Resident Research Associateships: Opportunities for Research at the Naval Research Laboratory (0)

Pages
48

Size
5 x 8

ISBN
0309365228

National Research Council; National Academy of Sciences; National Academy of Engineering

The National Academy of Sciences is an organization of distinguished scientists and engineers concerned with the furtherance of science and its use for human welfare. Although the Academy is not a government agency, it is called upon by its Congressional charter of 1863 to serve as an official adviser to the Federal Government in matters of science and technology. This responsibility is now shared with the National Academy of Engineering, organized in 1964 under the original NAS charter. The National Research Council, organized by the National Academy of Sciences in 1916 in order to provide for broader participation by American scientists and engineers, serves as an operating agency for both Academies.

Resident Research Associateships

OPPORTUNITIES FOR RESEARCH
at the
NAVAL RESEARCH LABORATORY

1971

administered by the
NATIONAL RESEARCH COUNCIL
National Academy of Sciences
National Academy of Engineering
2101 Constitution Avenue
Washington, D.C. 20418

THE NAVAL RESEARCH LABORATORY

The Naval Research Laboratory is one of the largest scientific institutions within the U.S. Government. The physical plant is a 50-million-dollar complex of over 100 buildings, located on the Potomac River, in Washington, D.C., about four miles south of the Capitol. In addition, there is a large support facility located on Chesapeake Bay and an underwater sound reference facility at Orlando, Florida. There are also several field experiment sites in Maryland, Virginia, and West Virginia.

The research activities of the Naval Research Laboratory are highly diversified, embracing the entire range of the physical and engineering sciences. The effort, apportioned among roughly 400 specific problems, is predominantly basic in character, carried out in pursuit of fundamental knowledge. Major programs are also carried on in applied research and development—such as increasing the range of radar, improving the steels in ship-building, or developing better methods for deep sea search. The program is carried forward by a technical staff of 1200 civilian scientists and engineers.

To instrument its diversified program, the Laboratory has built or purchased an impressive array of modern tools for research, many of which are unique. There are, for instance, a 75-MeV sector-focusing cyclotron; a 60-MeV Linac; a 5.5-MV Van de Graaff; an extensive variety of radio telescopes; versatile facilities for high magnetic field and cryogenics research; light-gas guns for studying hypervelocity impact; a high-level radiation laboratory; a 2-megajoule condenser bank and electromagnetic shock tube for thermonuclear investigations; extensive facilities for study of the mechanical properties of materials; a variety of gas and solid state lasers including devices of very high power and brightness; and innumerable other instruments needed for present-day investigations. In addition, NRL maintains four aircraft equipped as "flying laboratories," and has four research vessels available for experiments at sea.

INTRODUCTION

The National Research Council conducts Resident Research Associateship Programs on behalf of a number of Federal laboratories and research agencies. The objectives of the programs are

> to provide postdoctoral scientists and engineers of unusual ability and promise opportunities for research on problems of their own choice, and
> to contribute to the general research effort of the Federal laboratories.

The programs provide opportunities for basic research and advanced training to recent recipients of the doctoral degree in association with selected members of the permanent professional laboratory staff. In addition, the programs make available to the scientific and engineering community the excellent, and sometimes unique, research facilities which exist in the Federal laboratories.

Applications for the programs are received by the National Research Council and are evaluated on a competitive basis by NRC panels of scientists and engineers convened for this purpose.

Described in this booklet are some of the areas of research in which Resident Research Associateships may be awarded at the Naval Research Laboratory. An applicant is responsible for the selection of a research problem of his own interest related to one of the research areas, for the formulation of the research plan, and for obtaining the approval of one of the scientific advisers listed.

An applicant whose research interests appear to be related to the opportunities described herein should communicate directly with the research adviser who is designated for his field of interest. Within fields of activity, the areas described are illustrative only; inquiry is invited in any related research area.

Correspondence regarding additional information concerning an applicant's plan of research should be addressed to the appropriate adviser at the Naval Research Laboratory, Washington, D.C. 20390. It should be noted that opportunities exist in many cases for an Associate to work in interdisciplinary areas by association with more than one project.

A plan of research which the applicant proposes to conduct must be approved by an adviser. Approval by the adviser of a proposed research problem or of a modified problem must be received by the Associateship

Office before the application can be considered by the evaluation panels. Approval by an adviser does not guarantee panel recommendation for appointment.

Qualifications of Applicants

Resident Research Associateships at NRL are open only to citizens of the United States.

Applicants must produce evidence of training represented by the Ph.D., Sc.D., or other research doctoral degree, and must have completed the requirements for one of these degrees at the time of entering upon the Associateship. Applicants should have demonstrated superior ability for creative research. An applicant's training and research experience may be in any discipline, or combination of disciplines, which prepares him to undertake a significant research problem in the fields of interest of the Naval Research Laboratory.

These Associateships are intended for persons with less than 5 years postdoctoral experience. Since a major objective of the program is to provide opportunity for research in association with experienced scientists and engineers as a climax to formal career preparation, persons who have previously held comparable postdoctoral appointments will have a lower priority than those for whom it would be the first such experience. *(Scientists and engineers of demonstrated accomplishment with more than 5 years postdoctoral experience should apply for an* ***NRC Senior Resident Research Associateship*** *in one of those Federal research laboratories which support such programs.)*

Qualified applicants will receive consideration without regard to race, creed, color, sex, or national origin.

Conditions of Appointment

Appointments are made initially for one year. Extension of an Associateship for a period up to one additional year may be granted in certain cases when, after six months of tenure, an extension would appear to benefit both the Associate and the Laboratory. No commitment on the part of either the Associate or the Naval Research Laboratory with regard to later employment is implied by the acceptance of an award.

Appointments, subject to proper security clearance, will be made about March 1. The one-year tenure may begin at the mutual convenience of the Associate, the Naval Research Laboratory, and the National Research Council after July 1, 1971.

Associates will receive a stipend for self-support at the annual rate of $13,000 with provision for a vacation period. Stipends are subject to Federal and State income tax. Job-related death or injury will be

covered by insurance (Workmen's Compensation). Costs of relocation and transportation of household effects will be paid. A limited amount of professional travel during tenure will be available when this has been approved in advance by the Associate's adviser and the NRC.

It is expected that an Associate will devote his full-time effort entirely to advanced training and research. No additional monetary aid may be accepted from another appointment, fellowship, scholarship, or similar grant during the period of the Associateship.

These Resident Research Associateships are tenable only at the Naval Research Laboratory, Washington, D.C. 20390. The NRL will provide the necessary support services, supervision, facilities, and equipment for the approved program of the Associate.

Publication in the open scientific literature of research results obtained during the period of the Associateship is strongly encouraged. Publications should include a statement indicating that the research was conducted while the author held an NRC-NRL Resident Research Associateship.

Application Procedure

Detailed information on application procedures, all necessary forms, and a list of the supporting documents required are available from the Association Office (JH 604), National Research Council, 2101 Constitution Avenue, Washington, D.C. 20418.

The Associateship Office of the National Research Council will receive all applications and supporting documents. Applications must be postmarked *not later than January 8, 1971.*

OPPORTUNITIES FOR RESEARCH

Acoustics

Acoustic Radiation Theory

S. HANISH 64.15.04.01

Theoretical studies are now in progress in the acoustic radiation and scattering of sound generators of arbitrary size, shape, and number located in partially bounded enclosures in an otherwise infinite medium. Mathematical investigations of surface impedance, interaction impedance, and near field and far field distributions of pressure are known to lead to infinite sets of simultaneous equations or to corresponding linear or non-linear integral equations of various types. New methods are required for numerical computation of infinite determinants and integral equations. Auxiliary topics in this research include study and numerical evaluation of parabolic waves and spheroidal waves. Excellent computing facilities are available to permit rapid checking of results.

Signal Processing

W. J. FINNEY 64.15.04.02

A study is under way of the application of modern information theory and the application of high-speed digital computers to the detection or interpretation of signals in noise background. It includes a number of possible research areas, ranging from the mathematical development of advanced theories applicable to the problem to the simulation of systems in a well-equipped computer laboratory.

Acoustic Propagation in Ducts

H. P. BUCKER 64.15.04.04

With the assumption of no horizontal variations, solutions can be written for wave propagation in a duct in terms of the well-known normal mode series. Current investigations are along several lines of inquiry: alternate forms of calculations for very large ducts; stochastic solutions for cases where the boundary conditions are defined as statistical functions; and solutions valid when there are horizontal changes in the duct.

Besides the excellent computer facilities, a fixed platform in shallow water and shipboard facilities are available for these studies.

Interaction of Sound and Matter

C. M. DAVIS 64.15.04.05

Theoretical and experimental studies are now in progress to determine the physical properties of materials over a range of temperatures (0°C to 1000°C) and pressures (1 atm to 2000 atm) by means of the interactions of sound and matter. These measurements are presently performed at conventional ultrasonic frequencies (MHz range) but the measurements are being extended to higher frequencies (GHz range) by means of lasers. The materials investigated include liquids (molten metals and salts) and amorphous solids (through the glass transition temperature). The data obtained are of value both for engineering applications and for theoretical studies of the liquid and glassy states. A number of possible areas of investigation ranging from experimental to theoretical studies may be pursued. Appropriate instrumentation and equipment as well as computer and library facilities are available for these studies.

Acoustic Reflection from Bodies

W. G. NEUBAUER 64.15.04.06

Theoretical and experimental studies of the interaction of acoustic waves with reflecting, diffracting, and scattering bodies are in progress. Solutions by means of harmonic series, creeping-wave series, and integral equations are of interest utilizing idealized or elastic boundary conditions. Extensive computer facilities for these studies are available. Suitable experiments related to such solutions are to be carried out. Instrumented acoustic tanks are available for experimental measurements under laboratory-controlled conditions. Schlieren visualization of acoustic waves at MHz frequencies permits direct observation of radiated field and acoustic field-body interactions.

Acoustic Scattering Theory

J. A. DESANTO 64.15.04.07

Research is carried out in the general areas of scattering and propagation of scalar waves. Problems under investigation are (1) scattering of scalar waves by both deterministic and random boundaries; (2) propagation in a medium with random inhomogeneities.

Underwater Electroacoustic Measurement Methods

A. Z. ROBINSON, JR. 64.15.04.08

An opportunity now exists to make significant contributions in the development of improved methods of making and interpreting underwater acoustic and electroacoustic measurements. A program is being formulated which will apply information theory, decision theory, and methods of statistical estimation to the underwater acoustic measurement problem. A problem exists on how to introduce and make maximum use of redundancy in basic measurements. Methods will be developed to predict the performance of

transducers at great depths in the ocean using measurements taken in small enclosures. A particular opportunity exists to study the effects of errors in basic measurements on the application of advanced transform techniques to space-time fields. Excellent facilities for acoustic measurements and for computer analyses exist at the Underwater Sound Reference Division in Orlando, Florida.

Chemistry

Surface Chemistry

W. A. ZISMAN 64.15.11.01

Research on monomolecular and polymolecular films at phase boundaries and their effects on the properties of matter are being conducted. Typical points of interest are the mechanisms of adsorption and desorption at the solid/gas, solid/liquid, and liquid/liquid interfaces; the chemical, mechanical, electrical, and optical properties of adsorbed films; the kinetics and thermodynamics of surface phenomena; the wetting and spreading of liquids on solids, fundamentals of adhesion; and the basic mechanisms in friction, wear, lubrication, foaming, emulsification, frictional electrification, and evaporation control by films. Recent work has also concerned the role of adsorbed water in adhesion, the relation of interfacial tension to solubility, capillary wave damping in relation to molecular structure of adsorbed molecules, and the use of C^{14}-labelled organic polar compounds to study metal surface properties.

Electrode Mechanisms

S. SCHULDINER 64.15.11.02

Fundamental studies of electrode mechanism include such topics as kinetics of electrode reactions, sorption phenomena, catalytic properties of electrode materials (effects of ad- and absorbed species on electronic and atomic structure), transport phenomena, and structure of the double layer. High purity closed electrochemical systems are used. Measurement techniques use very short pulse and other transient and steady-state methods, including application of automatice control, data acquisition, and computing system. Areas investigated are (1) mechanisms and kinetics of water, hydrogen, oxygen and organic electrochemical reactions; (2) effects of pre-treatment on catalytic properties of electrode materials; (3) transport of hydrogen isotopes through metals; (4) metal and alloy structure effects on electrode catalytic activity; (5) passive film formation; (6) fundamentals of fuel cell reactions.

Colloids

R. C. LITTLE 64.15.11.03

There is a continuing program on the thermodynamic, rheological and hydrodynamic properties of colloids in both aqueous and non-aqueous

environments. Topics of interest include dispersions of isodimensional colloids, linear polymeric association colloids and high molecular weight linear macromolecules. Specific research areas include the following items: micelle size and shape, micelle formation and stability, solubilization, the Toms phenomenon (drag reduction), and structural turbulence. Experimental techniques available include ultracentrifugation, fluorescence depolarization, gas chromatography, viscometry, light scattering, osmometry, and special pipe flow equipment. Viscoelastic properties are determined through use of the Weissenberg Rheogoniometer.

Gas Chromatography

H. W. CARHART M. E. UMSTEAD 64.15.11.04

Research is in progress on gas chromatography for definitive identification of molecular species. Areas of interest include new principles on which to base detectors, enhanced detector sensitivity, selective detectors, column technology, and techniques for concentrating and handling exceedingly dilute samples. The facilities available include a wide variety of instruments and accessories.

Combustion Dynamics

H. W. CARHART F. W. WILLIAMS 64.15.11.05

Research is being conducted to study the chemical dynamics, including energy transfers, occurring in cool flames and other luminous and nonluminous flame stages which occur in the earlier parts of the overall combustion process. A search is also being made for active species that may exist in "inverted" populations, thereby having potential laser action. The facilities available include a wide variety of computerized research gas chromatographs, various combustion reactors, emission, absorption, electron spin resonance and mass spectrometers.

Magnetic Resonance

W. B. MONIZ 64.15.11.06

NMR and EPR spectroscopy are employed in investigations of molecular structure, kinetics, and mechanisms. Of current interest are studies involving low-field NMR of H^1 and F^{19}, N^{14} NMR of organic compounds, coordination chemistry and ligand exchange, free radicals generated in polymer degradation, and spectral analysis by transient nutations (Torrey oscillations). Equipment includes a Varian HA-100 (with low frequency capabilities), EPR, and broadline NMR. Both NMRIT and LAOCOON III, with plotting, are available for spectral analysis.

Gas-Solid Interface

V. R. DEITZ 64.15.11.07

The research, in general, is concerned with the interaction of selected gases

with the solid, taking into account the composition and structure of the boundary surface. The solids under investigation include carbon, pristine glass fiber, and selected inorganic crystals. Ultra-high vacuum equipment is available to reach very low surface coverages and a mass spectrometer is incorporated into the apparatus for monitoring the gas phase. The pressure range that can be studied is 10^{3} to 10^{-9} torr. Special attention is given to the preparation of the sample and the exact specification of the initial and final states of the system under study.

Mass Spectroscopy

F. E. SAALFELD 64.15.11.08

Currently the mass spectral topics of interest include (1) high pressure mass spectrometry as a method of identifying and investigating the nature of reactive species produced in lasers or flames and in measuring the very fast reaction rates of gas phase ion-molecule reactions. These studies also include investigations of the mechanisms involved in the ionization processes of these reactions. (2) Mass spectral studies of "high energy" compounds such as polynitro organic compounds. Study of the fragmentation of these molecules may lend some insight into the initial kinetic steps undergone by these molecules in gas phase pyrolysis or detonation. (3) Development of new mass spectrometric techniques such as the capability for the detection, identification and study of the neutral fragments produced in electron impact reactions. The Mass Spectroscopy Section is equipped with the following mass spectrometers and their associated accessories: Atlas CH4, CEC 21-103c, CEC 21-620, CEC 21-611 and a Bendix 12-107 T-O-F. In addition, the Section has several gas chromatographs equipped with fraction collectors to aid in the purification of the materials being investigated. Computer facilities for handling the data are available.

Molecular Spectroscopy

A. B. HARVEY W. H. GREEN 64.15.11.09

The following are a few of the topics of interest: (1) barriers to internal rotation about single bonds and nonbonded interaction; (2) structure and spectra of small ring molecules; (3) Coriolis coupling and normal coordinate calculations; (4) structure of liquids and measurement of correlation times; and (5) the resonance Raman effect.

The Chemical Spectroscopy Section is equipped with a Beckman IR-12; a Perkin-Elmer 457; a single-beam, double-pass grating instrument utilizing the P-E Model 99 monochromator; a one-meter single-pass Czerny-Tuner monochromator; two Cary 81 Raman spectrophotometers, one with He-Ne laser excitation and the other with an argon-ion laser; and a far-infrared interferometer with cooled bolometric detector. In addition, the Section has a ten-meter multireflection gas cell and facilities for carrying out matrix isolation studies.

Chemical Lasers and Molecular Relaxation

W. H. GREEN A. B. HARVEY 64.15.11.10

The following topics are of interest: (1) development of new molecular lasers by pulsed electrical discharge, chemical pumping or reaction, and flash photolysis; (2) study of mechanisms and kinetics of existing lasers by spectroscopic techniques; (3) investigation of molecular energy transfer and relaxation processes using laser excitation and double resonance experiments. In addition to monochromators, rapid response detectors, fast electronics, etc., the Chemical Spectroscopy Section is equipped with laser tubes, optical benches, gratings, power supplies and other ancillary apparatus necessary for such studies. Also available are a flash photolysis apparatus, pulsed-discharge equipment, and various gas mixing lasers.

Inorganic Chemistry

D. L. VENEZKY 64.15.11.11

Reactions of inorganic substances in solution are being studied with emphasis on electron transfer, ligand displacement and replacement, and polymerization or aggregation. For the investigation of the kinetics and reaction mechanisms of fast and slow reactions, the instrumentation available includes: NMR, EPR, IR, Raman, and ultraviolet-visible spectrophotometers; light-scattering apparatus; and the necessary equipment for use of radiochemical techniques.

Surface and Solid Kinetics

H. A. RESING 64.15.11.12

Pulsed nuclear magnetic resonance techniques and radio tracers are used to study molecular and atomic motions. Primary emphasis is on diffusion and rotation of molecules adsorbed on solid surfaces (charcoal, glass, zeolites, surfaces of biological origin) with special emphasis on adsorbed water. Diffusion and rotation in molecular and ionic crystals and in liquids are also under study. Facilities available include: high-power spin echo apparatus (used for conventional and "rotating frame" relaxation studies, field gradient diffusion studies, etc.) with crystal control and coherent operation; temperature control from 4.2 to 600°K; boxcar integrator for signal to noise improvement; and facilities for application of high pressure.

Polymer and Photochemistry

R. B. FOX 64.15.11.13

The photophysical processes and their relationship to the mechanisms of ultraviolet radiation-induced changes in prototype polymers and model compounds are under investigation. Present emphasis is on intramolecular electronic energy transfer in polymer chains, analogous to exciton transfer in crystals. Structures and reactions of electronically excited states in poly-

meric molecules are under study by means of flash photolysis and laser techniques.

Organic Lasers

R. B. Fox H. S. Pilloff 64.15.11.14

The influence of physical and chemical processes on stimulated emission in the ultraviolet and visible spectral regions by liquid and solid organic materials is under investigation. Detailed kinetic studies are emphasized. Examples of problems under consideration include excited-state spectroscopy, intra- and intermolecular energy transfer, solute-solvent interactions, and the role of excimer formation in both small molecules and polymers in lasing systems.

Chemical Dynamics

H. S. Pilloff 64.15.11.15

Present interests include experimental studies of the energy distribution in the products of simple gas phase chemical reactions as a function of both mass and reaction exothermicity, the effect of internal energy in the reactants on the reaction dynamics, and the dynamics of both photo-dissociation and photo-sensitization processes.

Gas Phase Oxidation

J. E. Johnson 64.15.11.16

Research in this area is directed towards developing a theoretical understanding of the factors and principles involved in the formation of chemi-ions and other energetic species during oxidation of hydrocarbon vapors at intermediate and low temperatures. For example, microwave irradiation of oxygen-hydrocarbon vapor mixtures, or of the oxygen before mixing, leads to oxidation at room temperature with the formation of chemi-ions. In addition, vapor-phase chemi-ions have been produced during the platinum-catalyzed oxidation of hydrocarbon vapors. The facilities available include a microwave generator, computerized research gas chromatographs, emission, adsorption, electron spin resonance and mass spectrometers.

Polymer Synthesis

J. R. Griffith 64.15.11.17

Research concerns the relationships between polymer molecular structure and material properties. Areas of interest include monomer syntheses; the effects of monomer structure and composition upon reaction rates; fluorinated condensation polymers of the epoxy and polyurethane types; studies of non-linear polymers including efforts to achieve three-dimensional, stereo-controlled polymerizations; and practical applications of new, thermosetting polymers as coatings, adhesives, filament-winding matrices, etc.

High-Temperature Electrochemistry

K. H. STERN 64.15.11.18

Fundamental studies of the interactions of materials involved in high-temperature electrochemistry—molten salts, metals, glasses, and ceramics—are carried out. These include thermodynamics and transport processes of molten salts, decomposition processes of salts, conduction mechanisms in glasses and ceramics, and membrane potentials at glass-molten salt, and ceramic molten salt interfaces. Charge transport at the metal-molten salt interface, and the behavior of metal oxides in molten salts are also major areas of study.

Corrosion Chemistry

R. L. JONES 64.15.11.19

Fundamental aspects of corrosion are being studied with emphasis presently on the high-temperature aqueous corrosion of metals. Current areas of interest include high-temperature electrochemistry, corrosion product film growth mechanisms, and high-temperature stress corrosion cracking. Specific investigations are being conducted concerning the influence of inhibitors and impurity ions in aqueous corrosion, the role of hydrogen in corrosion reactions, and the formation of passive iron oxide films circa 300°C. Principal means of research involve potentiostatic electrochemical polarization techniques, electron microscopy and diffraction, X-ray diffraction, and corrosion rate measurements by the hydrogen effusion method.

Mechanical Properties of Ceramics

R. W. RICE 64.15.11.20

An integrated program of studying the mechanisms of failure of refractory ceramics (e.g., MgO and Al_2O_3) and how to utilize such knowledge to further improve mechanical properties is under way. This is supported by work on fabrication of bodies and preparation of starting powders with low cation as well as anion impurity contents. Work on single crystals (e.g., ZrO_2) and surface preparation is also under way. Facilities for hot pressing, press forging, as well as some cold working, will be available.

Electron and X-Ray Diffraction

J. KARLE 64.15.11.21

Experimental and theoretical research in the fundamental diffraction instruments are employed to study the structure of solid surfaces and of the vapors of atoms and molecules. X-ray diffraction is used for the study of crystals, with emphasis on the new techniques for the determination of the phases of the structure factors. A research program may be based on either the experimental or theoretical aspects of these subjects.

Crystal Structure Analysis
I. L. KARLE 64.15.11.22

The area of research concerns the determination of unknown molecular formulas as well as the crystal and molecular structure of alkaloids, steroids, antibiotics, photorearrangement products, polypeptides, etc., by X-ray diffraction. Direct methods for phase determination are used, eliminating the need to introduce heavy atoms or the need to assume the configuration of fragments of the molecule. Although emphasis in the past has been on materials of biochemical importance, the research program is open to include all other classes of crystalline materials. Automatic diffractometers are available for data collection and high-speed computers for data processing.

Computer and Information Sciences

Computer Language Studies
B. WALD 64.15.18.01

Research proposals are solicited from investigators qualified to contribute to the design of syntax acquisition systems and to develop languages and information structures for information retrieval.

Digital Systems Design
B. WALD 14.15.18.02

A continuing interest exists in the systematization of the design of digital systems to permit automation of the design process. Current activities are in partitioning test sequence generation and embedding of circuits, but other activities consonant with the interests in systematic design will also be concerned.

Operations Research
L. WEISS 64.15.18.03

Research in this area at NRL currently emphasizes applications to Operations Research of modern control theory, including optimization theory, estimation theory, decision theory, and game theory.

Electronics

Electron Physics and Electron Tubes
S. T. SMITH 64.15.25.01

Basic and applied research concerns studies of surfaces involving electron reflections and interference, low-energy electron diffraction, Auger spectroscopy, secondary emission, and thermionic emission. Interest also includes

electron-hole pair generation in semiconductors due to electron beams. The interaction of electron beams with electromagnetic traveling wave fields is being studied for generation of wide-bandwidth high power. There is a continuous interest in all types of new electron devices involving electron beams especially those devices concerned with generation of power at millimeter-waves.

Electromagnetic Wave Scattering from Rough Liquid Surfaces

J. W. WRIGHT 64.15.25.02

A theoretical and experimental study of the scattering of electromagnetic waves is in progress. Current emphasis is on the use of measurements of Doppler spectra in microwave scattering to derive properties of wind wave systems such as phase speeds, wave lifetime and boundary layer thicknesses. The directional spectra of wind waves are measured by a novel photometric technique. Results are applied to problems of radar oceanography and sea clutter.

Semiconductor Device Technology

J. E. DAVEY 64.15.25.03

The program consists of research on and development of semiconductor devices for a broad range of Navy needs from optical to microwave frequencies. The techniques involved and available are all those connected with the silicon and GaAs technology for IC applications. In addition, there are programs in basic and applied research on thin films and on ion-implantation methods and devices. These programs include a wide range of deposition equipment and analytical equipment for transport, optical and structural evaluation. There is also a program on IGFET devices which include a detailed examination of the basic phenomena involving generation of interface states and oxide charges in the insulators and the methods for control of these states; radiation resistance of these devices is a fundamental part of this program.

Microwave Component Theory

R. M. BROWN 64.15.25.04

The following topics are of current interest: (1) propagation properties in waveguide containing magnetized ferrite material; (2) passive components for microwave integrated circuits; (3) microwave optics applied to systems of lenses and reflectors; and (4) techniques for electronically-scanned arrays.

Remote Sensing of Land and Sea

N. W. GUINARD 64.15.25.05

The program consists of the theoretical studies and field measurement programs required to define land and sea surface characteristics from their

optical and radar scattering signatures. Field experiments are conducted using a specially instrumented EC-121 aircraft which contains the Four-Frequency Radar System, aerial cameras, laser port and other peripheral equipments. Theoretical and processing efforts are conducted with the aid of specially configured digital computer, optical analysis laboratory, flying spot scanners, etc. Such topics as remote sensing of sea state, synthetic aperture radar mapping, interpretation of radar imagery, and studies of ocean wave spectra are typical topics in this program.

Generation of Electromagnetic Waves in a Magnetic Plasma

J. P. LEIPHART 64.15.25.06

Research is to be directed toward developing efficient means of transforming electrical energy from an oscillator into electromagnetic waves in a magnetoionic medium. Equations defining radiation efficiency and driving point impedance of the transducer immersed in a magnetoionic medium and operating well below the gyro frequency and plasma frequency are desired. Standard types of antennas (electric dipoles and loops) as well as unusual transducer configurations should be considered. The ultimate goal is design guidance of highly efficient VLF transducers that can be physically realized on spacecraft.

HF Radiowave Propagation

F. M. GAGER 64.15.25.07

The work would be concerned with better definition of propagation paths and better determination of path loss, variability, and instantaneous bandwidth. Data are available in the form of coherent pulse-doppler earth back scatter recordings. Facilities for amplitude-spectrum analysis and ray tracing are available.

Information from Electromagnetic Scattering

I. D. OLIN 64.15.25.08

The modulation (phase, amplitude, polarization) of an electromagnetic signal scattered from a radar target is characteristic of the object, its motion, and the background environment. This study should establish the theoretical limits on the information that can be extracted from the scattered signal. It should also determine the significant observables which, through appropriate pattern recognition techniques, serve to optimize target identification procedures.

Automatic Radar Detection

G. V. TRUNK 64.15.25.09

One of the most urgent needs in radar today is that of recognizing and automatically detecting targets in their natural environment of clutter and noise. When detecting targets in clutter, the problem is complicated by the

facts that the distribution of clutter may be Gaussian or non-Gaussian and that the time dependence of clutter is not known. Consequently, before the detection problem can be solved, an accurate statistical model of sea clutter needs to be formulated. A bank of experimental data is available from which to base the statistical model. It is desired that a detector could be found that would work well in a variety of environments and also could be implemented rather easily.

Radar and Radio Frequency Propagation and Ionospheric Studies

J. B. MEAD 64.15.25.10

Investigations of RF propagation and ionospheric parameters are currently being carried out in the UHF and VHF bands. Experiments are performed using a fully-steerable 150-foot antenna system and high-powered transmitter located at a field site near Washington. Thompson scatter techniques are used to determine electron density profiles and electron and ion temperatures in the E- and F-region, and to determine plasma drift vectors. A study of F-region irregularities and their motions is being performed. Of considerable interest is an adequate theoretical understanding of the RF scattering behavior of field-aligned ionization and measurements of these effects at VHF and UHF.

Signal Waveform Design

M. I. SKOLNIK S. F. GEORGE 64.15.25.11

Two areas of interest are (1) optimization of radar waveform for the extraction of echoes from specific targets embedded in undesired signals, such as clutter, and (2) the design of modulated or coded waveforms useful for pulse-compression radars and having desirable ambiguity diagrams. Research in these areas may be theoretical, experimental, or both.

Microwave Lens Array Antennas

G. P. OHMAN 64.15.25.12

A basic understanding is needed in the synthesis and design of feeds for microwave lens arrays, such as the Luneberg, to minimize sidelobe levels for improved decoupling between adjacent and near neighbor feeds. Beam shape and polarization control are important characteristics and therefore should be considered as important constraints as well as broadband (octive) operation. Either theoretical or experimental approaches may be considered.

Ionospheric Propagation

M. J. SHEETS 64.15.25.13

The objective of this work is better understanding of ionospheric effects for improved propagation predictions. Studies may include realtime modeling with emphasis on non-horizontally stratified models. Primary data are available through pulse and chirp sounders systems which include large aperture HF antennas and automatic data collection and processing equipment.

Theory of Functions
B. LEPSON 64.15.32.01

Properties of entire and meromorphic functions, such as rate of growth and distribution of values, are currently under investigation. This includes, in particular, the class of entire functions of bounded index. Research also is being conducted concerning both theoretical and applied aspects of elliptic functions and the higher transcendental functions, such as the Legendre and Bessel functions.

Numerical Analysis and Computational Mathematics
B. LEPSON 64.15.32.02

Both applied and theoretical aspects of numerical analysis are presently being studied. Topics of special interest include approximation theory, new and more efficient solution of systems of simultaneous linear algebraic equations, inversion of matrices and their eigenvalues and eigenvectors, and the numerical solution of differential equations. The field of computational mathematics includes other topics which are of particular interest in the application of automatic computers to scientific problems, such topics as Monte Carlo methods and combinatorial problems.

Mathematical Analysis
F. GROSS 64.15.32.03

Research is being conducted in the following areas: (1) distribution of values of meromorphic functions, including problems on rate of growth, deficient values, extensions of Nevanlinna theory; (2) functional equations of one variable, particularly those that can be studied by the methods of complex variable theory; (3) factorization of meromorphic functions, including the study of primes, pseudo primes and unique factorization; and (4) properties of meromorphic periodic functions as well as asymptotic periodic functions.

Ordinary Differential Equations
L. WEISS 64.15.32.04

Research at NRL in this subject is currently being pursued mainly in the areas of control and stability theory. The properties of controllability, observability, and "finite-time" stability are being investigated for various types of models, including differential-delay equations and difference equations.

Structural Mechanics and Failure

R. O. BELSHEIM 64.15.39.01

Comprehensive facilities exist for studies of structural dynamics and strength of materials under a wide variety of conditions. Emphasis is placed on complete consideration of structural response problems, from measurement and interpretation of loading environment, through rational analysis, to failure in the usage sense. A search for the fundamental behavior in all of these aspects is included, as well as answers to more immediate hardware problems. Increased emphasis is being placed on induced motions of undersea structures, e.g., buoy mooring systems, ocean bottom search and recovery systems, etc. Studies are continuing on ship environment effects, i.e., shock and vibration, and on advanced methods of understanding and analyzing these.

Fundamental Studies in Hydromechanics

G. J. O'HARA 64.15.39.02

Current areas of inquiry include both theoretical and experimental research into ocean-oriented fluid dynamics problems. The static and dynamic configurations of various cable systems under differing conditions of hydrodynamic loading are presently under investigation, together with the search for improved calculatory methods—particularly in the application of finite element techniques to unsolved fluid dynamics problems of interest. Experimental facilities are available for the investigation of the flow characteristics of cable and structural segments under both laminar and turbulent conditions. The experimental work is particulary concerned at present with the effects of current induced fluid-solid interactions, with emphasis on both the fluid forces acting on bodies of arbitrary cross-section and the changes induced in the wake flow.

Failure Behavior and Fracture Mechanics of Composites and Plastics

I. WOLOCK 64.15.39.03

Studies are being conducted to determine the mechanisms of failure in composite materials and in polymers, and to apply fracture mechanics to describe the failure behavior of these materials. In the case of composite materials such as fiber-reinforced plastics, the main problems are associated with the orthotropic nature of these materials and their complex failure modes. In the case of plastics, the main problems are associated with their strain-rate sensitivity. These problems are being approached from a theoretical viewpoint as well as in an experimental program utilizing computer-controlled testing systems.

Optical Stress Analysis
R. J. SANFORD 64.15.39.04

The development of new optical techniques of broad applicability for stress measurement is being emphasized. Current studies include basic research on the applications of interference holography in experimental stress analysis and the development of new techniques in scattered-light photoelasticity. The application of these methods to fracture mechanics, residual stress analysis, and non-linear continuum mechanics is of special interest.

Hypervelocity Ballistics and Impact Phenomena
W. W. ATKINS 64.15.39.05

The study of materials subject to rapid deformation necessarily includes elasticity theory, heat flow, wave and shock propagation, thermal stress fields, residual stress analysis, and high speed impact, strain-rate, and penetration phenomena across the hypervelocity range. A close correspondence between theoretical and experimental programs provides mutual correlation and stimulation.

Fracture Mechanics
J. M. KRAFFT 64.15.39.06

The fracture mechanics approach to an understanding of rupture, as a problem in the linear elastic mechanics of a continuum having defects, has benefited greatly by close correlation of theory, experiment, and application. Need is now clear for related investigations of plastic flow, strain rate, and finite deformation aspects. Extension from homogeneous to composite continua poses many new problems, experimental as well as theoretical. Equally formidable are the problems to be surmounted in linking strain-hardening rate-spectrum of the fracture strength to the dynamics of dislocation-lattice interactions.

Metallurgy

Alloy and Composite Material Stability
R. A. MEUSSNER 64.15.46.01

The utility of high temperature materials, conventional alloys and composite materials is directly related to the durability of their structures. The aim of this program is to develop basic information on the interacting processes determining this durability. Appropriate studies include: oxidation mechanisms and reaction kinetics, mass transport processes and defect structures, interface processes, and related equilibrium and thermodynamic measurements.

Electrochemistry of Marine Corrosion

B. F. BROWN M. H. PETERSON 64.15.46.02

As new deep-sea research vehicles are built and oceanographic programs become more ambitious and more sophisticated, alloys will be required whose compatibility with the marine environment will be unknown or at best poorly known. Fundamental studies of localized forms of corrosion (stress-corrosion cracking, differential aeration corrosion, and pitting) are needed in seawater in order to design rapid methods for satisfactorily characterizing the response of new materials to seawater, and also to design mitigative measures such as cathodic protection. Fundamental studies of reactions with seawater must incorporate many compromises and approximations, but compensating for these features is the pioneering nature of the work in a growing field. Research facilities with natural seawater are available at Key West, Florida.

Electron Theory of Metals and Alloys

A. I. SCHINDLER 64.15.46.03

The program consists of experimental and theoretical investigations of the electronic structure and the nature of electron-electron interactions in pure metals and alloys. Studies of strongly paramagnetic and ferromagnetic metals, transition metals, and intermetallic compounds are being emphasized. Facilities for producing alloys and single crystal specimens are available. Topics of current interest include Hall effect, magnetoresistance, electrical and thermal conductivity, electronic heat capacity, magnetoacoustic effect and thermoelectric power.

Kinetics and Morphology of Crystal Growth

R. J. SCHAEFER M. E. GLICKSMAN 64.15.46.04

This program is concerned with the nucleation and growth of metal crystals, with emphasis on study of the development of crystal morphologies. A holographic interferometry system is being developed, to make measurements of local growth rates on crystal surfaces. Studies are directed toward an understanding of the basic phenomena which control the development of crystal morphologies. These phenomena include heat and solute diffusion, surface energy, crystal perfection and interface reaction kinetics.

Thermodynamics and Kinetics of Phase Transformations

M. E. GLICKSMAN 64.15.46.05

A fundamental program is being developed in which a wide range of solid-state metallic phase transitions is investigated experimentally and theoretically. For example, classes of transformations characterized as diffusional, massive, and martensitic are of interest. The crystallography, interfacial reactions, and overall reaction kinetics of these transformations are studied with such modern techniques as electron microscopy, pulse heating, X-ray and electron diffraction.

Thin Ferromagnetic Films

G. C. Bailey 64.15.46.06

Basic studies of thin films are being carried out using a variety of techniques including spin-wave resonance at X-band and K-band, torque magnetometry, electron microscopy, and electrical resistivity. Present work includes a study of defects produced by various irradiation and annealing methods in thin-films of the iron-nickel system and the effects of these defects on the magnetic parameters of the films. In addition, the fundamental spin-wave relaxation mechanisms are being studied in the alloy films as well as in films of pure iron and pure nickel. Available facilities include spectrometers, magnetometers, vacuum systems, and an electron microscope.

Interaction of Mechanical-Metallurgical Factors in Elastic-Plastic Fracture

F. J. Loss 64.15.46.07

The formulation of macroscopic critical flaw size—stress level relationships based on local mechanisms of ductile fracture poses a major challenge in continuum mechanics and metallurgy. An initial phase of the problem requires the analytical determination of the elastic-plastic stress and strain state at crack tips. Finite element, numerical stress-analysis techniques incorporating general strain hardening behavior have provided an increasingly accurate picture of the stress-strain state at fracture. These achievements permit follow-on consideration of the local separation processes which are meaningful within the context of classical continuum mechanics. The studies entail detailed experimental study on a microscopic scale of the sequence of events leading to ductile failure by nucleation, growth, and coalescence of voids. These mechanisms are initially studied by investigations of simple metal systems in which the state of microstructural aggregation is well understood. The experimental observations can then form the bases of mathematical models incorporating a wide variety of other pertinent microstructural features. These models should be integrated with the continuum mechanics definition of the local stress-strain state to formulate rational fracture criteria. The general validity of such criteria will be established through a broad experimental research program incorporating a spectrum of specimen geometries of controlled mechanical constraint features.

Neutron Radiation Damage of Metal

L. E. Steele F. A. Smidt, Jr. 64.15.46.08

Studies are conducted of the defect aggregates formed during neutron irradiation and the influence of these aggregates on the flow and fracture properties of metals. Of particular interest are the areas of impurity atom-defect interactions, correlation between the yield stress and defect size, density and type; damage recovery kinetics, and the influence of radiation damage on slip lines and channeling. Techniques include a variety of physical and mechanical measurements correlated with observations by transmission electron microscopy.

Nuclear Interactions by Sector-Focusing Cyclotron

R. O. Bondelid R. B. Theus
L. A. Beach 64.15.53.01

The NRL variable energy sector-focusing cyclotron accelerates protons up to 70 MeV and other particles to corresponding energies. A nine-foot radius of curvature analyzing magnet with a resolution capability of 1 part in 5000 switches the beam through 135° into either of two experimental areas. Special scattering chambers are available for particle and gamma-ray spectroscopy, and solid state detectors with modern auxiliary equipment are provided as inputs to an automated data acquisition system (EMR 6050 Computer). Some of the experiments underway are (1) studies of applicability of J-dependence in (α,p) reactions as a spectroscopic tool; (2) investigation of collective states in odd-A highly deformed nuclei by (α,xn) and (^{3}He,xn) reactions; (3) shell model studies using the (^{3}He,n) reaction and time-of-flight techniques; (4) investigation of multiparticle breakup reactions in which three bodies are in the final state; (5) measurement of particle-neutron correlation in reactions such as (p,pn); (6) study of analog and "configuration" states through (^{3}He,p) and (α,d) reactions; and (7) polarization measurements in nuclear scattering and reactions.

Interaction of Positive Ions with Matter

K. L. Dunning P. R. Malmberg
A. R. Knudson E. A. Wolicki
J. W. Butler 64.15.53.02

Experimental investigations are carried out in connection with the implantation of ions in solids, radiation damage caused by high speed ions, channeling of ions in crystals, and utilization of atomic and nuclear radiations induced by positive ion bombardment to obtain information on the structure and composition of solids. Research apparatus includes a 5.5-MV positive-ion accelerator, a magnetic beam analyzer, a 2-meter electrostatic beam analyzer, a double-focusing magnetic reaction-particle spectrometer, a low-energy ion implantation system, a data gathering and process control system based on an SEL 840A digital computer, modern scattering chambers and detection systems.

Theoretical Nuclear Physics

J. B. Aviles M. Rosen 64.15.53.03

A broad program has been designed toward improving models of nuclear structure and in understanding how the various models arise out of the fundamental nuclear Hamiltonian. The problem of obtaining structure knowledge from reaction experiments is also under study. An area of special interest is the analysis of the scattering of high energy protons and electrons from deformed nuclei.

Photo- and Electronuclear Reactions and Neutron Capture Studies

T. GODLOVE L. FAGG 64.15.53.04
K. MURRAY A. STOLOVY

A 60-MeV electron linear accelerator is employed to conduct research programs in photonuclear, electronuclear, and neutron-nuclear physics. Six target stations allow production of secondary beams of bremsstrahlung, positrons, and neutrons, as well as the energy-analyzed primary electrons. Research programs include: high resolution nuclear excitation by inelastic electron scattering; Ge(Li) detector studies of decay gamma rays from residual states excited through photonuclear reactions; studies of the slow neutron capture mechanism by means of the observation of gamma rays from neutron capture resonances; and measurements of neutron capture spin states by means of gamma-ray coincidence measurements.

Rigorous Methods in Quantum Scattering Theory

A. W. SAENZ W. W. ZACHARY 64.15.53.05

A broad program of research in nonrelativistic scattering processes and axiomatic relativistic quantum field theory has been initiated employing modern functional analysis techniques.

Reaction Mechanisms and Nuclear Structure Studies

R. H. BASSEL G. H. HERLING 64.15.53.06
I. MANNING

A program of research is under way to identify the reaction mechanisms operating in a variety of nuclear reactions initiated by projectiles at various energies. This project is in collaboration with an experimental group. Nuclear shell model studies are also being carried out, including the investigation of nuclear structure in the Pb region.

Oceanography

Algal Physiology

P. J. HANNAN J. M. LEONARD 64.15.60.01

Experimental work is conducted on the metabolic processes of phytoplankton. The research is both basic and applied; equipment is available for diverse laboratory investigations. Empasis is placed on gas exchange measurements as criteria of growth for both fresh-water and marine algae; fluorescence measurements are used in numerous applications, particularly with those studies on effects of pollutants on algal growth rates.

Biochemical Ecology

D. F. WILSON J. M. LEONARD 64.15.60.02

Laboratory and field studies are performed on the distribution of marine

phyto- and zooplankton and certain aspects of their roles in the overall economy of the sea. The work includes organic analysis of seawater with special attention to the production, distributions and compositions of small particulars; there is special stress upon the roles of the latter in forming unique (e.g., sound-scattering) strata in the ocean.

Marine Biopolymers

G. I. LOEB 64.15.60.03

Research is carried out on the biopolymers of interest in the marine environment. Their interaction with surfaces is being approached via spectral studies, in addition to more classical surface chemistry techniques, which should lead to better understanding of biodeterioration and fouling. More conventional studies of marine biopolymers are approached with the usual tools of polymer physical chemistry.

Dissolved Gases in Seawater

J. W. SWINNERTON C. H. CHEEK 64.15.60.04

The concentrations of O_2, N_2, Ar, CO, and light hydrocarbons in seawater are measured by gas chromatography. The degree of saturation with respect to the atmospheric partial pressure of each gas is determined. Variations of dissolved-gas concentrations with location, depth and time are correlated with oceanic biological processes, environmental pollution, chemical oxidation-reduction properties of seawater, and the movement of water masses. Particular emphasis is placed on the development and use of analytical methods which are suitable for shipboard and/or *in situ* operation.

Physical Chemistry of Seawater

T. B. WARNER C. H. CHEEK 64.15.60.05

Electroanalytical methods and pressure vessels are utilized to determine the effects of temperature, pressure, reactant concentrations, and salinity on chemical equilibria in seawater. Ion pairing, solubility, and rates of precipitation and dissolution of inorganic salts are studied over the temperature and pressure ranges found in the oceans. The results are utilized to account for observed chemical distributions and to predict chemical behavior in seawater. The relationships between chemical equilibria and the bulk physical properties of seawater are studied.

Marine Geochemistry

P. E. WILKNISS 64.15.60.06

The distribution of trace elements in seawater is investigated by activation analysis and atomic absorption spectrophotometry. The transport of iron, manganese, and fluorine is traced from estuaries and submarine volcanoes into the bulk ocean. Conversely, anomalies in trace element concentrations can be used to trace circulation patterns and locate submarine volcanoes.

The distribution of inorganic salts in the marine atmosphere is under study, with particular emphasis on large changes in halogen ratios. These changes in halogen ratios are being studied with regard to chemical microstructure of the sea surface, the mechanism of injection of sea salt into the atmosphere, contamination by continental dust, and chemical processes in the atmosphere.

Cloud Physics and Atmospheric Electricity

W. A. HOPPEL 64.15.60.07

Opportunities are available for theoretical and experimental studies of the microphysics of cloud formation, circulation in convective clouds, electrical structure of thunderstorms, and fair weather atmospheric electricity. These studies should supplement the existing program which has emphasized (1) aircraft measurements within clouds of such variables as liquid water content, drop size spectrum, humidity, temperature, and the modification of these variables by seeding; (2) the measurement and origin of cloud nuclei; and (3) the interrelation between atmospheric electric variables and meteorological variables.

Optics and Spectroscopy

Atmospheric Optics

H. SHENKER J. A. CURCIO 64.15.67.01

Opportunities are available for experimental and theoretical research in the field of the optical characterstics of the atmosphere. Of special interest are the absorption, scintillation, scattering, and polarization characteristics of the atmosphere as a function of wavelength, distance, and meteorological parameters, and the transmission of information through a turbulent atmosphere. A variety of light sources, spectroscopic equipment, and paths are available for this work.

Quantum Optics

P. BEY H. RABIN 64.15.67.02

A variety of research in the general area of quantum optics is in progress. Specific areas include harmonic generation, parametric upconversion, parametric oscillation, stimulated and spontaneous photon scattering processes, pico-second pulse studies, and coherence effects. Both theoretical as well as experimental programs are under way. Complete optical facilities including various laser sources, time resolved spectroscopic equipment, and high speed oscilloscopes are available for research in these and related areas of quantum optics.

Nonlinear Optics

R. A. ANDREWS J. N. BRADFORD 64.15.67.03
L. S. GOLDBERG H. RABIN

Studies in nonlinear optics are carried out both theoretically and experimentally. Current areas of particular interest include ultrashort pulse research and parametric frequency conversion processes. Facilities are available to generate single high intensity pulses in the picosecond range. These pulses are used in a variety of environments to study ultrashort nonlinear optical phenomena. Parametric oscillators are being investigated as sources of tunable infrared radiation. Studies of the physics of parametric interactions and new experimental techniques are being applied to these tunable lasers. Work is also under way to upconvert infrared images to the visible via parametric interactions in nonlinear crystals.

Light Scattering Phenomena

M. HASS 64.15.67.04

A research program is under way to study a variety of photon scattering phenomena. Of particular interest is the study of the generation and detection of infrared radiation via polariton processes. Raman scattering studies associated with lattice vibrations in crystals and glasses are also being carried out. The program includes complete facilities for extensive experimental investigations and supporting theoretical studies.

Molecular and Chemical Lasers

T. KAN 64.15.67.05

This research program has the general objective of investigating chemical systems that can be developed into true chemical lasers; that is, exothermic chemical reactions in which a substantial portion of the reaction energy goes into vibrational energy of one of the reaction products which then can lase directly. The chemical kinetics of a large number of reactions will be examined, with emphasis on those reactions with high exothermicity; low molecular weight reaction products (to enhance channeling of available energy into one particular vibrational mode); a reaction product molecule able to lase directly; a direct reaction preferably in one step to the excited lasing molecule; and reactants which are readily available or easily prepared. A parallel research effort will seek to design continuous or quasi-continuous chemical lasers using the more promising chemical systems whose kinetics are established.

X-Rays

L. S. BIRKS 64.15.67.06

X-ray spectrometers (single and double crystal) are available for the study of spectral distributions of various X-ray sources, diffraction from perfect and imperfect crystals, and chemical composition using characteristic

line fluorescence. Problems include relating X-ray spectra to atomic structure through bonding theory, measurement of X-ray and electron cross sections, theory and measurement of characteristic and continuum radiation on an absolute intensity scale.

Plasma Physics

Experimental Plasma Physics

D. DUECHS R. C. ELTON G. C. GOLDENBAUM 64.15.76.01

Facilities for the production of high temperature plasma range from small shock tubes to a two-megajoule energy storage facility and include theta-pinch devices as well as a high-power laser for plasma production. Present efforts are directed toward two distinct areas, the development of controlled thermonuclear fusion prototype devices through such schemes as a theta-pinch with rapidly tailored fields for extended confinement, and high-density, high-temperature laser-produced plasmas, as well as the study of collisonless shock wave propagation through magnetic fields and background plasma. The development and use of new plasma diagnostic techniques continues to be emphasized.

Plasma/Atomic Physics

D. DUECHS R. C. ELTON G. C. GOLDENBAUM 64.15.76.02

The precise diagnostics and spectroscopic analysis of plasmas seeded with test gases are interpreted to yield fundamental atomic and ionic collisional rate coefficients. Presently electron collisional excitation of non-dipole transitions and collisional ionization are studied, as is the broadening of spectral lines by plasma perturbers.

Computational Plasma Physics

R. A. SHANNY J. M. DAWSON K. HAIN J. BORIS 64.15.76.03

Large-scale simulation of plasma phenomena is performed using many body models as well as fluid descriptions. Numerical models for the simulation of hurricanes and other weather phenomena are being pursued, and numerical models for the description of atomic processes.

Theoretical Plasma Physics

R. A. SHANNY J. M. DAWSON R. SUDAN K. PAPADOUPULOS 64.15.76.04

A theoretical effort of considerable size is devoted to fundamental research on collisionless shocks, turbulence and other nonlinear phenomena in

plasmas. The work is pursued through analysis and computer simulation techniques.

Electromagnetic Interaction Phenomena

E. F. KULIKOWSKI 64.15.76.05

A program is directed to the fundamental study and application of space plasma physics, particularly as related to nonlinear phenomena and coupling of an electromagnetic field to a magneto-ionic medium or plasma medium accompanying the operation of satellites and space probes; study the characteristics of intense laser beams and their interaction with matter in bulk. The program offers an opportunity for both theoretical and experimental studies. Field facilities for the latter are available.

Plasma Dynamics

W. W. BALWANZ 64.15.76.06

The dynamics of rocket exhaust, reentry and space plasmas and their interaction with the space environment are studied under a variety of simulated and operational conditions. The chemical, mechanical, and electrical properties are investigated with a range of diagnostic tools including photographic, spectrographic, and electromagnetic instrumentation. Studies are conducted in both simulated and operational environments. One goal is the development of empirical and theoretical models for use in predicting operational effect.

Solid State

Superconductivity

R. A. HEIN 64.15.81.01

Several aspects of superconductivity are under experimental investigation. Current problems include studies of (1) the isotope effect in relation to one- and two-band models; (2) the effects of ordering on transition temperatures in β-tungsten alloys: (3) superconductivity in semiconductors and correlations between their superconducting and other properties; and (4) materials heretofore not shown to be superconducting, essentially an investigation of the speculation that all materials, at sufficiently low temperature, may undergo some magnetic transition. Most of this work requires temperatures below 1°K, and these are obtained exclusively by adiabatic demagnetization of paramagnetic salts. Three air-core water cooled solenoids furnish the necessary magnetic fields. All have working bores 4.25 inches in diameter; one produces up to 25,000 oersteds, and two produce up to 100,000 oersteds. Extensive measurements to temperatures less than 0.01°K are more or less routine.

High Pressure Physics

L. C. TOWLE 64.15.81.02

Research programs currently in progress include studies of galvanomagnetic effects at low temperatures and high pressures. An X-ray tetrahedral press is available for studies of polymorphic transitions, compressibilities, and chemical reactions at high pressures. Measurements of shear strength as a function of temperature and pressure and discussion of the results in terms of dislocation theory are being carried out.

Ferroelectricity

J. W. DAVISSON 64.15.81.03

An experimental program in ferroelectricity is being carried out with emphasis on domain structures, internal bias fields, and pyroelectricity. The effect of lattice imperfections as well as impurities on domain structure and motion is of current interest.

Theoretical Physics

S. TEITLER 64.15.81.04

Theoretical areas of interest include the infrared magnetic-optical properties of solids, magnetoplasma in solids, noise and transport in photoconductive solids.

Permanent and Transient Defect Centers in Glasses

D. L. GRISCOM 64.15.81.05

The formation and stabilization of defect centers in glassy materials is being studied by vacuum-UV, optical, time-resolved optical, and ESR techniques. Emphasis is currently on determining the electronic structure and production kinetics of fundamental radiation-induced defects in chemically pure oxide glasses, principally the borates and silicates. Other materials and the effects of impurities are also under investigation. Facilities are available for *in situ* irradiation by a variety of pulsed and steady state sources. Variable temperature cryostats permit ESR and optical measurements over a wide temperature range. ESR spectra obtained at X-band or Ka-band frequencies are analyzed by computer simulation methods.

Physics and Chemistry of Glasses

R. J. GINTHER M. N. KABLER 64.15.81.06

A broad program of glass investigation is under way. It includes experimental and theoretical studies of band-like properties in the vacuum ultraviolet, optical and EPR measurements of oxygen, iron, and rare earth ions and their interpretation in terms of glass structures, far infrared and Raman studies of vibrational spectra of glasses, investigations of the processes of radiation damage by high energy radiation, and photochromic effects in glasses.

Excitons and Color Centers

M. N. KABLER 64.15.81.07

The electronic properties of defects in wide-band-gap solids are under investigation. Also under study are the processes whereby point defects are created by ionizing radiation. The methods employed include steady-state and time-resolved optical spectroscopy in both absorption and emission, polarization measurements, magneto-optic effects, conductivity measurements, double resonance, and theory. Research facilities include a wide variety of high energy radiation sources, pulsed (nanosecond) electron and X-ray sources with associated time-resolved optical spectrometers, various Q-switched and cw lasers, high-field magnets, extensive optical and electronic instrumentation, cryogenic equipment, magnetic resonance spectrometers, and support activities in materials preparation, chemistry, composition, and other areas.

Optical Properties of Color Centers

I. SCHNEIDER 64.15.81.08

Studies of transient bleaching effects, energy transfer, migration, linear dichroism, and zero-phonon spectra of both intrinsic and impurity-associated color centers are being carried out. Research facilities in use include instrumentation for the measurement of steady-state and transient optical absorption and luminescence spectra, various Q-switched and cw lasers, and a wide range of sources of high energy radiation. Investigations have concentrated on trapped-electron centers, primarily F, F-aggregate, and related centers in alkali halides.

Solid State Theory

H. B. ROSENSTOCK A. R. RUFFA 64.15.81.09

Theoretical studies are pursued in several fields related to the experimental work described under "Excitons and Color Centers" and "Optical Properties of Color Centers." This includes work on imperfections in solids, ionic crystals, luminescence, energy transfer in ordered and disordered lattices, radiation damage, and lattice dynamics, particularly of ionic crystals. In addition, investigations of the spectra of glassy materials, atomic structure, and chemical bonding effects in various types of crystals are in progress.

Paramagnetic, Nuclear, and Mossbauer Resonance

J. J. KREBS M. RUBINSTEIN 64.15.81.10

Facilities are available for electron paramagnetic resonance studies in solids by ENDOR and conventional spin resonance techniques at temperature down to that of liquid helium. Of current interest are studies of exchange—coupled ionic pairs, transferred hyperfine interaction, and the effect of electric fields on paramagnetic ions. Facilities are also available

for nuclear magnetic resonance and Mossbauer studies of metals and insulators. Variable frequency spin-echo and cw NMR spectrometers are at hand to study hyperfine fields in magnetically ordered alloys and compounds. Conventional fixed-frequency NMR spectrometers are also available to investigate metallic alloys and paramagnetic crystals. Of current interest are NMR and Mossbauer studies of hyperfine fields in iron alloys and selected magnetic structures, investigations of the transferred hyperfine interactions, and studies of Knight shifts in exchange-enhanced alloy systems.

Ferromagnetism and Antiferromagnetism

G. T. RADO V. J. FOLEN 64.15.81.11

The research in progress includes various problems in ferromagnetic and antiferromagnetic resonance, magnetocrystalline anisotropy, magnetoelectric effects, and optical absorption. Crystals isomorphous with important magnetically ordered materials are being studied by paramagnetic resonance. The available facilities include electromagnets, microwave apparatus, and liquid helium.

Radiation Damage in Semiconductor Materials

B. J. FARADAY 64.15.81.12

Facilities are available for the investigation of transient and permanent effects of ionizing radiation on the electrical, optical, and magnetic properties of semiconductor materials. There is also in progress an extensive program of study on the radiation-induced damage on devices constituted of semiconductor materials.

Magneto-Optical Studies and Solids

E. D. PALIK D. L. MITCHELL 64.15.81.13
B. D. MCCOMBE R. KAPLAN

The high magnetic field facility at the Naval Research Laboratory is being used to study magneto-optical effects in semiconductors and other solids. These include cyclotron resonance, Faraday effect, Voigt effect, magnetoplasma effects, and interband magnetoabsorption. Steady magnetic fields up to 150 kilo-oersteds and pulsed magnetic fields up to 300 kilo-oersteds are currently available. Current instrumentation allows experiments to be conducted over a wide spectral range extending from the ultraviolet to the far infrared, with sample temperatures ranging from 1.2°K to 400°K. The experiments are used to determine the band structures of solids, the character of electronic impurity states, and the effects of electron-phonon coupling.

Disordered Semiconductors

D. L. MITCHELL S. G. BISHOP 64.15.81.14

This program is directed to the experimental study of the electronic states in disordered semiconductors including amorphous semiconductors, glassy semiconductors and random impurities in a crystal matrix. Instrumentation is available for a wide variety of optical, magneto-optical and magneto-transport experiments. Current research includes studies of magnetic freezeout, free carrier and interband, Faraday rotation, interband optical absorption and photoconductivity, and optical studies in the microwave and far infrared.

Ultrasonic Properties of Solids

B. D. MCCOMBE 64.15.81.15

A program for the study of ultrasonic properties of solids is in progress. Problems of interest are attenuation of elastic surface waves in both piezoelectric and non-piezoelectric solids. Available equipment includes pulsed generators and receivers covering the frequency range between 10 and 1000 MHz; magnetic fields provided by superconducting and Bitter type solenoids, and dewars to provide sample temperatures from 1.2°K to 300°K.

Crystal Chemistry

F. L. CARTER 64.15.81.16

Studies in solid state chemistry are carried out in both theoretical and experimental topics. The theoretical topics include valence bond treatments of crystalline solids, with special emphasis on the use of bidirectional orbitals as basis functions for atoms having high coordination numbers, and bond order calculations by use of Pauling's semiempirical metallic radii. The experimental work involves preparation, identification, and single crystal structure determination of rare earth compounds and complexes. The equipment available includes a completely automatic single crystal diffractometer, a vacuum glove box, and an electron microscope. Theoretical predictions are compared with observed bond distances and angles.

Electron Paramagnetic Resonance

F. W. PATTEN 64.15.81.17

Electron paramagnetic resonance of point defects in insulating materials is being investigated. These defects include atomic and molecular solutes and radiation damage products. Recents work has centered upon alkali and ammonium halide crystals. X-band and K-band spectrometers are available, the former having an additional ENDOR capability. Experiments are performed down to liquid helium temperature, and apparatus is available to make correlating optical measurements.

Electron Transport in Solids

J. BABISKIN 64.15.81.18

The galvanomagnetic properties of high mobility conductors are being studied at low temperatures in steady high magnetic fields up to 150,000 gauss as provided by the NRL high magnetic field facility. Normal magnetoresistive phenomena are being investigated in order to determine the nature and the anisotropy of the electron scattering mechanisms. Oscillatory magneto-resistive phenomena of the Shubnikov-deHaas type are being investigated on high mobility semiconductors with small band gaps over a wide range of carrier concentrations to determine their Fermi surfaces and energy band parameters.

Electronic Structure in Solids

P. J. LIN 64.15.81.19

Calculations of electronic energy levels and wave functions are made for semiconductors and metals using various techniques such as the pseudo-potential method, the k•p method, etc. The results are employed in the analysis of optical and transport experiments.

Radiation Damage in Dielectric Materials

R. F. WENZEL 64.15.81.20

Radiation damage studies are being carried out in several interesting classes of dielectrics. Laser materials and crystalline quartz are of particular interest. Facilities are available for low temperature optical work, electron paramagnetic resonance studies, pressure experiments involving optical techniques, infrared spectroscopy, and optical and thermal bleaching experiments. In addition, a complete range of radiation sources exists at the Laboratory.

Space Science

Rocket Astronomy

H. FRIEDMAN R. TOUSEY 64.15.89.01
T. A. CHUBB D. P. MCNUTT

Optical measurements are made from rockets and satellites of various extreme ultraviolet, infrared, and X-ray radiations that cannot be seen from the earth, and the white-light corona. Flight instrumentation has included vacuum ultraviolet, infrared, and X-ray photometers; double dispersion and profile spectrographs; ultraviolet and X-ray imaging devices; and X-ray spectrographs, spectroheliographs and coronagraphs. Objects of study have been the sun, solar flares, early type stars, galactic and extragalactic X-ray sources, nebulae, and interplanetary medium, and the radiations from the night airglow.

Radio Astronomy

C. H. MAYER J. P. HOLLINGER S. H. KNOWLES 64.15.89.02

A broad program in Radio Astronomy includes studies of molecular spectral lines, ionized hydrogen regions, supernova remnants, radio galaxies, quasars, pulsars, the galaxy, the planets, and the sun and moon. A precision 85-foot radiotelescope good to 8-mm wavelength and an 84-foot radiotelescope good to 10 cm wavelength are located at the Maryland Point Radio Astronomy Observatory are used independently and in conjunction with other instruments for very long base line interferometry.

Ultraviolet

R. TOUSEY S. G. TILFORD W. R. HUNTER 64.15.89.03

Three one-meter vacuum ultraviolet normal incidence monochromators and two three-meter grazing incidence monochromators are available. These instruments will be used to continue the systematic study of metallic reflectivities and other optical properties of materials in the wavelength range 2000 A to 100 A. A 21-foot normal incidence vacuum spectrograph, two small vacuum ultraviolet monochromators, an automatic data reduction system, and a three-meter grazing incidence vacuum spectrograph have been installed to conduct research on atomic and molecular spectra of astrophysical and atmospheric interest.

Physics of the High Atmosphere

R. R. MEIER P. MANGE 64.15.89.04

The behavior of atomic hydrogen, helium, oxygen, and molecular nitrogen in the earth's atmosphere and in interplanetary and galactic space is being studied through rocket and satellite observations of the spatial and temporal variability of their characteristic far- and extreme-ultraviolet radiations. Related and theoretical work involves studies of radiation transport in optically thick planetary atmospheres and development of atmospheric models, both neutral and ionic. Particular areas of research have been (1) the geocoronal and extraterrestrial hydrogen emission (and absorption) lines of Lyman-α, Lyman-β, and Balmer-α; (2) the solar Lyman-α emission; (3) geocoronal helium Lyman-α (584 A); (4) the atmospheric atomic oxygen triplet (1304 A); (5) molecular nitrogen Lyman-Birge-Hopfield bands (1350-1550 A); (6) the "polar wind;" (7) nighttime ionosphere; and (8) the neutral atmosphere.

Aeronomy

J. C. HOLMES C. Y. JOHNSON 64.15.89.05

An experimental program is conducted using rocket and satellite-borne instrumentation to study the ionic composition and structure of the

ionosphere, the day and night sources of energy responsible for the ionization, and the relationship of solar activity to disturbances in the ionosphere. The nature of the earth's outer atmosphere and the interplanetary medium is investigated by analysis of incoming solar and stellar ultraviolet radiation.

Cosmic Rays

M. M. SHAPIRO 64.15.89.06

Experimental and theoretical studies of the primary cosmic radiation—its composition, propagation, age, origin, and its various astrophysical interactions—are pursued by exposing detectors, such as nuclear emulsion stacks, at very high altitudes. Research in the microscopy laboratory is facilitated by semiautomatic apparatus developed at NRL. Exploratory research in gamma-ray astronomy is under way with counter techniques and spark chambers. In addition to observations from balloon platforms, experiments on the primary radiation are being conducted in satellites and space probes, e.g., on project Apollo and Skylab.

Orbital Mechanics

C. H. CHRISMAN 64.15.89.07

This is a program to study satellite orbital paths with particular attention to the perturbations caused by radiation pressure, solar magnetic storms and other related forces. Orbital data are available through periods of disturbances to satellite orbits to assist in the evaluation of possible models of the various phenomena.

INDEX TO POSTDOCTORAL RESEARCH AREAS

INDEX TO POSTDOCTORAL RESEARCH ADVISERS

NRC-NRL POSTDOCTORAL ASSOCIATES APPOINTED IN 1970

Name	University	Field
De CORPO, James J.	Rice University	Chemistry
LOEB, Marcia J.	University of Maryland	Biochemistry
MELTZER, David W.	University of Rochester	Physics
MONTGOMERY, G. Paul, Jr.	University of Illinois	Physics
NELSON, Leonard Y.	University of California (Berkeley)	Chemistry
NOONAN, James W.	University of Maryland	Mathematics
PHILLIPS, William L.	University of Maryland	Metallurgy
ZELANO, Anthony J.	Brown University	Chemistry

RECIPIENTS OF NRC-NRL POSTDOCTORAL AWARDS IN PAST YEARS

Name	University	Field
Anderson, Gordon W. (1967)	University of Illinois	Physics
Baier, Robert E. (1965)	State University of New York (Buffalo)	Chemistry
Bailey, C. Edward (1968)	Dartmouth College	Physics
Baker, Samuel I. (1967)	Illinois Institute of Technology	Physics
Barret, Alan H. (1956)	Columbia University	Physics
Behof, Anthony F., Jr. (1965)	Notre Dame University	Physics
Bishop, Stephen G. (1966)	Brown University	Physics
Bonbright, Daniel I. (1969)	University of Maryland	Physics
Bonham, Russell (1960)	Iowa State University	Chemistry
Burr, Alexander F. (1965)	Johns Hopkins University	Physics
Byrnes, James S. (1966)	Yeshiva University	Mathematics
Comas, James (1966)	University of Delaware	Physics

Name	University	Field
Cooper, Larry P. (1967)	Oregon State University	Physics
Cozzens, Robert F. (1966)	University of Virginia	Chemistry
Davis, Alvin H. (1957)	Yale University	Physics
Drachman, Richard J. (1958)	Columbia University	Physics
Dweck, Joel A. (1965)	Brown University	Physics
Ehrlich, Alexander C. (1966)	Carnegie Institute of Technology	Physics
Flinn, David R. (1968)	North Texas State University	Chemistry
Fratini, Albert V. (1965)	Yale University	Chemistry
Fujii, Charles T. (1958)	University of Hawaii	Chemistry
Fuller, Robert G. (1965)	University of Illinois	Physics
Garrison, Allen K. (1964)	Duke University	Physics
Giddings, Lorraine E., Jr. (1962)	Vanderbilt University	Chemistry
Gilardi, Richard D. (1966)	University of Maryland	Chemistry
Glicksman, Martin E. (1961)	Rensselaer Polytechnic Institute	Metallurgy
Gomez-Rodriguez, Manuel (1967)	Cornell University	Physics
Green, William H. (1967)	University of South Carolina	Chemistry
Griscom, David L. (1967)	Brown University	Physics
Haftel, Michael I. (1969)	University of Pittsburgh	Physics
Hansen, Robert J. (1968)	Massachusetts Institute of Technology	Chemistry
Hansen, Uwe J. (1966)	Brigham Young University	Physics
Harris, Isadore (1956)	Northwestern University	Physics
Hendrickson, Wayne A. (1969)	Johns Hopkins University	Biophysics
Howard, Russell A. (1969)	University of Maryland	Chemistry
Jarvis, Neldon L. (1957)	Kansas State University	Chemistry
Jeck, Richard K., Jr. (1968)	St. Louis University	Physics
Johnston, Kenneth J. (1969)	Georgetown University	Astronomy
Jones, Dallas (1964)	University of Virginia	Physics
Joseph, David W. (1961)	University of Chicago	Physics
Kane, Raymond J. (1969)	Georgetown University	Physics
Kellogg, Paul J. (1955)	Cornell University	Physics
Kershenstein, John C. (1968)	Georgetown University	Electronics
Kinzer, Robert L. (1967)	University of Oklahoma	Physics
Klein, Barry M. (1969)	New York University	Physics
Kleinberg, Robert (1964)	Michigan State University	Physics
Kolata, James (1968)	Michigan State University	Physics
Konnert, John H. (1967)	University of Minnesota	Chemistry
Krebs, James (1969)	St. Louis University	Physics
Kriz, Harry M. (1970)	Brown University	Physics
LaCourse, William C. (1969)	Rensselaer Polytechnic Institute	Physics
Levine, Leslie S. (1967)	Columbia University	Physics
Lucas, Robert A. (1965)	Lehigh University	Mechanical Engineering
MacInnes, William M. (1969)	Syracuse University	Metallurgy
Mancuso, Richard (1967)	State University of New York (Buffalo)	Physics
Masumura, Robert A. (1969)	University of California (Los Angeles)	Metallurgy

Name	University	Field
Matous, George M. (1964)	Notre Dame University	Physics
McCombe, Bruce D. (1965)	Brown University	Physics
Meyer, Edwin F. (1965)	Northwestern University	Chemistry
Moravek, Paul H. (1962)	Vanderbilt University	Physics
Mueller, George P. (1969)	Washington University	Physics
Palik, Edward D. (1958)	Ohio State University	Physics
Piersma, Bernard (1964)	University of Pennsylvania	Chemistry
Reilly, Michael H. (1966)	University of Rochester	Physics
Resing, Henry A. (1959)	University of Chicago	Chemistry
Rosen, Murray (1967)	University of Michigan	Chemistry
Schaefer, Robert J. (1964)	Harvard University	Metallurgy
Schneider, Irwin (1964)	University of Pennsylvania	Physics
Schoomer, Alva B. (1960)	California Institute of Technology	Chemistry
Share, Gerald H. (1966)	University of Rochester	Physics
Shepard, Roger N. (1955)	Yale University	Psychology
Silberberg, Rein (1960)	University of California (Berkeley)	Physics
Silverstein, Joseph D. (1964)	Columbia University	Physics
Sink, Charles W. (1968)	University of South Carolina	Chemistry
Skelton, Earl F. (1967)	Rensselaer Polytechnic Institute	Physics
Smith, Gary L. (1968)	University of California (Davis)	Physics
Takken, Edward H. (1967)	Ohio State University	Physics
Talham, Robert J. (1960)	Rensselaer Polytechnic Institute	Mathematics
Taylor, P. Craig (1969)	Brown University	Physics
Temkin, Aaron (1957)	Massachusetts Institute of Technology	Physics
Tilford, Shelby G. (1961)	Vanderbilt University	Chemistry
Tsao, Chen-Hsiang (1965)	University of Washington	Physics
Vander Lugt, Karel (1967)	Wayne State University	Physics
Verble, Joseph L. (1967)	Tulane University	Physics
Wagner, Robert J. (1967)	Northwestern University	Physics
Warner, Theodore B. (1963)	Indiana University	Chemistry
Webb, Alan W. (1967)	Brigham Young University	Chemistry
Whetsel, Kermit B. (1960)	University of Tennessee	Chemistry
White, Jack L. (1955)	University of California (Berkeley)	Metallurgy
Weiting, Terence J. (1969)	Cambridge University	Physics
Williams, Frederick W. (1965)	University of Alabama	Chemistry
Yoder, George R. (1969)	Syracuse University	Metallurgy
Young, Frank C. (1962)	University of Maryland	Physics