler, and C++ compiler software were purchased. The NAVSEA-provided Intergraph computer hardware and personal computers running Windows NT have been incorporated into the TSSE laboratory area.

Ocean Acoustics and Air/Sea Interactions

Assistant Professor Kevin Smith worked on several projects concerning ocean acoustic propagation. High quality acoustic reverberation data were collected during the Acoustic Reverberation Special Research Program's (ARSRP) main acoustics cruise in the summer of 1993. The ability to correlate these measured returns with bathymetric features depends on the signal resolution. A study of the effects of multipath propagation on signal resolution was proposed. Analysis of the measured data provided a means of confirming predictions of these effects. An advanced PE propagation model was used to quantify these effects in the ARSRP environment. This research is a continuation of a FY96 research project sponsored by ONR. During FY97, a direct comparison between a simpler continuous wave (CW) approach and an advanced broadband calculation was made to determine the exact influence of such multipath propagation. It was determined that in isolated regions these secondary multipaths can influence the reverberation by as much as 20 dB, but that over most ranges of interest, the simple CW approach works extremely well.

The objective of another project was to study the physics and predictability of 3-D, broadband acoustic propagation upslope onto the continental shelf in the presence of strong oceanographic frontal features, specifically in the vicinity of the mid-Atlantic Bight. Finally, he was involved with a study of the influence of the physics mismatch due to less-than-ideal acoustic ray model predictions on the localization of full-wave signals and to coordinate future research efforts towards a system demonstration of passive transient localization.

Research Associate Professor Donald Spiel is continuing a research project involved in determining the ocean's aerosol source function. That is, to determine how many aerosols per unit time per unit area are generated by oceanic processes. In the past year, the effort to determine the birth of jet drops over the range of bubble sizes 350 to 1500 μm radius was completed. The ejection speeds, time of ejection, and the height at which all the jet droplets broke off the ascending jet were measured. Previously, the size distributions of these drops were determined. In addition, a theoretical solution to the problem of the number of film drops as a function of bubble size was advanced. Experiments were begun to test the efficacy of this theory. Work on the ejection parameters of jet drops for the bubble size range 0.5 to 3 mm-diameter was completed during 1997. During this year, a hypothesis was advanced to explain the peak in film drop production in the bubble size range 2 to 2.5 mm-diameter was advanced. Measurements of film drop production and theoretical calculations have led to a broad understanding on film drop production.

Combat Systems Technology and Policy

Professor Xavier Maruyama participated in activities associated with the Institute for Joint Warfare Analysis. The project investigated available and potential technologies related to Technologies for Operations Other than War (TOOTW), including Less-than-Lethal Weapons, Landmines, Defensive Technologies, Situational Awareness Technologies, and Training and Simulation Issues.

Solid State Physics and Fundamental Processes

Associate Professor James Luscombe is involved with a project to advance the state of the art in quantum device modeling. He is developing a wide variety of models for electrons in semiconductor nanostructures and associated issues related to the ultimate scaling of electronic devices. In addition, he is developing models of the self-consistent electrostatic potential in quantum dot nanostructures as well as solutions to the Schrödinger equation in quantum wire geometries. He is also working to develop models of the time-dependent, nonequilibrium elastic scattering structure factor for the investigation of strongly nonequilibrium processes in adsorbed surface overlayers.

There were two separate thrusts to his research this year: (1) He examined theoretically the effects of deliberate compositional modifications to semiconductor superlattices on electron dynamics. He then used the insights gained to develop a proposal for a spatially selective photo-excitation process that would reduce the dephasing of Bloch oscillation signals, and hence lead to significantly longer-lived Bloch oscillations. Bloch oscillations in semiconductor superlattices are a possible means of generating TeraHertz electromagnetic radiation. (2) He developed models of the magnetic properties of recently synthesized molecular clusters containing a relatively small number (4-10) of magnetic atoms. He developed a classical spin model to predict the magnetic susceptibility and compared it with recent experimental data. The insights gained from this theory were used to develop a model of the nuclear-magnetic-resonance (NMR) spin-lattice relaxation time in small magnetic clusters. Magnetic molecular clusters have possible applications as ultra-dense information storage systems.

Assistant Professor Andrés Larraza is establishing basic experimental and theoretical research in nonlinear waves. Two areas of research were covered: absorption of sound by noise with possible applications to the excess attenuation in a shallow water environment and basic experimental and theoretical research on acoustic analogs to effects predicted from the properties of the electromagnetic zero point field (ZPF). This new area of research has the potential to test a broad array of new concepts where the ZPF may play a major role, including inertia, gravitation and sonoluminescence. The use of broadband noise in the acoustic analog to the Casimir effect may lead to non-resonant acoustic levitation and manipulation.

The Department of Physics maintains and a linear electron accelerator (linac) and a flash x-ray machine. The facilities are used for classroom and research use especially by the Departments of Physics and Electrical and Computer Engineering. The principal investigator for these facilities is Professor Xavier Maruyama. He collaborated on a research project that studied the radiation effects on electronics and investigation of parametric x-radiation.