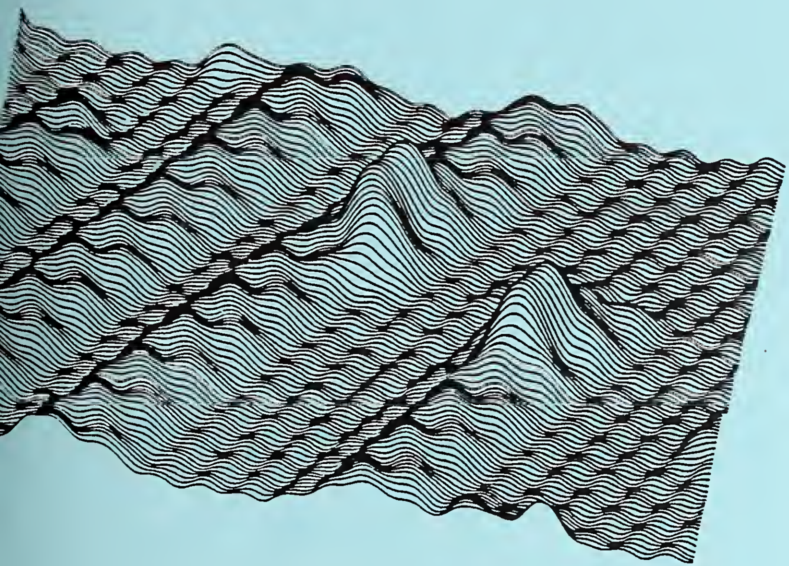
NISTIR 4553



# Technical Activities 1990 Electron and Optical Physics Division

**Charles W. Clark**
**Division Chief**

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards
and Technology
Physics Laboratory
Electron and Optical Physics Division
Gaithersburg, MD 20899



Prepared for
U.S. DEPARTMENT OF COMMERCE
National Institute of Standards
and Technology
Gaithersburg, MD 20899

U.S. DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary
NATIONAL INSTITUTE OF STANDARDS
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## FOREWORD

This report describes the activities of the Electron and Optical Physics Division during the period October 1, 1989 - December 31, 1990.

Inquiries regarding the Division's activities are always welcome. They may be directed to:

General information: Charles W. Clark, Chief
Electron and Optical Physics Division
B206 Metrology Building
National Institute of Standards and Technology
Gaithersburg, MD 20899
(301)975-3709
e-mail: clark@bruce.nist.gov

Far UV Physics: Robert P. Madden, Group Leader
A251 Physics Building
(301)975-3726
e-mail: maddenr@gnos.nist.gov

Electron Physics: Robert J. Celotta, Group Leader
B206 Metrology Building
(301)975-3710
e-mail: celotta@epg.nist.gov

Photon Physics: Thomas B. Lucatorto, Group Leader
A251 Physics Building
(301)975-3734
e-mail: toml@enh.nist.gov

The facsimile number for all members of the Division is (301)975-3038.

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**Cover illustration:** Scanning tunneling micrograph of Cs atoms adsorbed on the (110) surface of InSb. The characteristic zigzag Cs chains are often found to be terminated by the humps seen here, which contain a few extra atoms. Scale of figure: 14 nm x 7 nm. See L. J. Whitman, J. A. Stroscio, R. A. Dragoset, and R. J. Celotta, Phys. Rev. Lett. **66**, 1338 (1991)

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## FUNCTIONAL STATEMENT

ELECTRON AND OPTICAL PHYSICS DIVISION: Provides the central national basis for absolute measurements of far ultraviolet and soft x-ray radiation; conducts theoretical and experimental research with electron, laser, ultraviolet, and soft x-ray radiation for measurement applications in fields such as atomic and molecular physics, multiphoton processes, radiation chemistry, space and atmospheric science, microelectronics, electron spectroscopy, electron microscopy, surface magnetism, and condensed matter physics; determines the fundamental mechanisms by which electrons and photons transfer energy to gaseous and condensed matter; develops advanced electron- and photon-based techniques for the measurement of atomic and molecular properties of matter, for the determination of atomic and magnetic microstructure, and for the measurement and utilization of ultraviolet, soft x-ray, and electron radiation; develops and disseminates ultraviolet, soft x-ray and electron standards, measurement and calibration services, and data for industry, universities, and government; and develops and operates well-characterized sources of electrons and photons including the NIST synchrotron ultraviolet radiation facility (SURF-II), a scanning tunnelling microscopy facility, and scanning electron microscopes with spin polarization analysis.

## I. OVERVIEW

The Electron and Optical Physics Division is broadly chartered to advance the capabilities for absolute measurement of electron and photon interactions with matter, and to diffuse such capabilities into industry, academia, and other branches of Government. In pursuit of this mission, it maintains an array of research, measurement, and calibration activities.

The Division provides the central national basis for absolute radiometry in the far ultraviolet and soft x-ray regions of the electromagnetic spectrum, which together span the photon energy range of 5 to 250 eV. This basis is maintained through a combination of ionization chambers, calibrated transfer standard detectors, and an electron storage ring, the SURF-II Synchrotron Ultraviolet Radiation Facility, which provides a dedicated source of radiation over this spectral range. SURF-II is unique among synchrotron radiation sources in maintaining the electrons in a nearly perfect circular orbit, so that its absolute emission spectrum can be calculated with high accuracy. It is a long term goal of the Division to place SURF-II at the top of the measurement chain for absolute radiometry from the infrared through the soft x-ray spectral regions. In addition to supporting local measurement missions, which include the provision of calibrated photodiodes for transfer standards, SURF-II is utilized by a wide range of scientific users. Dedicated beamlines are in place to support basic research in surface science, high-resolution far ultraviolet spectroscopy of atoms and molecules, and soft x-ray reflectometry studies of advanced materials; another is being made available for general scientific use. One beamline is reserved for absolute calibration of spectrometers, primarily by NASA and its contractors. Virtually all U.S. space-borne XUV instruments of the past decade have been calibrated in this facility or have used SURF-II calibrated transfer standard detectors.

Since elementary photoabsorption processes in atoms, molecules, and condensed matter lie at the heart of radiation measurements and their applications in this spectral region, the Division undertakes research in basic photophysics. Experimental and theoretical work is performed in atomic spectroscopy, multiphoton processes, x-ray emission spectroscopy, and the generation of coherent radiation. Elucidation of the electronic structure of matter, which is necessary for a rational understanding of its interaction with radiation, is a major goal of this work, and is pursued for its own sake in cases of compelling interest. For instance, independent efforts in the basic theory and experimental spectroscopy of high-temperature superconductors are carried out in the Division, under the auspices of the NIST-wide Superconductivity Initiative. The application of optical physics to other scientific or measurement problems is also actively explored, often in collaboration with other NIST Divisions or industry; some examples of these collaborations are: participation in the laser cooling effort centered in the Atomic Physics Division, the development of ultrasensitive isotopic detection techniques in cooperation with Eastern Analytical, Inc., and work on optics for projection x-ray lithography with the Precision Engineering Division and AT&T Bell Laboratories.

The Division's work in electron physics is directed towards understanding electron interactions with and in matter at the most basic level, and the application of electron microscopic techniques to determine the structure and properties of materials. As in our work in optical physics, its success is based upon the possession of unique research facilities, which have for the most part been developed internally, and upon active collaboration with industry. Electron-atom interactions are studied in unprecedented detail by a polarized electron - polarized atom scattering apparatus, which enables all the collision parameters allowed by quantum mechanics to be determined in practice. Two major electron microscopy facilities are maintained. Scanning electron microscopy with polarization analysis (SEMPA), an outgrowth of the Division's basic research on polarized electron scattering, allows magnetic domain structure to be studied at spatial resolutions of a micron. This technique is of great interest to the magnetic storage industry, and has resulted in many collaborative studies of the microstructure of magnetic recording media. Scanning tunneling microscopy (STM), which was initiated in the Division two decades ago by the pioneering work of Russell Young, is used to study the electronic structure of surfaces, in particular the electronic states associated with adsorbed metal atoms. This work has made a dramatic advance in the past year by demonstrating the ability to manipulate chemisorbed atoms on semiconductor surfaces. The Division also supports basic theoretical research in the electronic structure of solids and surfaces, and advanced analytical and computational capabilities for electron optical design.

The Division is organized in three Groups: Far Ultraviolet Physics, Electron Physics, and Photon Physics. The several activities of these Groups are described below. Some highlights of work done in FY90 include:

- ***Si photodiode program receives IR-100 award.*** For the past several years Mr. L. Randall Canfield has been engaged in research on semiconductor photodiodes, to determine their suitability as transfer standards to replace our existing line of windowless far-ultraviolet photodiodes. The stability and accuracy of Si photodiodes has been found to be highly satisfactory, and they are not subject to the surface contamination problems that degrade the long-term performance of the windowless systems. The promise of these devices was recognized by an IR-100 award in 1990, shared by Mr. Canfield and Dr. Jonathan Kerner of the Far Ultraviolet Physics Group and Dr. Raj Korde of Universal Detector Technology Inc., our principal industrial collaborator in this program. One of the main disadvantages of the Si diodes, the degradation of an SiO protective layer by Ly-$\alpha$ radiation, may be eliminated by use of alternative semiconductor systems such as GaAsP, and research on a new generation of such devices has begun.

- ***Development of a new SEMPA microscope.*** During the past several years, Drs. Robert Celotta, Daniel Pierce, Michæl Scheinfein, and John Unguris have worked in collaboration with the Physical Electronics Division of Perkin Elmer, Inc. on the development of a new SEMPA microscope. This instrument utilizes a $LaB_6$ electron source to provide a dramatic increase of current, which will enable magnetic structures to be imaged at sub-micron resolution. The first model of this microscope was delivered to the Electron Physics Group in February 1990; commercial production is planned. We view this as a highly successful example of the transfer of basic technology to industry.

- ***Manipulation of Cs atoms on semiconductor surfaces.*** The Electron Physics Group has a long-standing program of research on the molecular and electronic structure of metal atoms adsorbed on semiconductor surfaces, as determined by scanning tunneling microscopy. Some noteworthy results obtained in the past few years include the observation of the metal-insulator transition in Fe clusters on GaAs, and the discovery that Cs atoms form long, non-conducting chains when deposited on GaAs. In the past year, Drs. Lloyd Whitman and Joseph Stroscio have found that the Cs structures can be manipulated by application of an electric pulse to the STM tip. Such pulses produce a significant increase in the number of Cs atoms in the vicinity of the tip, and also give rise to novel chain structures, presumably consisting of metastable configurations of Cs atoms on the surface, which have not previously been observed. This work may lead to controlled manipulation of molecular structure by a macroscopic probe.

- ***Advances in the strong-coupling theory of high-temperature superconductivity.*** A variety of electronic mechanisms have been invoked to explain the phenomenon of high-temperature superconductivity, but none has yet been found to be conclusive. The existing framework for interpretation of experimental results often does not provide critical tests of alternative theories. Dr. David Penn, working in collaboration with Prof. Marvin Cohen of the University of California, has solved a variety of strong-coupling models of superconductivity, incorporating constraints from experimental data, such as the known phonon spectrum, the isotope effect, and the superconducting transition temperature. They have found that the phonon coupling constants that emerge from the calculations are much too small. This provides strong evidence that many proposed electronic mechanisms are inconsistent with experimental data.

- ***Characterization of x-ray optical components and systems.*** During the past year, the soft x-ray reflectometer on Beamline 8 at SURF-II has been upgraded with an automated data acquisition and control system, and a variety of measurements on multilayer mirrors and photographic film have been performed for external customers by Dr. Richard Watts. This system now provides the only dedicated facility in the Nation for such measurements. A collaborative program with the Precision Engineering Division, directed towards comprehensive characterization of x-ray optical systems, was awarded support through the NIST Competence Program, beginning in FY91. This program will result in the construction of a new, dedicated beamline at SURF-II for x-ray optics studies.

- ***Massively parallel processing applied to calculations of multiphoton ionization.*** Theoretical research on the dynamics of atoms in strong radiation fields began a new direction this year: integration of the time-dependent Schrödinger equation on a massively parallel computer, the Connection Machine. This approach exploits the availability of computers with thousands of independent central processing units, by assigning a dedicated processor to compute the wavefunction in each of thousands of small regions of configuration space. Implementation of this approach has been started by Drs. Jonathan Parker, Charles Clark, and Mrs. Sayoko Blodgett-Ford, using facilities at the Northeast Parallel Architectures Center at Syracuse University. Calculations of multiphoton ionization and high-harmonic generation of atomic hydrogen in intense laser fields have given results that agree well with experimental data and with other calculations. Extension to two-electron systems is in progress.

❧ ***SEMPA studies of magneto-optical recording media.*** Scanning electron microscopy with polarization analysis (SEMPA), developed during the past few years in the Electron Physics Group, provides capabilities for studying the magnetic microstructure of surfaces with a spatial resolution on the order of a micron. This technique is of great interest in the magnetic storage industry, as it provides the most highly-resolved images of magnetic domains that yet have been obtained. Drs. Martin Aeschlimann, Michæl Scheinfein, and John Unguris, working in collaboration with Philips Research Laboratories, have used SEMPA to study the domain structure of the TbFeCo films that constitute the basis of new magneto-optic recording materials. This work has suggested optimal demagnetizing field strengths to assure uniformity of thermomagnetically-written bits.

❧ ***Theory of the "Coulomb blockade" in tunneling junctions.*** Single electron charging effects, or Coulomb blockade effects, become important as devices become smaller and smaller. It has been proposed that these effects can be used to make a standard for current that would be as accurate as the existing standards for resistance and voltage, allowing independent determinations of all three. Drs. David Penn and Mark Stiles, in collaboration with Prof. Steven Girvin of Indiana University have performed a theoretical study of charging effects in isolated tunnel junctions, within the framework of classical transmission line theory. One major conclusion of this work was that the classical discharge time of a charged junction provides an important time scale for the quantum-mechanical Coulomb blockade process.

❧ ***Pump-and-probe experiments using laser and synchrotron radiation.*** A variety of time dependent processes can be studied if independent excitation sources can be synchronized on short time scales. For example, one can hope to modify x-ray absorption cross sections by laser excitation of valence electrons, thereby providing a "shutter" for x-radiation that operates in the picosecond regime. Preliminary work on these problems has been started by Drs. David Ederer and Donald Mueller, in collaboration with Prof. Reuben Shuker of Ben-Gurion University. They have succeeded in mode-locking a Nd:YAG laser to the NSLS synchrotron at Brookhaven National Laboratory, and are now attempting to observe laser modifications of the reflectance of AlO and of x-ray emission by the valence band of Si.

❧ ***Electronic structure of buried interfaces.*** It is known that the electronic structure of solids is modified near interfaces, but it has been extremely difficult to make direct spectroscopic observations of these effects. Photon-excited x-ray emission spectroscopy is a technique that offers bulk (vs. surface) sensitivity, nondestructive intrusion, and site specificity, which are ideal for the study of buried interfaces. Dr. David Ederer, working in collaboration with Dr. Rupert Perera of Lawrence Berkeley Laboratories and Prof. Thomas Callcott of the University of Tennessee, has observed Si $L_{2,3}$ emission in a 50-layer C-Si structure with variable Si layer thickness. The spectra of the thinnest layers resemble those of silicon carbide, and as the layer thickness increases they tend towards those of amorphous Si.

- ***Laser focusing of atomic beams.*** A beam of atoms travelling coaxially down the center of a focused, hollow laser beam (in a $TEM_{01}$* "donut" mode) can be focused to a spot size of a few tenths of nm. Such a "laser-atomic" lens has potential use in controlled deposition, atomic microscopy, and precision measurements. Extensive analysis of the properties of such a lens has been carried out by Drs. Jabez McClelland and Michæl Scheinfein. They found the equations of motion to be analogous to those for an electron beam in a well-known magnetic electron microscope objective, and were thus able to employ powerful existing tools for electron optics modelling in the analysis. Analytic expressions were obtained for all the focal properties, as well as aberrations. The treatment provides a simple, yet accurate description of the lens, and hence provides a foundation for its possible experimental realization and practical application.

- ***Sum-frequency generation of Lyman-$\alpha$ radiation.*** Although there have been great advances in laser cooling and trapping of alkali atoms, little progress has been made on atomic hydrogen due to the lack of laser sources at the appropriate wavelength. Drs. Paul Lett and Thomas Lucatorto, working in collaboration with the Laser Cooling Group, have been building a laser source designed to deliver enough power in the appropriate spectral region. This source, based on a titanium:sapphire laser with a beta-barium-borate (BBO) crystal, has now achieved conversion efficiencies as good or better than other existing methods. The BBO crystal allows the use of a two-photon resonance to enhance nonlinear sum-frequency generation.

## II. PERSONNEL

The Division began FY90 with 31 full-time scientific and technical members of staff on the payroll. It experienced a significant decrease in permanent staff during the year. There were two retirements and one resignation, and a term appointment that had been intended for conversion to career-conditional status but instead was allowed to expire. Because of financial exigencies, it is unlikely that any of these positions will be filled in FY91; the deficiencies will be dealt with by a combination of program termination and reprogramming of existing staff. One new hire was made in FY90 to support the x-ray optics initiative. Two NRC Postdoctoral Research Associates left during FY90 due to expiration of their terms. The Division had 16 applicants for NRC Postdoctoral Research Associateships beginning in FY91; two of these applicants were offered positions, one accepting and the other declining. Two graduate students in physics worked in the Division full-time during the summer and part-time during the academic year, under Cooperative Study agreements (with Howard University and the University of Maryland).

Our programs have benefitted greatly by the efforts of Guest Scientists, the majority of whom work on a full-time basis on the NIST campus. During FY90 two Fulbright Fellows worked full-time in the Division; another Fulbright Fellow is scheduled to arrive in FY91. Two research associates and two graduate students from the University of Maryland worked full-time in the Division in FY90. A Cooperative Research and Development Agreement (CRDA) with Eastern Analytical, Inc. resulted in one of their employees working essentially full-time in the Photon Physics Group; a second CRDA, with Hampshire Industries for the development of x-ray focussing systems, will take effect in FY91. Through the Physics Department of the University of the District of Columbia, the National Science Foundation supports a research and educational program centered upon the High-Resolution Spectrograph on Beamline 3 at SURF-II. This provided us the equivalent of a full-time staff member during the academic year, and brought in several students during the summer.

The chart on the opposite page shows the roster of full- and part-time members of staff, and Guest Scientists who were on full-time assignments for a month or more during the reporting period.

## ELECTRON AND OPTICAL PHYSICS DIVISION

C. W. Clark, Chief
A. Roess, Secretary

* Guest Scientist
† NIST-NRC Research Associate
‡ Part-time
∞ Fulbright Fellow

### FAR UV PHYSICS GROUP

R. P. Madden, Leader
P. Elspas, Secretary (1/2)

#### FAR UV RADIOMETRY

L. R. Canfield
M. L. Furst
R. M. Graves
J. A. Kerner (to 6/90)
N. Swanson (to 4/90)

#### SURF-II OPERATIONS

A. D. Hamilton
L. R. Hughey
W. H. Wooden

#### SURF-II USERS

A. Asfaw (from 5/90) *
J. Fortna *
H. Morgan *
M. Seyoum *
L. Hudson (Div. 837)
R. Kurtz (Div. 837)
S. Robey (Div. 837)

### ELECTRON PHYSICS GROUP

R. J. Celotta, Leader
R. McIntyre, Secretary (to 7/90)
K. Chaney, Secretary (from 9/90)

R. D. Cutkosky
R. A. Dragoset
P. N. First (to 8/90) †
M. W. Hart (to 7/90) †
M. H. Kelley
S. R. Lorentz †
J. J. McClelland
S. R. Mielczarek (to 1/90)
D. R. Penn
D. T. Pierce
M. R. Scheinfein (to 9/90)
M. D. Stiles (1/2)
J. A. Stroscio
J. Unguris
B. J. Waclawski
L. J. Whitman
P. Apell *
M. H. Cohen *
S. M. Girvin *
R. Scholten ∞

### PHOTON PHYSICS GROUP

T. B. Lucatorto, Leader
P. Elspas, Secretary (1/2)

B. Berry ‡
S. Blodgett-Ford (from 6/90) ‡
D. L. Ederer
K. Law (from 6/90) ‡
P. D. Lett
T. J. McIlrath ‡
D. R. Mueller
E. B. Saloman
R. N. Watts
I. Belal (3/90 - 11/90) ∞
T. Callcott *
M. Hou (from 9/90) *
P. Jessen (to 9/90) *
Q. Li (to 11/90) *
L. Pan *
J. S. Parker (from 5/90) *
K. T. Taylor *
N. Vansteenkiste *
X. Xiong *

## III. FAR UV PHYSICS GROUP

### A. Far UV Detector Calibrations (L.R. Canfield)

Specially selected far ultraviolet radiometric detectors are calibrated, as an ongoing service documented in (NIST SP 250-2), and made available to those in the scientific community concerned with absolute radiometry in the 5-254 nm spectral region. These transfer standards are widely used in such fields as plasma physics, space astronomy, æronomy, and solar physics. During the 21 years during which this program has been conducted, over 500 calibrations have been accomplished for outside users. In FY90 29 such calibrations were carried out.

Two classes of detectors have been required to cover the above region: a windowless photoemissive photodiode for the 5-122 nm portion of the region, and a magnesium fluoride-windowed photoemissive photodiode for the 116-254 nm portion. During FY90 in collaboration with industry, development was concluded on a new high-efficiency, low cost silicon detector for the 5-50 nm region. This detector was the subject of an R&D 100 award for 1990, as one of the 100 most significant technological developments of the year. It is now being made available as an alternative NIST transfer standard in the 5-50 nm region, and offers greatly improved sensitivity, long term stability, and significantly reduced sensitivity to surface contaminants.

Two facilities at NIST are used in this program: a radiometric lab in the Physics Building with a vacuum monochromator and plasma light source to do calibrations in the 50-254 nm region; and a dedicated beamline at the NIST SURF-II electron storage ring facility, containing an ultra-high vacuum monochromator and calibration chambers, in which the calibrations in the 5-50 nm region are carried out. In both facilities, the absolute standard used is a rare gas ionization chamber.

In addition to the above activities, special calibrations of spectrally selective filters, and specialized detectors are conducted as research collaborations. Also, studies of potential new types of transfer standard detectors are being conducted as they become available. In a recent development, a silicon photodiode specially prepared by NIST with an integral thin aluminum filter has been successfully used by the University of Southern California Space Sciences Center to measure the XUV solar flux in a rocket flight. This represents the second such flight and calibration sequence, with quite satisfactory results. Plans are in progress to include such a detector/filter in an upcoming satellite experiment.

### B. SURF-II Operations (A.D. Hamilton, L.R. Hughey, R.P. Madden and W.H. Wooden)

The average beam current for this year was 194.1 mA, which is slightly below the FY89 average of 203 mA but, substantially above the FY88 average of 170 mA. The decline in the average was due primarily to a series of unrelated maintenance problems with both the injector and RF power source, which caused the November and December beam currents to be lower than normal. In July, the injector cathode had to be replaced, and the new cathode required a considerable amount of time attain full performance. These problems have been corrected.

During the period from February 1989, to June 1990, the monthly average never fell below 208 mA and peaked at 227 mA.

Overall, SURF-II reliability remains quite high. During FY90, beam was available for users 95.6% of the scheduled time. Beam was made available outside of the normally scheduled hours (2 beams/day, 9 hours/day, 4 days/week) during a three month period, so that the percentage of available to scheduled time actually exceeded 100%. The following table summarizes FY90 performance:

**SURF-II Operations during FY90**

| *Month* | *No. of Beams* | *Avg. Current (mA)* | *Availability (%)* |
|---|---|---|---|
| 10/89 | 28 | 184.2 | 93.2 |
| 11/89 | 25 | 146.2 | 97.4 |
| 12/89 | 32 | 155.8 | 100.3 |
| 1/90 | 32 | 199.1 | 98.5 |
| 2/90 | 31 | 207.6 | 100.3 |
| 3/90 | 36 | 211.1 | 95.0 |
| 4/90 | 33 | 214.2 | 92.2 |
| 5/90 | 32 | 214.0 | 99.7 |
| 6/90 | 36 | 227.1 | 103.1 |
| 7/90 | 21 | 173.0 | 73.1 |
| 8/90 | 34 | 189.6 | 97.5 |
| 9/90 | 34 | 183.3 | 99.3 |

During FY90, the first SURF-II computer-based data acquisition system was fully integrated into routine operations. The system monitors both ring beam current and main coil cooling system temperature. Beam current is sampled once per second and displayed in real time. The beam current - half life product (in milliampere-hours) is calculated and displayed once per minute. This allows the operator to see almost immediately when ring parameters are not correctly set or if other conditions are causing unexpectedly low lifetime. The exit water temperature is measured and displayed once every ten seconds. Since the range between normal full energy temperature and maximum allowable temperature is less than 10° F, this is an extremely critical parameter. The computer will immediately sound an alarm to alert the operator if the threshold temperature is exceeded. Several times during the first six months of operation this has warned the operator of decreased cooling performance due to outside problems (typically an increase in the temperature of the plant chilled water) and has averted serious trouble. The monitoring system will serve as the central point for a planned data broadcast system to users' computers, a video rebroadcast to various beamlines of both ring data and important messages, and eventually is expected to lead to a closed-loop system controlling ring magnet currents, RF power and other operating parameters.

Also during FY90, the operations group identified a number of crucial hardware items for which there were no spares. Backups were purchased for the injector modulator power supply and the fuzz RF power amplifier to enhance reliability.

### C. **SURF-II Users Programs** (R.P. Madden)

SURF-II was utilized by a variety of NIST and outside users during FY90 for spectrometer calibrations, and for research in surface science and UV and soft x-ray optical physics. In the following sections, progress by these users is summarized by beamline.

#### 1. **Surface Science, BL-1 and BL-8** (R.L. Kurtz, S.W. Robey, and L.P. Hudson, *Surface Science and Microstructures Division*, R.L. Stockbauer, *Louisiana State Univ.*; T.E. Madey, *Rutgers Univ.*)

The NIST research efforts in surface science are supported at SURF-II with two beamlines and associated ultra-high vacuum chambers that are used for a wide range of studies of solid surfaces. The experimental techniques employed in these efforts include ultraviolet photoelectron spectroscopy (UPS) where variable-wavelength photons are used to probe the valence electronic structure of bulk solids and the molecular orbitals of adsorbed species. In addition, photon stimulated desorption (PSD) of ions from surfaces is studied to elucidate the mechanisms involved in radiation damage of materials. These studies have shown that the atomic-scale structure of defects and steps may be revealed by stimulated desorption techniques.

Resonant photoemission has been used on BL-1 to study two types of materials of potential technological importance. The first class of materials is a Heusler alloy system composed of Ni-Mn-Sb; this is a half-metallic material that has unique magnetic properties important in information storage. The half-metallic nature is manifest in the location of the Fermi level between the spin-split majority and minority carriers. Theory predicts that the location of the Fermi level can be controlled by varying the composition, and this effect has been studied using photoemission. The strength of the magnetic coupling giving rise to the spin-splitting has also been assessed using the resonant photoemission technique: the coupling was found to give a less pronounced effect in the photoemission resonances than predicted.

The second type of material that has been studied is the ferroelectric perovskite $BaTiO_3$. This material has unusual temperature-dependent optical and structural properties. It shows promise as a material for optical computation and is related in a number of ways to high-temperature superconductors. Initial studies will allow comparison with future measurements of $YBa_2Ti_3O_{7-x}$, a non-superconducting electron conductor with the crystal structure of the high $T_c$ material. Below the Néel temperature of 120° C, the material is ferroelectric with a net electric dipole moment. Above the Néel temperature, the lattice polarization is lost and the crystal structure becomes that of a classic perovskite. The polarization of the lattice involves a displacement of the Ti relative to O and this is predicted to give a substantial change in Ti-O hybridization that should be observable in photoemission spectra. Our recent measurements have observed this coupling and refinements are being made to establish the degree to which it changes through the structural transition. Core level spectroscopies have also been performed that show that the material is substantially more ionic than recent theory has predicted.

The work on high-temperature superconducting thin-films has progressed substantially with the completion of the deposition system. Superconducting $DyBa_2Cu_3O_{7-x}$ films have been produced with $T_{c\text{-}onset}$ of 89 K and transition widths of > 1 K. Compositional cross-correlations using Rutherford Backscattering (RBS) and Energy Dispersive X-ray Analysis (EDX) have been performed. The crystal structure has been assessed using x-ray diffraction, and microstructural studies using scanning electron and transmission electron microscopy have been performed. As parameters are refined and depositions become routine, these films will be the heart of our studies using the SURF-II storage ring. We will assess the development of the superconducting electronic structure with film thickness, study the effect of slight variations in composition and study the effect of buffer layers (for growth on Si) and passivation layers.

The ellipsoidal-mirror analyzer located on BL-1 is now operational, and many of the potential spectroscopies thought possible using it have been successfully demonstrated. This instrument combines charged- particle (electron and/or ion) detection with simultaneous analysis of energy, mass, and emission angle from the substrate surface. The electron spectroscopies performed include angle-resolved photoemission (UPS), low-energy electron diffraction (LEED), and angle-resolved constant-initial-state and constant-final-state spectroscopy (CIS and CFS). These techniques have been applied to the adsorption of CO, $H_2O$ and $NH_3$ on Ru(0001). The ion spectroscopies that have been demonstrated include measurements of electron-stimulated desorption ion angular distributions (ESDIAD) and the ultraviolet photon-stimulated analog. The instrument uses time-of-flight techniques to identify the ion masses and the first mass-resolved imaging of ion desorption angular distributions has been performed. Synchrotron radiation has been used to tune the photon energy to a specific electronic excitation and monitor desorption probability, ion energy and angular distributions and the mass of the species desorbed. This combination of spectroscopies permits a more complete description of systems of interest than had been possible previously and holds the promise of providing new classes of angle-resolved structural information.

### 2. **Radiometric Instrumentation Calibration, BL-2** (M.L. Furst and R.M. Graves)

Synchrotron radiation from the SURF-II storage ring is used as a primary irradiance standard for characterizing instrument response over a wide range of wavelengths from 4-400 nm in a NASA-supported facility. BL-2 remains the only existing user facility for calibration of spectrometers and other radiometric instrumentation over this wide wavelength range. The radiometric uncertainty for this facility is maintained at 1-3% depending on wavelength.

There were 16 instruments calibrated by 7 user groups over a period of 37 weeks during FY90. Facility users included NASA/Goddard Space Flight Center, Naval Research Laboratory, Laboratory for Atmospheric and Space Physics/University of Colorado, Stanford University, National Institute of Standards and Technology, and Space Sciences Center/University of Southern California.

Two of the instruments which received their final pre-flight calibrations at the SURF-II Spectrometer Calibration Facility will be among the instruments on

NASA's Upper Atmosphere Research Satellite (UARS) which is scheduled to be launched from a shuttle flight scheduled for 1991. UARS will perform the first systematic, comprehensive study of the stratosphere and furnish important new data on the mesosphere and thermosphere. It is the spearhead of a long-term national program of space research into global atmospheric change. These two instruments are the Solar Ultraviolet Spectral Irradiance Monitor (SUSIM) instrument from NRL and the Solar/Stellar Irradiance Comparison Experiment (SOLSTICE) instrument from the Laboratory for Atmospheric and Space Physics (LASP) which will monitor solar ultraviolet light in the range 115 to 430 nm with about 0.1 nm resolution. Data from these instruments will provide a record of the long-term variation of the solar ultraviolet spectrum. One of the uses of these measurements is for determining the net effect of ultraviolet radiation on the amount and distribution of ozone in the stratosphere.

Several improvements were made to the facility in the past year. A new motion control system was installed and implemented for the spectrometer gimbals mount in the large vacuum chamber. A modern computer with a user friendly graphical interface now provides the user with a control panel for interaction with the system. The control panel provides simultaneous display of the location of the gimbals mounting system along its four degrees of freedom. Various aspects of the motion of the system, such as motor feedrate, ramp time, and the choice of absolute or relative motion, can also be controlled from the control panel. In addition, users have the ability to control the motion system through a remote user RS-232 port.

Part of the upgrade in the motion system was the addition of linear encoders to the pitch and yaw motions to provide direct readout of angular orientation. The old stepping motor shaft encoders have been retained in the new system providing for redundancy in the event of a failure.

Work is also nearly completed on upgrading the motion control system for the 11 m (milling table) calibration station. Linear encoders have been installed for the pitch and yaw motions of the gimbals system on the milling table. This will provide compatibility and interchangeability with the vacuum chamber system. In addition, modifications are being made to the stepping motor drive system.

The upgrade of the motion control systems and the provision for additional pumping speed and capacity has resulted in a significant decrease in the amount of time needed for initial vacuum preparation of user instrumentation and for actual calibration of their spectrometers.

3. **High Resolution Spectrometer, BL-3** (NSF-sponsored collaboration: J.D.E. Fortna, H.D. Morgan, and M.M. Seyoum, *Univ. of the District of Columbia*; D. Cleary, *Naval Postgraduate School*; A. Asfaw, *Howard Univ.*; N.C. Das, *Bhabha Atomic Research Centre*; M.L. Furst, L.R. Hughey and R.P. Madden; T.B. Lucatorto and D.L. Ederer, *Photon Physics Group*)

Last year in the first use of this instrument, the photoabsorption cross section of $N_2$ in the region around 83.4 nm was studied to help the atmospheric physics community resolve an inconsistency between plasma density measurements of the F2 region of the ionosphere by various remote sensing techniques. The SURF-II measurements showed that the discrepancy could possibly be explained by the presence of extremely narrow features in the $N_2$ spectrum in that region, but it was decided that improvements in the resolution and sensitivity of the 6.65 m instrument were needed to fully identify the source of the discrepancy. Therefore this past year, the SURF-II staff joined the team to help analyze the efficiency of the spectrometer and its illumination system. Measurement and analysis determined that the three mirrors of the illumination system were down in throughput by a factor of 100. They were removed and the coatings were stripped, greatly reducing the scattering losses. The mirrors have now been reinstalled and, in addition, their alignment has been much improved.

In the meantime the spectrometer itself has been undergoing repair and upgrading. The adjustment and seal for the entrance slit has been repaired, motion feedthroughs for the grating drives (which were leaking) have been redesigned and replaced, the drive system has been repaired, and limit switches have been installed to limit the linear grating drive. We anticipate that the mirror system and the spectrometer will be ready for return to the experimental program by February 1991.

A guest researcher, Dr. N.C. Das, visiting us from the Spectroscopy Division of the Bhabha Atomic Research Centre, Bombay, through the US-India Exchange Program, has recently joined the effort on the high resolution spectrometer. He is making excellent progress in calculating the optimum tilt and curvature of the entrance and exit slits for our off-plane Eagle mounting. These calculations will be invaluable when we introduce a two-dimensioned array detector to this instrument. To this end, a proposal is being developed to extend the NSF grant and develop a state-of-the-art two-dimensional array detector for the instrument of the type developed by Gethyn Timothy of Stanford University.

4. **Reflectometry and Optical Properties of Materials, BL-8** (R.N. Watts, D.L.Ederer, and E.B. Saloman, *Photon Physics Group*; T.W. Barbee and N. Ceglio, *Lawrence Livermore Laboratory*; D. Husk, *Univ. of Virginia*; R. Hoover, *Marshall Space Flight Center*)

As part of its commitment to support the microelectronics industry, NIST has begun a Competence Program on the metrology of soft x-ray optical systems for use in both basic and applied research. As part of that program, the SURF reflectometer system, used with the 2.2 m grazing-incidence monochromator on Beamline 8 is being upgraded for better ongoing performance, while a new monochromator and reflectometer are being designed and procured for significantly higher performance in the future. The new system will measure scattering from reflective surfaces as well as specular reflectance.

The present reflectometer has been used, over the past year, for the measurement of the reflectivity of a variety of normal -incidence soft x-ray mirrors comprised of multilayer structures, for a number of laboratories throughout the country, covering the spectral range 8 - 50 nm. Other measurements of filter transmission, film dosimetry, and other optical properties have also been carried out. (See also discussion in the Photon Physics report.)

The absolute fluorescent response and linearity of response of phosphors in the VUV has been studied in this system by D. Husk of the University of Virginia.

# IV. ELECTRON PHYSICS GROUP

The Electron Physics Group has ongoing research efforts in electron collision physics including electron-atom collisions, electron-surface interactions, surface magnetism, electron interaction theory, electron polarization phenomena, tunneling and scanning electron microscopy, and electron optics and instrumentation. The wide applicability of electron-based measurement technologies allows us to contribute to the solution of many diverse scientific and technological problems.

In the past year, we have seen significant achievements in all of our areas of research. The STM has been used to study the electronic structure of cesium nanostructures on semiconductor surfaces and, most recently, to move these structures and create new ones. The electron- atom scattering program has obtained important elastic scattering data and developed an approach to optical atom focusing. Our theory efforts include an important paper on the need for phonon coupling to explain high $T_C$ superconductivity. Our SEMPA research continues, and has been extended to include *in situ* thin film growth. Industrial interactions continue to be very strong, as do our other collaborative efforts.

We continue our focus on interfacial phenomena with special emphasis on the use of microscopy to study microstructures, clusters, defects, growth, and dynamics on the atomic scale. Our SEMPA work involves studying the effects of size, dimensionality, shape, topography and epitaxial substrate on magnetic microstructures. Photoemission experiments focus on understanding magnetic phenomena in novel epitaxial systems through measurements of spin resolved band structure. Our STM measurements investigate the electronic structure of atoms, molecules, clusters, and microstructures on surfaces. The STM allows us to study the growth of microstructures with atomic resolution. It also permits us to verify, for example, that the novel epitaxial structures we grow have the physical structure we planned, and that their observed magnetic phenomena results from our tailoring of the physical structure.

This year, we have increased our experimental efforts in magnetic scanning tunneling microscopy and the optical control of metal atom beams. In order to permit these new activities, we have phased out our work on inverse photoemission and are limiting our involvement at NSLS.

## A. Electron - Atom Collision Studies (M.H. Kelley, J.J. McClelland, and S.R. Lorentz; R.E. Scholten, *Fulbright Fellow, Flinders Univ. of South Australia*)

This project is aimed at exploring the fundamental physics associated with the spin-polarized electron phenomena being investigated and used in other efforts in the Electron Physics Group and elsewhere. We examine the interaction of spin-polarized electrons with free atoms in as complete a manner as possible, with the expectation that the information provided by our detailed studies will lead to a much more solid understanding of the complex processes at work in spin-polarized electron interactions.

We perform electron scattering experiments, in which a beam of electrons is incident upon an isolated atomic target (in our case, sodium), and the scattered electrons are detected as a function of scattering angle. In our experiments, we endeavor to control the quantum channel in which the scattering takes place, so that the information obtained is simply related to theoretical predictions without the complications of averaging over a number of channels. This is done by selecting the spin state of the incident electrons (i.e., using a spin-polarized electron beam), and by laser-optically pumping the target atoms. Laser optical pumping can produce spin-polarized ground state Na atoms, or spin-polarized excited state atoms with their electron orbitals in pure angular momentum states. Thus we can specify the quantum states of the electrons and the atoms before collision and, hence, have a high degree of control over the scattering process.

One of our major goals has been to examine the rôle played by exchange in the electron scattering process. The exchange interaction has a strong influence on electron scattering at intermediate and low energies, and also lies at the heart of magnetic phenomena in solids. In electron scattering from Na with spin-polarized collision partners, the presence of exchange is detected by observing a difference in the cross sections for the singlet and the triplet scattering channels.

This year we have made significant progress toward a fuller understanding of exchange by performing elastic scattering measurements at 10 eV incident energy, and inelastic 3S-3P scattering measurements at 7.9 eV. These two sets of measurements complement our earlier measurements at 54 eV and 20 eV, and represent a significant step toward lower energies where exchange produces dramatic effects. In fact, our 10 eV elastic results show that the cross section is completely dominated by the triplet channel at scattering angles of 45-50 degrees, but is entirely taken over by the singlet channel at 60°.

These new measurements have been made possible by a number of major upgrades to our apparatus that we have accomplished over the past year. We have introduced two-frequency optical pumping to our laser optical pumping of sodium by inserting a acousto-optic modulator into the beam. This scheme allows us to achieve a minimum of 97% polarization in the atom beam, as opposed to the maximum of 60% attainable with a single frequency. The result has been a significant improvement in our signal-to-noise ratio. Another improvement in our signal-to-noise has been achieved by inserting a mechanical chopper in the atom beam, allowing us to continuously measure the background signal during a run, and thereby effectively lengthening the time over which data can be taken under computer control. Finally, our energy calibration has been improved by the introduction of detection of the He resonance at 19.36 eV. The increased performance of our apparatus generated by these improvements has opened the door to even lower energy measurements, which will be forthcoming in the early part of FY91.

Besides to the experimental work described above on sodium, theoretical work was carried out on the possibility of "deep laser focusing" of atom beams. The motivation for this work arises from our interest in laser optical pumping on the one hand, and the interests in microstructures in other parts of the group on the other. Using electron optical methods, we analyzed the trajectories of atoms travelling coaxially through a "donut"-mode (i.e. hollow) laser beam. The focus of the laser beam acts as a lens for the atoms, focusing the atom beam to a very small spot. The lens properties were found to be completely analogous to those of a magnetic electron microscope lens, so analytic expressions could be obtained for all the first-order properties of the lens. In addition, all the major spot-size limitations could be investigated, including diffraction, spherical and chromatic aberration, and diffusion caused by spontaneous emission. It was found that with fairly reasonable laser and atom beam parameters, spot sizes as small as 1 nm can, in principle, be obtained.

### B. Magnetic Microstructure Research (J. Unguris, M.H. Kelley, M. R. Scheinfein, R.J. Celotta, and D.T. Pierce)

Our goal is to investigate the micromagnetic structure of ferromagnetic surfaces and thin films. Our primary tool in this work is scanning electron microscopy with polarization analysis (SEMPA). The SEMPA technique was developed at NIST and involves the combination of an ultrahigh vacuum scanning electron microscope (SEM) with electron spin polarization analyzers in order to measure the polarization of secondary electrons emitted from a magnetic specimen. In transition metal ferromagnets the spin polarization of the secondary electrons is directly proportional to the polarization of the electrons within the ferromagnet. Polarization analysis of the secondary electrons provides a direct, quantitative measurement of the magnitude and the direction of the magnetization in the region probed by the SEM. SEMPA can therefore image magnetic structures, such as domains and domain walls, with an ultimate spatial resolution of about 10 nm. This is the highest resolution available of any technique for looking at magnetic structures in reflection. In addition, the short escape depth of the secondary electrons (about 1 nm) gives SEMPA good surface sensitivity for probing surface and thin film magnetism.

Our initial investigations of the magnetic structure of ultra-thin ferromagnetic films have been very productive. By adding thin film evaporators to our SEMPA apparatus we are able to examine the magnetic structure of thin films and multilayers that were grown *in situ* and characterized using Auger spectroscopy and reflection high-energy electron diffraction (RHEED). Using these techniques we have grown Cr and Ag films on Fe substrates in order to measure the attenuation of the secondary electron spin polarization by these non-magnetic overlayers.

Our thin film evaporation capabilities have also been useful in applying the SEMPA technique to some difficult magnetic materials. For example, we found that the domain structure of ferromagnetic electrical insulators could be studied by evaporating a thin ferromagnetic film on top. The film eliminated electrical charging but did not alter the domain structure. We applied this method to examine the magnetic domain structure of an Fe garnet magnetic bubble media. We also found that thin Fe films could be used to increase the polarization signal and hence the domain contrast of weakly ferromagnetic materials, such as permalloy. Again the films are thin enough, about 2 nm, that they do not disturb the underlying domain structure.

We have continued to investigate the domain structure of magnetic recording media. This year we extended our studies to include magneto-optic recording media. Specifically, we examined laser-written bits recorded in TbFe based media of various compositions. We found that the spin polarization came primarily from the Fe sublattice which is coupled antiferromagnetically to the Tb. SEMPA was therefore able to image domain structures near room temperature, even though the media are prepared so that the Fe and Tb have equal magnetization and thus, the material has no net magnetization near room temperature. We also observed that the magnetization, which was perpendicular to the surface inside the material, could either be perpendicular or in-plane at the surface depending upon the amount of Fe in the media.

We have also continued our mutually beneficial collaborations with private industry by using SEMPA to solve applied magnetics problems. We continued working with Seagate Magnetics in studying the relationship between the domain fine structure of recorded bits in thin film media and the signal-to-noise performance of the media. We worked with Digital Equipment Corporation to look at the details of domain wall motion in thin film recording heads that are driven by small applied magnetic fields. We also worked with the Naval Research Laboratory in examining the effects of cutting and annealing on the domain structure of ferromagnetic metallic glass ribbons that are used in magnetostrictive magnetic field sensors.

Currently, we are continuing our investigations of thin film and multilayer magnetism. With the future addition of a cold stage for the SEM we will be able to look at the domain structure of films that are only a single monolayer thick. We are also completing work with Physical Electronics Corporation to bring a new high spatial resolution SEMPA apparatus on line, so that we will be able to begin an exciting new series of experiments looking at even smaller magnetic structures.

### C. Scanning Tunneling Microscopy (J.A. Stroscio, R.A. Dragoset, L.J. Whitman, D.T. Pierce, and R.J. Celotta)

The goals of the scanning tunneling microscopy (STM) program are to investigate the novel properties of matter that occur in nanometer size structures, and to develop advanced methods which further the application of scanned electron probe techniques. At present our focus is on semiconductor and magnetic materials, along with the development of a synergistic marriage between the two with epitaxially grown magnetic films on semiconductor substrates. The STM operates utilizing the quantum tunneling of electrons from a sharp probe tip to a specimen. By raster scanning the tip over an exposed surface, information is obtained about the structural properties of the examined specimens. In addition to topographic features, the STM is inherently sensitive to surface electronic properties due to the dependence of the tunneling process on the availability of electron states. Such tunneling spectroscopy expands the simple 2-dimensional image of a specimen to 3-dimensions; the third dimension represents the energy of the surface electronic states. We now have in operation two state-of-the-art devices operating with a lateral resolution of 2-3 Å with customized computer interfacing allowing enhanced spectroscopic capabilities.

We have been examining the physical properties of Cs structures on III-V semiconductor surfaces as a function of dimensionality, going from 1- to 3-dimensional structures. We have shown that this system represents an ultimate limit of small scale structures. Frst, 1-dimensional "wires", *one-atom wide* and fractions of a micron long, are shown to form at low Cs densities. With increased Cs coverage they develop further to an ordered 2-dimensional phase consisting of five-fold clusters. We have shown that both the 1- and 2-dimensional phases are *not metallic*, with a band gap that narrows in going from 1- to 2-dimensions. Metallic characteristics are found in growing a second layer of Cs, which represents the beginning of a 3-dimensional phase. These results are particularly interesting in trying to understand the onset of metallization in solid state systems, particularly on semiconductors, and they have spurred theoretical interest in both the US and European scientific communities.

In examining the physical properties of alkali atoms on semiconductor surfaces, we have discovered that we can manipulate Cs atoms by pulsing the field of the STM probe tip. We have succeeded in inducing a directional flow of Cs atoms beneath the tip. Depending upon surface and pulse parameters, Cs structures from one nanometer to a few tens of nanometers across have been created in this way on GaAs and InSb(110) surfaces. These include structures that do not occur naturally. These manipulative abilities are significant in two respects. First, they have been demonstrated on room-temperature substrates, to which the chemisorbed alkali atoms are tightly bound; in contrast, other recent demonstrations of STM manipulation have involved weakly-bound, physisorbed atoms on cryogenic substrates. Second, we have shown that the STM can be used to produce phases of materials that do not occur naturally in atomic adsorption. Thus this discovery opens up a new research area: the atomic engineering of nanometer-scale structures on room temperature surfaces by electric-field manipulation.

We have completed construction of our second scanning tunneling microscope and UHV system which will support magnetism research within the Electron Physics Group. This STM incorporates techniques for growing ultra-thin magnetic films and a RHEED capability to characterize and monitor the film growth. Later, we hope to add macroscopic magnetic characterization measurements to coordinate the atomic scale structure of ultra-thin films with their magnetic properties. In addition, this UHV system incorporates a field emission microscope and an electron spin detection system, which we plan to use to prepare electron spin polarized tips. Such tips will allow us to test the feasibility of obtaining a spin dependent tunneling signal on magnetic samples. This added ability would greatly enhance our ability to correlate microstructure with magnetic properties, by opening a new field of micro-magnetism in which magnetic properties can be examined on an atomic scale.

**D. Electron Theory** (D.R. Penn and M.D. Stiles; M.L. Cohen, *Univ. of California, Berkeley*; S.M. Girvin, *Indiana Univ.*; P. Apell, *Chalmers Univ., Sweden*; D. Hamman, *AT&T Bell Laboratories*)

Our purpose is to study various aspects of the electronic behavior of solids. In view of the Electron Physics Group emphasis on SEMPA we are currently studying the behavior of secondary electron escape in solids with magnetic overlayers in order to gain understanding of the results of SEMPA measurements. We have also worked on high $T_c$ superconductivity, laser-induced resonant tunneling junctions, and Coulomb charging effects in tunnel junctions.

The advent of high-temperature superconductivity (HTS) in oxides has led to an explosion of theoretical work aimed at explaining the novel properties of these materials. The many theories proposed range from minor variations on the phonon-based BCS/Eliashberg theories to mechanisms completely independent of phonons, and both strong-coupling and weak-coupling theories have been suggested. Generally, these theories yield the high transition temperatures found in the oxide superconductors but differ in their predictions for other characteristic parameters of superconductivity such as the isotope effect parameter $\alpha$, the gap ratio $2\Delta/k_BT_c$, the electronic specific heat discontinuity $\Delta C/\gamma T_c$ and some normal state parameters. If it could be unequivocally determined whether the HTS oxides are weak or strong coupling superconductors, a large number of suggested mechanisms for HTS in the oxides could be eliminated. Although the experimental data does not yet clearly indicate strong or weak coupling, the aim of our work was to show that the data can be used in conjunction with theory to constrain several of the suggested mechanisms. We have summarized some relevant experiments and reviewed predictions of the conventional theory in both the strong and weak coupling limits. We have used Eliashberg theory together with the experimental data to constrain and/or eliminate candidate theories. An exclusively phonon-based mechanism and a combined phonon-nonphonon mechanism have been considered. The limitations of this method have been discussed, and alternative explanations of the experimental results examined. This work is performed as part of the NIST-wide initiative on HTS.

Resonant tunneling has been studied by applying a method, originally due to Heitler, to extend the transfer-Hamiltonian description. We have calculated transition probabilities and general frequency response characteristics of coupled systems. The Scanning Tunneling Microscope (STM) was treated as an example of a single barrier, and an irradiated quantum well as an example of a double barrier. The saturation of the contact resistance in the STM has been derived, and a simple physical explanation for the high-frequency response of an irradiated double junction has been presented. In the latter case it is found that the cut-off in the frequency response for high frequencies is limited by the optical properties of the outer electrodes of the double barrier, a result which is different from that of previous workers.

As devices are made smaller and smaller, it becomes important to answer several questions to better understand how these devices operate. During the past year, a series of investigations have been conducted into some of these issues. These include the effect of Coulomb charging effects in tunnel junctions as the junctions (and leads) become smaller and smaller, the coupling between electrons associated with different minima in abrupt interfaces between gallium arsenide and aluminum arsenide, and the transmission of electrons across interfaces between silicon and nickel disilicide.

There is a particular energy associated with a capacitor being charged. When an electron tunnels across a junction, the junction is temporarily charged and the energy is raised by the charging energy. If the junction does not discharge quickly enough, this charging energy can "block" the tunneling, leading to an increase in the junction resistance. Only recently have devices become small enough for this effect to be observable; as devices become smaller this effect could degrade their performance. On the other hand, it may be possible to use this effect to construct a new current standard. In collaboration with people from several other institutions, a way of understanding these effects has been developed for model systems. The results of this study indicate when these effects might be important and when they can be ignored.

One proposal for the next generation of high-speed devices is based on the use of gallium arsenide-aluminum arsenide materials. Some of these devices use aluminum arsenide tunnel barriers. We have applied a first-principles method to the problem of electron transmission across interfaces between these materials. A complication in this system is that the conduction band in the gallium arsenide is at the zone center and in aluminum arsenide it is at the zone boundary. We have shown that under some circumstances the behavior of electrons is dominated by the coupling between these different types of electrons. We have developed techniques that allow these effects to be calculated simply in many different situations.

Prompted in part by our previous calculations, recent measurements of the transmission of electrons across silicon-nickel disilicide and silicon-cobalt disilicide are being made using a technique called Ballistic Electron Emission Microscopy (BEEM). These new experiments have allowed us to extend our previous calculations to provide a more complete comparison with the experimental data. Neither the calculations nor the experiments are complete, but preliminary indications show that they agree in the most important details. This system provides the first good test of our understanding of metal-semiconductor interfaces, particularly electron transport across them.

## V. PHOTON PHYSICS GROUP

The Photon Physics Group investigates the interaction of electromagnetic fields with atoms and molecules in various environments, in support of radiation measurements and standards programs important to NIST and the outside technical community. This work includes theoretical and experimental studies on the electronic structure of atomic and molecular systems in field-free environments, in crystalline environments (atomic effects in solids), and in strong external fields. In addition, the group has applied its special capabilities in XUV physics to perform measurements in support of the development of XUV multilayer optics for the scientific and industrial community.

Studies are currently focused on shell contraction in atoms, VUV fluorescence in solids, the generation of coherent VUV radiation for multiphoton spectroscopy and for the laser cooling of atoms, multiphoton physics, atoms in high electric and magnetic fields, and the structure of highly excited atoms. Collaborative work is directed toward the laser cooling of atomic hydrogen, laser isotope separation, and elemental isotope analysis through resonant multiphoton ionization. Our XUV multilayer optics measurements include characterization of mirrors used for XUV telescopes, XUV projection lithography, and XUV plasma diagnostics. For many of the activities, the synchrotron radiation from SURF-II or NSLS is used as a source of tunable vacuum ultraviolet and soft x-ray radiation.

### A. **Generation of Coherent VUV** (P.D. Lett, T.B. Lucatorto, and T.J. McIlrath)

This work is primarily motivated by two applications: the possibility of laser cooling of atomic hydrogen, and the possibility of making a precise test of the theory of QED in two-electron atoms through the measurement of the Lamb shift in ground state He. The cooling of atomic hydrogen will require the efficient generation of coherent radiation at the Lyman-$\alpha$ wavelength, 121.6 nm; the experimental determination of the He ground state Lamb shift requires radiation at 120.3 nm. In this past year, we have generated these two wavelengths by exploiting the recent advances in laser technology represented by the Ti:sapphire laser and the $\beta$-barium borate (BBO) non-linear crystal.

The upconversion schemes utilize tunable Ti:sapphire or dye lasers and BBO non-linear crystals to generate radiation near 215 nm which is then used in resonantly enhanced, four-wave ($2\omega_1 - \omega_2$) mixing schemes in mixtures of Kr:Ar or Xe:Ar. The new capability for efficient generation of radiation near 215 nm provided by BBO allows us to effectively pursue these $2\omega_1 - \omega_2$ schemes which have considerable resonant enhancement of efficiencies as compared to those previously obtained; preliminary measurements show for both the generating of 121.6 nm and 120.3 nm radiation four-wave mixing efficiencies of about $10^{-4}$.

The development of sources to laser cool hydrogen will be done in two stages. First, we shall build a 10 Hz source to cool hydrogen that is confined in a magnetic trap or "bottle". Such traps have been constructed by several of our colleagues. They use a He dilution refrigerator to cool spin-aligned hydrogen to a temperature of $T$ = 80 mK which remains trapped for a period of many minutes. The application of a 10 Hz pulsed laser source of Lyman-$\alpha$ will cool the trapped H to approximately 7.5 mK, which will allow further experimentation to proceed such as on Bose-Einstein condensation and collisions at ultra-cold temperatures.

The second stage will be the development of a more powerful source to decelerate H formed by dissociation of $H_2$ at liquid helium temperature (4 K). This capability will free us from the need to use a He dilution refrigerator. This source will use either a series of 100-picosecond mode-locked pulses at a 100 MHz repetition rate in a 10- microsecond macro-burst or a single 5-microsecond pulse to decelerate and cool the hydrogen beam. The construction of such a source will advance the state of the art in coherent VUV generation and benefit other areas such as spectroscopy and plasma diagnostics as well.

The techniques developed for the Lyman-$\alpha$ source at 121.6 nm are obviously similar to those needed for the 120.285 nm source which is to be used for the precise measurement of the He ground state energy. Presently, the Spectroscopy Group in the Atomic Physics Division has an ongoing program to provide highly accurate laser spectroscopic measurements (uncertainties of several MHz) of many He excited state energy levels, including the 1s2s $^1$S. Because the ground 1s$^2$ $^1$S is over 21 eV from the lowest single-photon allowed excited state, no laser measurement has yet been made of the ground level, and the best present value is derived from conventional grating-based spectrometry with an uncertainty of 4.5 GHz. We plan to measure the 1s$^2$ $^1$S – 1s2s $^1$S energy separation by a laser-induced two-photon transition between the two levels with the 120.285 nm source. The preliminary accuracy is expected to be in the range of 150 MHz, or about 30 times better than the present status.

## B. Soft X-Ray Emission Studies of Advanced Materials (D.L. Ederer and D.R. Mueller; T.A. Callcott, *Univ. of Tennessee*; J.-E. Rubensson, *Univ. of Uppsala, Sweden*)

Soft x-ray fluorescence can provide important information about the electronic states of solid state materials. Fluorescence measurements can be used to study the properties of alloys, impurities, clusters, surface layers, organics, and other fragile compounds. A novel, high sensitivity soft x-ray spectrometer especially designed for fluorescence measurements has been in operation at the NSLS for almost four years now and is the proud accomplishment of a joint NIST - University of Tennessee - Oak Ridge National Laboratory collaboration. Recent experiments have proven it to be one of the best instruments in the world for soft x-ray fluorescence measurements.

The unique capabilities of the instrument have attracted a number of collaborators including scientists at the University of Hawaii, the University of Connecticut, the University of Uppsala, AT&T Bell Laboratories, Bellcore Laboratories, and NIST colleagues from the Materials Science and Engineering Laboratory (MSEL). The collaboration with AT&T has focussed on studies of thin film epitaxially grown samples of cobalt and nickel silicide and disilicide. Through collaboration with our MSEL colleagues, we commenced studies of $Nd_{1.85}Ce_{0.15}Cu0_4$ superconducting ceramics. This last area of research has been funded as part of a NIST-wide initiative on high temperature superconductors.

A few of the highlights of this program are:

### 1. High-$T_c$ Superconductors

We have examined the valence electronic structure of $Nd_{1.85}Ce_{0.15}Cu0_4$ and of $Nd_2Cu0_4$ via photon-excited Cu $M_{2,3}$ and O *K* soft x-ray emission spectra. For $Nd_{1.85}Ce_{0.15}Cu0_4$ the Cu $M_2$ and $M_3$ emission shows three peaks each separated by ~ 4 eV and extending over an energy range of more than 8 eV. The O *K* emission spectrum shows a single broad band ~ 6 eV in width. The measurements do not resemble partial density of states predictions based on either local density approximation band structure calculations or simple Hubbard-type models. The measurements of photon-excited Cu $M_{2,3}$ emission from $Nd_{1.85}Ce_{0.15}Cu0_4$ were compared with similar spectra obtained from Cu0 and $Cu_20$. Large differences in the energy position of these bands have been observed and are being interpreted. We have also observed significant modification of the emission bands in hydrogenated $YBa_2Cu0_x$. These measurements have been made in collaboration with Reuben Shuker of Ben-Gurion University.

### 2. Local Partial Density of States in Ni and Co Silicides Studied by Soft X-Ray Emission Spectroscopy

The Ni and Co mono- and di-silicides have been studied by soft x-ray emission spectroscopy in the spectral region of the Si $L_{2,3}$ valence emission band. Partial densities of states localized on Si sites in these silicides have been derived from the spectra and compared with available theoretical calculations. We found that the measured s and d partial densities of states agree well with available theoretical calculations, which predict the s-d bonding observed. The Ni and Co $M_{2,3}$ emission spectra for these silicides were also obtained and provide a representation of d-symmetry states localized at nickel atoms in these silicides.

### 3. Resonant Absorption and Emission From Localized Core-Hole States in $Al_2O_3$ and $SiO_2$

We have compared the Al $L_{2,3}$ and Si $L_{2,3}$ emission and reflection spectra of $Al_2O_3$ and $SiO_2$ to obtain information on the nature of the excited states in the presence of the $L_{2,3}$ holes. We are able to report fine structure in the emission spectra above the $L_{2,3}$ edges which coincides with structure in the reflection spectra. These features appear both in the bandgap and in the conduction band. Features such as these in the bandgap are typically identified as excitons, while those in the conduction band must be localized excited states. Therefore, we are proposing that measurements of the absorption coefficient for $SiO_2$ and $Al_2O_3$ above the $L_{2,3}$ edge should be interpreted in terms of localized excitations in the presence of a core hole, rather than interband transitions.

### 4. The Design of the Plane Grating Monochromator

Last year we put a transmission grating monochromator into service. This device selects a narrow band of the continuum radiation from the storage ring to excite the fluorescence. Fluxes between $10^{12}$ and $10^{13}$ photons/sec are readily obtainable in a band width of about 4 eV. One year of operation with the transmission grating monochromator has proven the instrument of marginal use at many synchrotron radiation facilities. The high power density (10 W/cm$^2$) incident on the grating damages it and renders it useless after several hundred hours of operation. We have designed a new instrument using a plane diffraction grating and will place it in operation during FY91.

### 5. The Low Noise, Large Area Position Sensitive Detector

A new position sensitive detector that has two orders of magnitude less noise and a factor of two more sensitivity than the old CCD detector has been installed at the soft-x-ray spectrometer at the National Synchrotron Light Source. This detector system, now in operation for about one year, has permitted us to obtain higher quality data in a shorter time, and to examine samples that are more dilute or more fragile than those we were able to examine previously. We have made a study of the electron rich superconductor $Nd_{1.85}Ce_{0.15}CuO_4$ and of the copper oxides, CuO and $Cu_2O$, using photon excitation. In these studies very weak copper emission features were observed and interpreted.

## C. Synchrotron-Laser Hybrid Experiments: Quenching the Fluorescence from a Core-Exciton (D.L. Ederer and D.R. Mueller; R. Shuker, *Ben-Gurion Univ.*)

The laser-synchrotron hybrid multicolor photon project is heading in the direction of developing new technology to explore the nanosecond and ultimately the pico- and sub-picosecond time regime in the VUV and soft x-ray region of the spectrum. In our first attempt to test the feasibility of the technique, we use synchrotron radiation to quench the fluorescence from a core exciton. The localized electron-hole pair is similar to a Rydberg state. The results of the experiment can be used to infer the radiative lifetime of the exciton. The expected signal level from these experiments is low, and most work to date has involved refinement of the measurement system.

Progress in this research was made in several areas during FY90. We tested a frequency divider to lock the laser to SURF-II. However, most work continued to be done at NSLS. A diode was installed in the sample chamber at NSLS to provide an absolute real-time monitor of the spatial and temporal positions of the laser and synchrotron light pulses. Preliminary experiments were performed to study the modified reflectance of a aluminum oxide sample. A measurement of the silicon valence emission band was made using soft x-rays when the laser was used to create localized excited states in silicon. The results of these two experiments are still being analyzed.

### D. Resonance Ionization Mass Spectrometry Data Service (E.B. Saloman)

The techniques of Resonance Ionization Spectroscopy (RIS) and Resonance Ionization Mass Spectroscopy (RIMS) have demonstrated high elemental sensitivity and the potential for almost 100% efficiency. They should become most valuable tools for analytical chemistry. For these techniques to meet their potential, they must be made available to practicing analytical chemists. Presently much of the information needed to apply RIS and RIMS is scattered in several atomic data bases, which contain much more information than the chemists would need. It is the object of this project to organize the available data and supplement it with calculations where the many gaps exist to provide the needed information to permit the application of RIS and RIMS to routine use in analytical chemistry.

We calculated and collected the required information and produced the second set of ten data sheets for the RIS/RIMS data service. This work is being carried out in close collaboration with the RIS/RIMS community to make sure the necessary information is provided. The first set of data sheets covering the elements Al, Ca, Cs, Cr, Co, Cu, Kr, Mg, Hg, and Ni have been published. Arrangements were made with the editor-in-chief of the widely read analytical chemistry journal Spectrochimica Acta Part B for publication on a continuing basis of the RIS/RIMS data sheets in the journal. The second ten data sheets have been accepted for publication. In addition a data base of RIS/RIMS work is being maintained.

### E. Resonant Ionization for Isotope Separation and Ultrasensitive Analysis (T.B. Lucatorto and T.J. McIlrath; L.J. Moore and X. Xiong, *Eastern Analytical, Inc.*; Q. Li, *Univ. of Maryland*; I. Belal, *Fulbright Fellow, Tishreen Univ. Syria*)

In most present applications of RIS, the selectivity of the resonantly enhanced ionization is used to distinguish between different elements, but not between different isotopes of the same element (A notable exception is the laser isotope separation project at Livermore National Laboratory.). We have been employing high resolution, Doppler-free RIS to explore the potential of using the optical isotope shift to add isotopic selectivity to the ionization process as a means of improving isotope abundance sensitivity in analytical mass spectrometry and of developing viable techniques for producing separated isotopes.

We are currently engaged in two experiments: a study of the AC Stark effect in the 4s8p and 4s9p $^1P^\circ_1$ levels in Ca; and a study of efficient ionization pathways in Ca. The AC Stark effects causes a shifting and broadening of the resonance in the multiphoton ionization process, a factor that can affect the selectivity markedly. We have chosen to look at the AC Stark effects that would arise when an intense IR laser is used to produce efficient ionization of the resonantly excited atoms. The model now used to calculate the AC Stark shifts for Rydberg levels predicts a blue shift nearly equal to the pondermotive potential of a free electron in the laser field. Recent experimental results disagree with these calculations by over a factor of two. Our work is intended to check these experiments and extend the range of the measurements in an effort to resolve the discrepancies.

Research on bone demineralization in weightlessness and in certain diseases has created large demands for samples highly enriched in the rare isotopes $^{46}$Ca (0.003% natural abundance) and $^{48}$Ca (0.18% natural abundance). Enriched samples are now produced by a Calutron (a large scale electromagnetic isotope separator) at costs ($3000/mg for $^{46}$Ca and $260/mg for $^{48}$Ca) that seriously limit the level of biomedical research activity in this field. Our goal is to find an effective Doppler-free resonant ionization pathway that will allow efficient laser isotope separation with existing laser technology.

A candidate pathway has been identified: a two-photon resonant transition $4s^2\ ^1S_0$ - $3d5s\ ^1D_2$, driven by a laser tuned to 421.5 nm followed by a resonant $3d5s\ ^1D_2$ - $3d7p\ ^1P^\circ_1$ (autoionizing) transition driven by a laser tuned to 843.0 nm. Our preliminary measurements show that it should be possible to achieve fairly efficient CW isotopically selective ionization of an atomic Ca beam with laser intensities of $I_{412.5} \sim 5$ W cm$^{-2}$ and $I_{843} \sim 300$ W cm$^{-2}$. We expect that such intensities should be available with the new Ti:sapphire laser technology in the near future.

This work is being done under a Collaborative Research and Development Agreement (CRDA) with Eastern Analytical Inc., a company that is part of the University of Maryland Technology Advancement Program.

### F. Soft X-ray Optical Metrology (R.N. Watts, D.L. Ederer, and T.B. Lucatorto; R.P. Madden, *Far UV Physics Group*)

In order to support the development of x-ray optics for basic research and for applications to such areas as x-ray lithography and XUV astronomy, a NIST Competence Program has been initiated which involves our Division and the Precision Engineering Division. At present, our part of this program consists of maintaining the Nation's only reflectrometry facility for the characterization of the spectral reflectivity of soft x-ray optics. The work in the Precision Engineering Division focusses on developing new techniques to characterize surface figure and surface finish of these optics.

Our reflectometer has been used, over the course of the past year, in a variety of measurements. We have measured the spectral reflectivity of mirrors used by: AT&T Bell Laboratories in their demonstration of an experimental capability to achieve 0.05 micron resolution projection lithography; IBM for applications to XUV telescopes; Lawrence Livermore National Laboratory (LLNL) for x-ray lasers; Stanford University and the University of Colorado for XUV telescopes; and Johns Hopkins University for XUV plasma diagnosis. In addition to these reflectivity measurements, we have performed measurements on the transmission of soft x-ray filters, the dosimetry of soft x-ray films, and optical studies of the magnetic properties of the transition metals. One measurement of particular interest involved an intercomparison of our facility with the BESSY reflectometry facility in West Berlin. Both laboratories measured the same set of multilayer mirrors, supplied by LLNL, within a one month period and found the reflectivity as a function of wavelength to be virtually identical. This test gives an important confirmation to the accuracies of both the NIST and BESSY instrumentation.

We are presently looking to upgrade and extend our XUV capabilities and are in the process of designing and constructing a new monochromator/reflectometer beamline at SURF-II. The plan is to install the new instrument within two years. The new reflectometer should be able to reach energies slightly above the carbon edge, the limit imposed by the output of SURF-II. In addition, the fixed entrance and exit slit design of the monochromator should allow larger samples to be examined and more sophisticated measurements to be made. The use of a higher order filter should decrease the amount of second order light present at the sample, the main source of systematic error in the present device. Also, we expect to be able to make measurements of both s and p polarization reflectivity and to add the capability, via a sensitive two-dimensional CCD detector, to make non-specular diffuse scattering measurements.

We are also in the process of developing an optical test bed for the characterization of entire optical systems. Our first goal is to develop a "nanodetector", a two-dimensional electronic detector with 20 nm resolution. This detector will allow us to make real time measurements of image quality and field illumination for assembled systems and measurements of interference patterns for soft x-ray interferometric characterization of figure. The present nanodetector will be designed to work at 13 nm. In principle, the concept should be capable of implementation at shorter wavelengths and higher resolutions, and we envision broad applications of such detectors to mask checking and repair and to x-ray microscopy in general.

### G. Theoretical Atomic, Molecular, and Optical Physics (C.W. Clark and S. Blodgett-Ford, NIST; L. Pan and J.D. Parker, *Univ. of Maryland*; K.T. Taylor, *Royal Holloway and Bedford New College, Univ. of London*)

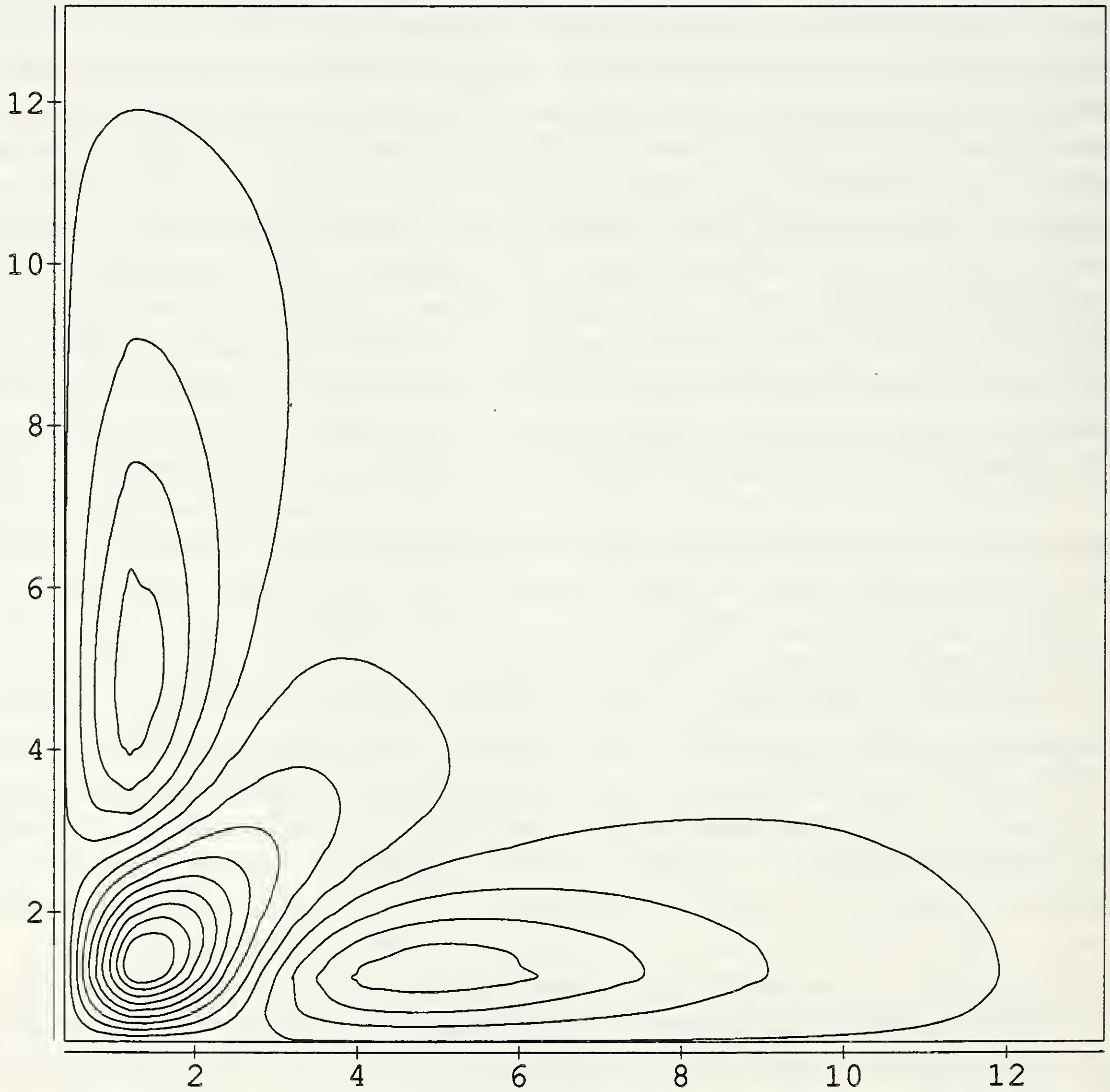
The main research activities in this program involve the study of atoms in strong radiation fields, and XUV photoabsorption by transition metals and lanthanides.

Work on atoms in strong radiation fields was carried out in two independent directions: the application of high-order perturbation theory, which continues an approach developed over the past two years; and numerical integration of the time-dependent Schrödinger equation, which is a new thrust.

The main development in the work on high-order perturbation theory involved the extension of our Sturmian function approach to treat final states in the photoionization continuum. This was done via a complex-coordinate-rotation technique, which gives us a perturbative expansion for the complex energies of a non-Hermitean Hamiltonian in powers of the external field strength. In this picture, all atomic states become resonances in the presence of the field; the imaginary part of the complex energy of a resonance is inversely proportional to its lifetime. The coefficients in the expansion are independent of the complex-coordinate rotation angle, which is a significant advantage over previous methods. By this approach we are able to compute the energy shifts associated with above-threshold ionization (ATI) channels, in which photons are absorbed by a continuum electron. We find that the onset of ATI can either increase or decrease the total ionization rate, in a manner which depends in a complicated fashion upon the radiation frequency. Comparisons made with independent, non-perturbative calculations show that corrections to lowest-order perturbation theory can be significant in intensity regimes where perturbation theory is effectively convergent, so the utility of this approach is not limited to cases in which lowest-order perturbation theory is dominant. The nonlinear susceptibilities that describe high-harmonic generation were also calculated by this method. The qualitative behavior of the high-order susceptibilities changes when the highest virtual state lies in the continuum vs. the discrete spectrum: the critical intensity $I_c$, at which perturbation theory breaks down, decreases with increasing order when ionization is energetically forbidden, but exhibits an increase as the ionization threshold is crossed. Perturbation theory was also applied to the excitation of hydrogen by radiation at two frequencies, $\omega$ and $2\omega$, with a fixed phase relationship. This is a problem that has recently become of experimental interest. The results show that the ionization rate depends upon the phase, in a manner that is determined by the continuum phase shifts of the electronic wavefunction. This is a completely different mechanism than the enhanced tunneling that is predicted in classical treatments of the problem.

Numerical integration of the time-dependent Schrödinger equation for hydrogen in a radiation field began in earnest, building upon preliminary work done in FY89. The main advance involved the adoption of massively parallel processing techniques on a Connection Machine computer. This approach divides configuration space into many (up to several thousand) distinct regions, each of which is handled by a dedicated central processing unit (CPU) with a small amount of local memory. Each CPU integrates the equations of motion within its own region, using the contents of its own local memory and that of its nearest neighbors. Thus the time taken to solve the equations is roughly independent of the number of regions, if a sufficient number of processors are available. We have integrated the equations of motion for hydrogen in radiation fields of various frequencies and intensities (up to $10^{15}$ W cm$^{-2}$), over about ten optical cycles. Machine performance of several gigaflops has been attained, which is still somewhat below the theoretical limit for the configuration we are using (the CM-2 facility at the Northeast Center for Parallel Architectures, Syracuse University). We find the plateau phenomenon in the harmonic radiation spectrum, and get field-induced shifts of above-threshold ionization peaks that are in good agreement with recent experimental results from the University of Bielefeld. Work has been started on the dynamics of two-electron atoms in strong radiation fields. A significant amount of analytical work has been done in support of the numerical effort. This has led to a comprehensive understanding of the propagation of a free wavepacket on a discrete mesh, and to a closed-form solution of the bound s states of hydrogen in the discretized representation.

Our work in core-electron excitation in transition metals and lanthanides resulted in the completion of a study of 3p photoabsorption in Cr, Mn, and their ions. Some progress was made towards the understanding of electron impact excitation of collapsed 4f states in Cs and CsO. In addition, some systems of interest in the x-ray emission experiments were dealt with.The one permanent staff member in this area assumed significant administrative duties, but the resulting loss in productivity was offset by the addition of a postdoctoral research associate.




Level contours of the difference of probability distributions between the ground state of $H^-$, as computed by the diffusion method on the Connection Machine (in the approximation $l_1 = l_2 = 0$), and the Hartree-Fock (HF) density. Axes give the electronic coordinates $r_1$ , $r_2$ in atomic units. The HF density is larger in the region $r_1 \approx r_2$. The electron affinity in the diffusion approximation is 384 meV, compared to the experimental value of 754 meV. Radial correlation thus accounts for about 2/3 of the correlation energy.

## VI. CALIBRATION SERVICES PERFORMED

| *Type of Service* | *Customer Type* | *SP 250 Item No.* | *Number of Calibrations or Tests* |
|---|---|---|---|
| Far UV radiometric transfer standard detectors (photodiode calibrations) | 1,4-8 | 40510C<br>40511C<br>40520C<br>40531C<br>40560C<br>40561C<br>40599S | 29 |
| Spectrometer calibration using SURF-II as an absolute source | 5-7 | N/A | 16 |
| Total Calibrations | | | 45 |

Customer types: 1) calibration labs; 2) hospitals; 3) nuclear energy establishments; 4) industry; 5) US government labs; 6) DoD labs; 7) universities; 8) foreign governments.

## VII. PUBLICATIONS

### A. Publications appearing in print

Aeschlimann, M., Scheinfein, M.R., and Unguris, J., "Magnetic-Field-Modulated Written Bits in TbFeCo Thin Films: Transmission Electron Microscopy Lorentz and Scanning Electron Microscopy with Polarization Analysis Studies," J. Appl. Phys. **68** 4710 (1990).

Apell, P., Albertsson E., and Penn, D.R., "Extended Transfer Hamiltonian Method for Resonant Tunneling," in Proceedings of the 12th Werner Brandt International Conference on Penetration of Charge Particles of Matter, San Sabastian, Spain, April 1990, p. 183.

Barbee, T.W., Jr., Weed, J.W., Hoover, R.B., O'Neal, R.H., Lindblom, J.F., Walker, A.B.C., Jr., Roberts, J.R., Saloman, E.B., Watts, R.N. and Barbee, T.W., III, "Performance of the Multi-Spectral Solar Telescope Array II: The Multilayer Mirrors," in Proceedings of the Society of Photo-Optical Instrumentation Engineers Symposium, **1343** (1990).

Brandt, R.G., Colton, R.J., Marrian, C.R.K., Murday, J.S. and Stroscio, J.A., "Fourth International Conference on Scanning Tunneling Microscopy/Spectroscopy (STM'89)," ONRFE Sci. Bul **15**, 75 (1990).

Calcott, T.A., Zhang, C.H., Ederer, D.L., Mueller, D.R., Rubensson, J.-E. and Arakawa, E.T., "The Photon Excitation of Soft X-Ray Emission Spectra," Nucl. Instr. and Methods **A291**, 13 (1990).

Canfield, L.R., Ogawa, H.S., McMullin, D. and Judge, D.L., "Sounding Rocket Measurement of the Absolute Solar FUV Flux Utilizing a Silicon Photodiode," J. of Geophys. Res. **95**, 4291 (1990).

Canfield, L.R., Kerner, J., Korde, R., "Silicon Photodiodes Optimized for the EUV and Soft X-Ray Regions," in Proceedings of the Society of Photo-Optical Instrumentation Engineers Symposium, **1344**, 372 (1990).

Clark, C.W., Pan, L., and Taylor, K.T., "High-order Harmonic Generation by Hydrogenic Ions," in Advances in Laser Science-IV, ed. by J.L. Gole, D.F. Heller, M. Lapp, and W.C. Stwally (AIP, New York, 1989) p. 504.

Clark, C.W., "Frequency-Dependent Polarizability of an Electron Bound by a Zero-Range Potential," J. Opt. Soc. Am. B **7**, 488 (1990).

Clark, C.W., Matthew, J.A.D., Ramsey, M.G., and Netzer, F.P., "Electron-Excited 4d $\rightarrow$ 4f Ba Resonances in $YBa_2Cu_3O_{7-\delta}$: Selection Rules at Intermediate Electron Energy," Phys. Rev. A **40**, 4902 (1989).

Cohen, M.L., Penn, D.R., and Barbee, T.W.,III, "Limitations on Electronic Mechanisms for High Temperature Superconducting Oxides," Solid State Commun. **75**, 971 (1990).

Cohen, M.L. and Penn, D.R., "Weak vs Strong Coupling Theory for $Bi_2Sr_2CaCu_2O_8$," Phys. Rev. B **42**, 8702 (1990).

Cutkosky, R.D., "Versatile Scan Generator and Data Collector For Scanning Tunneling Microscopes," Rev. Sci. Inst. **61**, 960 (1990).

Ederer, D.L., Callcott, T.A. Zhang, C.Hl, Tsang, K.-L., Arakawa, E.T., Kerner, J., "A Transmission Grating Beamline Monochromator for the VUV Synchrotron Light Source at NSLS," Nucl. Instruments and Methods in Physics Research **B40/41**, 398 (1989).

Falicov, L.M., Pierce, D.T., Bader, S.D., Gronsky, R., Hathaway, K.B., Hopster, H.J., Lambeth, D.N., Parkin, S.S.P., Prinz, G., Salamon, M., Schuller, I.K., and Victora, R.H., "Surface, Interface, and Thin-Film Magnetism," J. Mater. Res. **5**, 1299 (1990).

Girvin, S.M., Glazman, L.I., Jonson, M., Penn, D.R., and Stiles, M.D., "Quantum Fluctuations and the Single Junction Coulomb Blockade," Phys. Rev. Lett. **64**, 3183 (1990).

Hart, M.W., Scheinfein, M.R., Unguris, J., Pierce, D.T., and Celotta, R.J., "Scanning Electron Microscopy with Polarization Analysis (SEMPA) Studies of Surface Magnetic Microstructure," in Proceedings of the Symposium on Magnetic Materials, Processes and Devices, ed. by L.T. Romankiw and D.A. Herman, Jr. (The Electrochemical Society, Inc., 1990), p. 111.

Henke, B.L., Gullikson, E.M., Kerner, J., Oren, A.L., and Blake, R.L., "Design and Characterization of X-Ray Multilayer Analyzers for the 50-1000 eV Region," J. of X-Ray Sci. and Tech., **2**, 17 (1990).

Kelley, M.H., Becher, K.H., and Neill, P.A., "Synopsis of the Fifth International Symposium on Polarization and Correlation in Electronic and Atomic Collisions," Com. At. Mol. Phys. **24**, 171 (1990).

Kelley, M.H., McClelland, J.J., Celotta, R.J., "Spin Dependence in Electron-Atom Collisions," in Proceedings of the DOE Contractor's Workshop on Atomic Physics (Lawrence Berkeley Laboratory Report LBL- 27850, 1989) p. 37.

Kelley, M.H., "Spin Polarization, Orientation and Alignment in Electron-Atom Collisions," in The Physics of Electronic and Atomic Collisions, ed. by A. Dalgarno, R.F. Freund, P.M. Koch, M.S. Lubbell and T.B. Lucatorto, (AIP Conference Proc. **205**, American Institute of Physics, New York 1990) p. 103.

Kelley, M.H., "Uses of Spin-Polarized Electrons in Fundamental Electron-Atom Collision Processes and the Analysis of Magnetic Microstructures," Aust. J. Phys. **43**, 565 (1990).

Kurtz, R.L., Robey, S.W., Stockbauer, R.L., Mueller, D., Shih, A., Toth, L., Singh, A.K., and Ogofsky, M., "Electronic Structure of High-$T_c$ Superconductors Studied Using Photoelectron Spectroscopy," Vacuum **39**, 611 (1989).

Lett, P.D., Phillips, W.D., Rolston, S.L., Tanner, C.E., Watts, R.N., and Westbrook C.I., "Optical Molasses," J. Opt. Soc. Am. B **6**, 2084 (1989).

Lett, P.D., Westbrook, C.I., Watts, R.N., Rolston, S.L., Tanner, C.E., Phillips, W.D., and Gould, P.L., "Heterodyne Spectrum of the Fluorescence from Optical Molasses," in Coherence and Quantum Optics 6, ed. by J. Eberly, L. Mandel and E. Wolf, (Plenum Publishing, New York 1990), p. 681.

McClelland, J.J., Buckman, S.J., Kelley, M.H., and Celotta, R.J., "Search For a Joint Spin-Orbit and Exchange Asymmetry in Elastic Electron Scattering from Spin-Polarized Sodium," J. Phys. B: At. Mol. Opt. Phys. **23**, L21 (1990).

McClelland, J.J., "Progress on Spin Detectors and Spin-polarized Electron Scattering from Na at NIST," in Proceedings of the Fifth International Symposium on Polarization and Correlation in Electronic and Atomic Collisions, (NIST Special Publication 789, 1990) p. 102.

Mueller, D.R., Ederer, D.L., Rubensson, J.E., Shuker, R., Wallace, J., Zhang, C.H., Tai, J., Callcott, T.A., Dong, Q.-Y., Toth, L.E., Ragne, R., and Ogofsky, M., "A Soft X-Ray Emission Spectroscopy Investigation of $Bi_2Sr_2CaCu_2O_8$," Physica Scripta **41**, 979 (1990).

Mueller, D.R., Kurtz, R.L., Stockbauer, R.L., Madey, T.E., and Shih, A., "A Photoemission Study of BaO Overlayers Adsorbed on W(100) and Their Interaction with $H_2O$, $Co_x$, and $O_2$," Surface Science, **237**, 27 (1990).

Pan, L., "Treatment of Continuum-Continuum Coupling in the Theoretical Study of Above-Threshold Ionization," in Atoms in Strong Fields, ed. by C. Nicolaides, C.W. Clark and M. Nayfeh (Plenum Publishing, New York 1990) p. 447.

Pan, L., Taylor, K.T., and Clark, C.W., "Perturbation Theory Study of High Harmonic Generation," J. Opt. Soc. Am. **B 7**, 509 (1990).

Penn, D.R. and Apell, P., "Theory of Spin-Polarized Metastable Atom De-excitation Spectroscopy," Phys. Rev. B **41**, 3303 (1990).

Phillips, W.D., Westbrook, C.I., Watts, R.N., Rolston, S.L., Tanner, C.E., Lett, P.D. and Gould, P.L., "A Heterodyne Measurement of the Fluorescence Spectrum of Optical Molasses," in Laser Spectroscopy 9, ed. by M.S. Feld, J.E. Thomas and A. Mooradian (Academic Press, Inc., San Diego, CA, 1989) p. 8.

Roberts, J.R., Kerner, J. and Saloman E.B., "Soft X-ray Optics Characterization on SURF II," Physica Scripta **41**, 9 (1990).

Rubensson, J.E., Mueller, D.R., Shuker, R., Ederer, D.L., Zhang, C.H., Jia, J., and Callcott, T.A., "Excitation Energy Dependence in the $L_{2,3}$ Fluorescence Spectrum of Si," Phys. Rev. Lett. **64**, 1047 (1990).

Saloman, E.B., Kim, Y.-K., "A Comment on Labeling Conventions in Isoelectronic Sequences," (reply to), Phys. Rev. **42**, 1824 (1990).

Saloman, E.B., "A Resonance Ionization Spectroscopy/Resonance Ionization Mass Spectrometry Data Service I - Data Sheets for As, B, Cd, C, Ge, Au, Fe, Pb, Si, and Zn," Spectrochimica Acta Part **45B**, 37 (1990).

Scheinfein, M.R., Ryan, P.J., Unguris, J., Pierce, D.T., and Celotta, R.J., "180° Surface Domain Wall Magnetization Profiles: Comparisons Between Scanning Electron Microscopy with Polarization Analysis Measurements, Magneto-Optic Kerr Microscopy Measurements and Micromagnetic Models," Appl. Phy. Lett. **57**, 1817 (1990).

Scheinfein, M.R., Unguris, J., Pierce, D.T., and Celotta, R.J., "Surface Magnetic Microstructural Analysis Using Scanning Electron Microscopy with Polarization Analysis (SEMPA)," in Proceedings of the XIIth International Congress for Electron Microscopy, (San Francisco Press, San Francisco, CA 1990) p. 216.

Scheinfein, M.R., Unguris, J., Celotta, R.J., Pierce, D.T., Lee, M.R., Lee, S.Y., and Pressesky, J.L., "Correlation Between Magnetic Microstructure and Noise Spectra for CoNi and CoCr Ta Thin Film Media," INTERMAG-90 Digest, HB-08 (1990).

Scheinfein, M.R., Unguris, J., Pierce, D.T. and Celotta, R.J., "Surface Magnetic Microstructure," in Magnetism in Low Dimensional Systems II, ed. by L.M. Falicov, F. Mejia-Lira, and J.L. Moran-Lopez (Springer Verlag, Berlin, 1990) p. 1.

Scheinfein, M.R., Unguris, J., Kelley, M.H., Celotta, R.J. and Pierce, D.T., "Scanning Electron Microscopy with Polarization Analysis," Rev. Sci. Inst. **61**, 2501 (1990).

Scheinfein, M.R., Unguris, J., Pierce, D.T. and Celotta, R.J., "High Spatial Resolution Quantitative Micromagnetics," J. Appl. Phys. **67**, 5932 (1990).

Slaughter, J.M., Kearney, P.A., Schulze, D.W., Falco, C.M., Hills, C.R., Saloman, E.B., and Watts, R.N., "Interfaces in Mo/Si Multilayers," in Proceedings of the Society of Photo-Optical Instrumentation Engineers Symposium **1343**, (1990).

Slaughter, J.M, Burkland, M.K., Kearney, P.A., Lampis, A.R., Milanovic, Z., Schulze, D.W., Falco, C.M., Roberts, J., Kerner, J., and Saloman E.B., "Multilayer mirrors for 182 Å," in Proceedings of the Society of Photo-Optical Instrumentation Engineers Symposium **1160**, 235 (1989).

Stiles, M.D., and Hamann, D.R., "Electron Transmission Through Silicon Stacking Faults," Phys. Rev. B **41**, 5280 (1990).

Stiles, M.D. and Hamann, D.R., "Electron Transmission Through $NiSi_2$-Si Interfaces," Phys. Rev. B **40**, 1349 (1989).

Stockbauer, R.L., Robey, S.W., Kurtz, R.L., Mueller, D., Shih, A., Singh, A.K., Toth, L., and Ogofsky, M., "Resonant Photoemission and Chemisorption Studies of T1-Bu-Ca-Cu-O," in Proceedings of AIP Conference on High-$T_c$ Superconducting Thin Film Devices and Applications, ed. by G. Margaritondo, R. Joynt and M. Onellion (AIP Conference Proceedings v.182, American Institute of Physics, New York 1989) p. 276.

Stroscio, J.A., First, P.N., Dragoset, R.A., Whitman, L.J., Pierce, D.T., and Celotta, R.J., "Dispersion of Evanescent Band Gap States in Fe Clusters on GaAs(110)," J. Vac. Sci. Tech. A, 8, 284 (1990).

Tanuma, S., Powell, C.J., and Penn, D.R., "Material Dependence of Electron Inelastic Mean Free Paths at Low Energies," J. Vac. Sci. Tech. A, 8, 2213 (1990).

Tanuma, S., Powell, C.J., and Penn, D.R., "Electron Inelastic Mean Free Paths in Solids at Low Energies," J. Electr. Spect. **52**, 285 (1990).

Unguris, J., Scheinfein, M.R., Celotta, R.J., and Pierce, D.T., "Scanning Electron Microscopy with Polarization Analysis: Studies of Magnetic Microstructure," in Chemistry and Physics of Solid Surfaces VIII, ed. by R. Vanselow and R. Howe (Springer-Verlag, Berlin, 1990) p. 239.

Westbrook, C.I., Watts, R.N., Rolston, S.L., Tanner, C.E., Lett, P.D., Phillips, W.D., and Gould, P.L., "Localization of Atoms in a Three-Dimensional Standing Wave," Phys, Rev. Lett., **65**, 33 (1990).

Whitman, L.J., Joyce, S.A., Yarmoff, J.A., McFeely, F.R., and Terminello, L.J., "The Chemisorption of Chlorosilanes and Chlorine on Si(111)7x7," Surf. Sci. 232, 297 (1990).

Whitman, L.J., Joyce, S.A., Yarmoff, J.A., McFeely, F.R. and Terminello, L.J., "Summary Abstract: The Chemisorption of $SiCl_4Si_2Cl_6$, and Chlorine on Si(111)7x7," Vacuum 41, 1056 (1990).

Whitman, L.J., Stroscio, J.A., Dragoset, R.A., and Celotta, R.J., "Scanning Tunneling Microscopy Study of InSb(110)," Phys. Rev. B 42, 7288 (1990).

Zwicker, A.P., Regan, S., Finkenthal, M., Moos, H.W., Saloman, E.B., Watts, R., and Roberts, J.R., "Peak Reflectivity Measurements of W/C, Mo/Si and $Mo/B_4C$ Multilayer Mirrors in the 8-190 Å Range Using Both K$\alpha$ Line and Synchrotron Radiation," Appl. Opt. 29, 3694 (1990).

**B. Publications Submitted or in Press**

Buckman, S.J. and Clark, C.W., "Atomic Negative Ion Resonances," Rev. Mod. Phys. (in preparation).

Callcott, T.A., Zhang, C.H., Tsang, K.-L., and Ederer, D.L., "Densities of States in LiAl From Soft X-ray Emission Spectra," Phys. Rev. B (in preparation).

Canfield, L.R., Mueller, D.R., Ederer, D.L., Shuker, R., Blendell, J.E., Clark, C.W., Zhang, C.H., Callcott, T.A., and Tsang, K.L., "Soft X-Ray Emission and the Electronic Structure of $YBa_2Cu_3O_x$," Synchrotron Radiation News (in press).

Celotta, R.J., Unguris, J., Scheinfein, M.R., "The Polarized Electron Microscope," Scient. Amer. (submitted).

Celotta, R.J., Scheinfein, M.R., Unguris, J., Pierce, D.T., "Magnetic Imaging Via Scanning Electron Microscopy with Polarization Analysis," in Proceedings of NATO ASI Advance Study Institute on the Science and Technology of Nanostructured Magnetic Materials, July 1990, Crete, Greece, (Plenum Press, New York) (in press).

Costello, J.T., Kennedy, E.T., Sonntag, B.F., and Clark, C.W., "3p-Photoabsorption of Free and Bound Cr, $Cr^+$, Mn and $Mn^+$," Phys. Rev. A (in press).

First, P.N., Stroscio, J.A., Pierce, D.T., Dragoset, R.A., and Celotta, R.J., "A System for the Study of Magnetic Materials and Magnetic Imaging with the STM," J. Vac. Sci. Technol. (in press).

Jai, J.J., Callcott, T.A., O'Brien, W.L., Dong, Q.Y., Rubensson, J.-E., Mueller, D.R., Ederer, D.L., and Rowe, J.E., "Local Partial Densities of States in Ni and Co Silicides Studied by Soft X-Ray Emission Spectroscopy," Phys. Rev. B (submitted).

Kelley, M.H., McClelland, J.J., Lorentz, S.R., Celotta, R.J., "Polarized-Electron - Polarized-Atom Scattering," in Proceedings of the 15th International Symposium on the Physics of Ionized Gases, September 3, 1990, Dubrovnik, Yugoslavia. (submitted).

Lett, P.D., Jessen, P., Westbrook, C.I., Rolston, S.L., Phillips, W.D., Julienne, P.S., and Gould, P.L., "Ultracold Collisions: Associative Ionization in a Laser Trap," in Proceedings of the LIKE Workshop, Isola de Elba, Italy, May 4, 1990, ed. by L. Moi (in press).

Li, Q., McIlrath T.J., Saloman, E.B., and Lucatorto, T.B., "RIS Studies of Autoionization of Calcium," in Proceedings of the Fifth International Symposium on Resonance Ionization Spectroscopy and Its Applications (in press).

McClelland, J.J. and Scheinfein, M.R., "Laser Focusing of Atoms: A Particle Optics Approach," J. Opt. Soc. Amer. B (submitted).

Mueller, D.R., Ederer, D.E., Rubensson, J.-E., Shuker, R., Jai, J., Calcott, T.A., Chang, C.K., and Wong-Ng, W., "A Soft X-Ray Fluorescence Investigation of the Superconducting Oxide $Nd_{1.85}Ce_{0.15}CuO_4$ and its Parent Compound $Nd_2CuO_4$," Phys. Rev. B. (submitted).

Pan, L., Taylor, K., and Clark, C.W., "Perturbative Calculation of the AC Stark Effect by the Complex Coordinate Method," Phys. Rev. A (submitted).

Pan, L., Taylor, K., and Clark, C.W., "Convergence of Rayleigh-Schrödinger Perturbation Theory in Calculations of Multiphoton Processes," Radiation Effects and Defects in Solids (submitted).

Penn, D.R. and Apell, P., "Spin Polarized Metastable Atom De-excitation, Theory," in Proceedings of the 11th European Conference on Surface Science (in press).

Phillips, W.D., Lett, P.D., Rolston, S.L., Tanner, C.E., Watts, R.N., Westbrook, C.I., Salomon, C., Dalibard, J., Clairon, A., and Guellati S., "Atoms in Optical Molasses: Applications to Frequency Standards," in Proceedings of the Fourth European Frequency and Time Forum, Neuchatel, Switzerland, March 1990, (in press).

Phillips, W.D., Lett, P.D., Rolston, S.L., Tanner, C.E., Watts, R.N., Westbrook, C.I., Salomon, C., Dalibard, J., Clairon A., and Guellati, S., "Optical Molasses: Cold Atoms for Precision Measurements," in Proceedings of CPEM 90, Ottawa, Canada, June 1990, IEEE (in press).

Phillips, W.D., Lett, P.D., Rolston, S.L., Tanner, C.E., Watts, R.N., Westbrook, C.I., Salomon, C., Dalibard, J., Clairon, A., and Guellati S., "Optical Molasses: The Coldest Atoms Ever," Physica Scripta (1990) (in press).

Phillips, W.D., Lett, P.D., Rolston, S.L., Tanner, C.E., Watts, R.N., Westbrook, C.I., Salomon C., Dalibard, J., Clairon A., and Guellati, S., "Atoms in Optical Molasses," in Proceedings of the LIKE Workshop, Isola de Elba, Italy, May 1990, (in press).

Saloman, E.B., "The National Institute of Standards and Technology Resonance Ionization Spectroscopy/Resonance Ionization Mass Spectroscopy Data Service," in Proceedings of the Fifth International Symposium on Resonance Ionization Spectroscopy and Its Applications (in press).

Saloman, E.B., "A Resonance Ionization Spectroscopy/Resonance Ionization Mass Spectroscopy Data Service II - Data Sheets for A1, Ca, Cs, Cr, Co, Cu, Kr, Mg, Hg, and Ni, Spectrochim," Acta B (1991) (in press).

Scheinfein, M.R., Unguris, J., Blue, J.L., Coakley, K.J., Pierce, D.T., Celotta, R.J., Ryan, P.J., "Micromagnetics of Domain Walls at Surfaces," Phys. Rev. B (in press).

Scheinfein, M.R., Unguris, J., Aeschlimann, M., Pierce, D.T., Celotta, R.J., "Scanning Electron Microscopy with Polarization Analysis (SEMPA) Studies of Domains, Domain Walls and Magnetic Singularities at Surfaces and in Thin Films," J. Mag. Mat. (in press).

Scheinfein, M.R., Unguris, J., Pierce, D.T., Celotta, R.J., "Correlations of Magnetic Microstructure and Anisotropy with Noise Spectra for CoNi and CoCrTa Thin Film Media," IEEE Transactions on Magnetics, September 1990 (in press).

Shih, A., Hor, C., Elam, W., Kirkland J., and Mueller, D.R., "The Surface Geometry of BaO on W(100): A Surface EXAFS Study," Phys. Rev. B (submitted).

Taylor, K.T. and Clark, C.W., "The Finite-Difference Approximation to the Schrödinger Equation: Solution for a Free Particle and the Hydrogen Atom," J. Phys. B: At. Mol. Opt. Phys. (in preparation).

Westbrook, C.I., Jessen, P., Tanner, C.E., Lett, P.D., Rolston, S.L., Watts, R.N., and Phillips, W.D., "Measurements of Fluorescence from Cold Atoms: Localization in Three-Dimensional Standing Waves," Atomic Physics 12 (in press).

Whitman, L.J., Stroscio, J.A., Dragoset, R.A., and Celotta, R.J., "A Scanning Tunneling Microscopy Study of Clean and Cs-covered InSb(110)," J. Vac. Sci. Technol. A, March/April 1991 (in press).

Whitman, L.J., Stroscio, J.A., Dragoset, R.A., and Celotta, R.J., "Geometric and Electronic Properties of Cs Structures on III-V (110) Surfaces: from 1-D and 2-D Insulators to 3-D Metals," Phys. Rev. Lett. (submitted).

Windt, D.L., Waskiewicz W.K., Kubiak, G.D., Barbee, T.W., Jr., and Watts, R.N., "XUV Characterization Comparison of Mo/Si Multilayer Coating," X-Ray/EUV Optics for Astronomy, Microscopy, Polarimetry, and Projection Lithography, ed. by R.B. Hoover and A.B.C. Walker, Jr. (in press).

## VIII. TECHNICAL PRESENTATIONS

### A. Invited Talks

Aeschlimann, M., "Spatial and Temporal Resolved Studies on Magneto-Optical Recording Materials," Argonne National Laboratory, Chicago, IL, March 30, 1990.

Aeschlimann, M., "Ultrafast Thermomagnetic Writing Processes in Rare-Earth Transition-Metal Thin Films," 34th MMM Conference, Boston, MA, November 28, 1989.

Apell, P., "Spin Polarized Metastable Atom De-excitation, Theory," Norwegian Institute of Technology, Trondheim, Norway, September 7, 1990.

Apell, P., "Spin Polarized Metastable Atom De-excitation, Theory," NATO Advanced Study Institute, Alicante, Spain, May 7, 1990.

Celotta, R.J., "Frontiers of Electron Microscopy," Council for Chemical Research, 12th Annual Meeting, Washington, DC, October 25, 1990.

Celotta, R.J., "SEMPA Imaging," NATO Advanced Study Institute on the Science and Technology of Nanostructured Magnetic Materials, Heraklion, Greece, June 30, 1990.

Celotta, R.J., "Tunneling Microscopy of Atoms on Surfaces," Division of Atomic, Molecular, and Optical Physics Meeting, Monterey, CA, May 23, 1990.

Celotta, R.J., "Magnetic Microstructure Via SEMPA," Physics Colloquium, University of Texas, Austin, TX, November 9, 1989.

Celotta, R.J., "Magnetic Microstructure Via SEMPA," Physics Colloquium, Rice University, Houston, TX, November 8, 1989.

Celotta, R.J., "Atom and Surface as Observed by Polarized Electrons," Chemistry Department Colloquium, Johns Hopkins University, Baltimore, MD, October 10, 1989.

Clark, C.W., "Order and Chaos in the Spectra of Highly-Excited Atoms," Physics Seminar, Towson State University, Towson, MD, December 4, 1990.

Clark, C.W., "The Solution of the Schrödinger Equation on a Discrete Lattice," Surface Lunch Bunch Meeting, NIST, Gaithersburg, MD, November 5, 1990.

Clark, C.W., "High-Order Perturbation Theory of Atoms in Strong Radiation Fields," International Conference on Coherent Radiation Processes in Strong Fields, Catholic University of America, Washington, DC, June 19, 1990.

Clark, C.W., "Further Adventures in Shell Collapse," Electron and Optical Physics Division Seminar, NIST, Gaithersburg, MD, March 30, 1990.

Clark, C.W., "Atomic Physics in the Solid State: Giant Resonances, Excitons, and High-Temperature Superconductivity," Physics Department Colloquium, University of Connecticut, Storrs, CT, February 16, 1990.

Clark, C.W., "Progress Towards the Generation of Coherent XUV Radiation," Winter College on High Resolution Spectroscopy, International Center for Theoretical Physics, Trieste, Italy, January 23, 1990.

Clark, C.W., "Progress Towards the Generation of Coherent XUV Radiation," Conference on Lasers in Science and Technology, Amman, Jordan, October 9, 1989.

Ederer, D.L., "Soft X-Ray Fluorescence Spectroscopy as a Tool for the Study of Exotic Materials," University of Nevada-Reno, March 12, 1990.

First, P.N., "Scanning Tunneling Microscopy of Metals on Semiconductor Surfaces," Condensed Matter Seminar, University of Washington, Seattle, WA, March 8, 1990.

First, P.N., "Growth and Electronic Properties of Metals on GaAs(110)," IBM Almaden Research Center, San Jose, CA, March 5, 1990.

First, P.N., "Scanning Tunneling Microscopy of Metals on Semiconductor Surfaces," Physics Department, University of Tennessee, Knoxville, TN, October 23, 1989.

First, P.N., "Scanning Tunneling Microscopy of Metals on Semiconductor Surfaces," Oak Ridge National Laboratory, Oak Ridge, TN, October 24, 1989.

Hart, M.W., "Scanning Electron Microscopy With Polarization Analysis (SEMPA) Studies of Magnetic Microstructure," The 176th Meeting of the Electrochemical Society, Hollywood, FL, October 16, 1989.

Kelley, M.H., "Spin Dependence in Electron-Atom Collisions," 1990 DOE/BES Atomic Physics Program Workshop, Albuquerque, NM, November 16, 1990.

Kelley, M.H., "Polarized Electron - Polarized Atom Scattering," Department of Physics, Australian National University, Canberra, Australia, January 30, 1990.

Kelley, M.H., "Electron-Atom Collision Studies Using Optically State Selected Beams," Atomic and Molecular Physics and Quantum Chemistry Conference, University of Western Australia, Perth, Western Australia, February 1, 1990.

Kelley, M.H., "Uses of Spin-Polarized Electrons in Fundamental Electron-Atom Collision Processes and in the Analysis of Magnetic Microstructure," International Workshop on Interfaces of Molecular, Electron, and Surface Physics Conference, Fremantle, Western Australia, February 6, 1990.

Kelley, M.H., "Polarized Electron - Polarized Atom Scattering," Flinders University, Adelaide, South Australia, February 9, 1990.

Kelley, M.H, "Electron-Atom Collision Studies Using Optically State Selected Beams," Department of Physics, Griffith University, Brisbane, Australia, February 14, 1990.

Kelley, M.H., "Polarized Electron - Polarized Atom Scattering," XVth International Symposium on the Physics of Ionized Gases, Dubrovnik, Yugoslavia, September 3, 1990.

Lett, P.D., "Laser Cooling, Optical Molasses and the Coldest Atoms in the Universe," Physics Department Colloquium, Catholic University, Washington, D.C., March 14, 1990.

Lett, P.D., "Localization of Atoms in a Three-Dimensional Standing Wave," Quantum Optics Seminar, University of Rochester, Rochester, N.Y, September 25, 1990.

Madden, R.P., "Silicon Photodiodes as Transfer Standards for the EUV and Soft X-Ray Region," Workshop on Extreme Vacuum-Ultraviolet Radiometry for Solar and Terrestrial Physics, Berlin, Germany, October 23, 1990.

Madden, R.P., "Laboratory Intercomparison of UV Solar Irradiance Instruments," Workshop on Extreme Vacuum-Ultraviolet Radiometry for Solar and Terrestrial Physics, Berlin, Germany, October 22, 1990.

Madden, R.P., "The Development of Silicon Photodiodes for the Vacuum Ultraviolet Spectral Region," X-Ray and Ultraviolet Techniques Technical Group, Annual Optical Society of America Meeting, Orlando, Florida, October 18, 1989.

McClelland, J.J., "Spin-Polarized Electron Scattering From Optically Pumped Sodium," Conference on Atomic and Molecular Collisions in Excited States, University of Idaho, Moscow, ID, April 19, 1990.

Pan, L., "Atoms in Intense Laser Fields: New Challenges in Physics," Department of Physics Colloquium, University of Kentucky, Lexington, KY, October 13, 1989.

Pan, L., "Theoretical Study of Intense-Field Laser-Atom Interactions: Progress and Outstanding Issues," Institute for Physical Sciences and Technology, University of Maryland, College Park, MD, September 12, 1990.

Pan, L., "Theoretical Study of Intense-Field Laser-Atom Interactions: Progress of a Dressed-State Approach," Naval Research Laboratory, Washington, DC, September 26, 1990.

Parker, J.S., "Crunching Schrödinger's Equation on the Connection Machine," Laser Lunch Bunch Meeting, NIST, Gaithersburg, MD, November 21, 1990.

Parker, J.S., "ATI in Atomic Hydrogen - Role of Coherent Population Trapping," International Conference on Coherent Radiation Processes in Strong Fields, Catholic University of America, Washington, DC, June 19, 1990.

Penn, D.R., "Spin Polarized Metastable Deexcitation Spectroscopy," Surface Lunch Bunch Meeting, NIST, Gaithersburg, MD, December 3, 1990.

Penn, D.R., "Theory of Spin-Polarized Metastable-Atom-Deexcitation Spectroscopy," University of Chalmers, Göteborg, Sweden, August 1, 1990.

Pierce, D.T., "High Resolution Imaging of Magnetic Microstructure," Physics Department, University of Missouri, Rolla, MO, November 29, 1990.

Pierce, D.T., "High Resolution Imaging of Magnetic Microstructure," Reactor Radiation Division Seminar, NIST, Gaithersburg, MD, September 27, 1990.

Pierce, D.T. "Scanning Electron Microscopy with Polarization Analysis (SEMPA) and Scanning Auger Microscopy to Map the Magnetization, Topography, and Composition of Magnetic Surfaces," American Chemical Society Meeting, Washington, DC, August 29, 1990.

Pierce, D.T., "Surface Magnetism: High Resolution Imaging of Magnetic Structures," Northern California Chapter, American Vacuum Society Symposium, San Jose, CA, February 9, 1990.

Pierce, D.T., "The Profound Effect of the Surface on Magnetic Microstructure," Swiss Federal Institute of Technology, Zürich, Switzerland, October 2, 1989.

Saloman, E.B., "The National Institute of Standards and Technology Resonance Ionization Spectroscopy Resonance Ionization Mass Spectrometry Data Service," Fifth International Symposium on Resonance Ionization Spectroscopy and Its Applications (RIS 90), Varese, Italy, September 17, 1990.

Scheinfein, M.R., "Micromagnetic Structures at Surfaces Observed with Scanning Electron Microscopy with Polarization Analysis," Arizona State University, July 5, 1990.

Scheinfein, M.R., "Scanning Electron Microscopy with Polarization Analysis (SEMPA) Studies of Domains, Domain Walls and Magnetic Singularities at Surfaces and in Thin Films," European Materials Research Society, Council of Europe and European Parliament, Strasbourg, France, May 30, 1990.

Scheinfein, M.R., "Electron Energy Loss Spectroscopy at High Spatial Resolution," Northwestern University, Chicago, IL, April 11, 1990.

Scheinfein, M.R., "Scanning Electron Microscopy with Polarization Analysis Studies of Surface Magnetic Microstructure," Physics Symposium at Physical Electronics, Inc., Eden Prairie, MN, April 6, 1990.

Scheinfein, M.R., "Micromagnetic Structure at Surfaces Observed with Scanning Electron Microscopy with Polarization Analysis," Physics Colloquium, Materials Science Department, Northwestern University, Evanston, IL, April 2, 1990.

Scheinfein, M.R., "Magnetic Microstructure at Surfaces Observed with Scanning Electron Microscopy with Polarization Analysis (SEMPA)," Department of Physics, McMaster University, Hamilton, Ontario, Canada, March 28, 1990.

Scheinfein, M.R., "Scanning Electron Microscopy with Polarization Analysis (SEMPA) of Surface Magnetic Microstructure," Physics Symposium, Simon Fraser University, Burnaby, B.C., Canada, December 8, 1989.

Scheinfein, M.R., "Magnetic Microstructure at Surfaces Observed with Scanning Electron Microscopy with Polarization Analysis (SEMPA)," Physics Department, Renssaelaer Polytechnic Institute, Troy, NY, November 1, 1989.

Scheinfein, M.R., "High Spatial Resolution Quantitative Micromagnetics," 34th MMM-Conference, Boston, MA, November 30, 1989.

Stiles, M.D., "Coulomb Blockade Effects in Transmission Lines," IBM, Yorktown Heights, NY, April 13, 1990.

Stiles, M.D., "Electron Transmission Through Interfaces," Workshop on Ballistic Electron Emission Microscopy, Jet Propulsion Laboratory, Pasadena, CA, March 9, 1990.

Stiles, M.D., "Theory of Electron Transmission Through Epitaxial Interfaces," Department of Physics, University of Florida, Gainesville, FL, January 30, 1990.

Stroscio, J.A., "STM Studies of the Interaction of Alkali and Transition Metals on III-IV (110) Surfaces," Fall Meeting of Materials Research Society, Boston, MA, November 26, 1990.

Stroscio, J.A., "Geometric and Electronic Properties of 1- and 2-dimensional Cs and Fe Structures," AT&T Bell Laboratories, Murray Hill, NJ, November 9, 1990.

Stroscio, J.A., "Geometric and Electronic Properties of 1- and 2-dimensional Cs and Fe Structures," Physics Department Colloquium, University of Rhode Island, Kingston, RI, October 26, 1990.

Stroscio, J.A., "STM Studies of Alkali and Transition Metals on III-V (110) Surfaces," Physics Department Colloquium, New York University, New York, NY, October 25, 1990.

Stroscio, J.A., "Scanning Probe Measurements with Point Electron Sources," Scanning 90 Meeting, Crystal City, VA, April 17, 1990.

Stroscio, J.A., "Scanning Tunneling Microscopy of Metal Atom Structures on III-V (110) Surfaces," Chemical Engineering and Material Science Department, University of Minnesota, Minneapolis, MN, February 27, 1990.

Stroscio, J.A., "Scanning Tunneling Microscopy of Metal Atom Structures on GaAs(110) Surfaces," 36th National Symposium of the American Vacuum Society, Boston, MA, October 23, 1989.

Unguris, J., "SEMPA Measurements of Magnetic Microstructure in Ultrathin Films," Magnetism and Magnetic Materials Conference, San Diego, CA, November 1, 1990.

Unguris, J., "High-Spatial-Resolution Magnetic Imaging by Scanning Electron Microscopy with Polarization Analysis," IUVISTA Workshop on Surface and Interface Characterization, University of York, York, England, September 12, 1990.

Unguris, J., "SEMPA Investigation of Magnetic Microstructure," 1990 TMS Meeting, Anaheim, CA, February 12, 1990.

Unguris, J., "Magnetic Microstructure Imaging at Surfaces," American Physical Society Meeting, Anaheim, CA, March 12, 1990.

Whitman, L.J., "STM Studies of Clean and Cs-Covered III-V (110) Semiconductor Surfaces," Molecular and Surface Dynamics Group Seminar, Philadelphia, PA, November 30, 1990.

Whitman, L.J., "Field Induced Diffusion of Cs on III-V (110)," Surface Lunch Bunch Meeting, NIST, Gaithersburg, MD, October 29, 1990

## B. Contributed Talks

Aeschlimann, M., "SEMPA Studies on Magnetic Field Modulated Written Domains in TbFeCP Thin Films," March '90 Meeting of the American Physical Society Meeting, Anaheim, CA, March 13, 1990.

Aeschlimann, M., "Ultrafast Thermomagnetic Writing Processes in Rare-Earth Transition-Metal Thin Films," 34 MMM-Conference, Boston, MA, November 28, 1990.

Clark, C.W., "The Frequency-Dependent Susceptibility of an Electron Bound by a Zero-Range Potential," Spring Meeting of the American Physical Society, Washington, DC, April 18, 1990.

Clark, C.W., "Interference of Multiphoton Ionization Final States in a Coherent Two-Color Radiation Field," Division of Atomic, Molecular and Optical Physics Meeting, American Physical Society, Monterey, CA, May 23, 1990.

Clark, C.W., "R-Matrix Method for Multiphoton Processes: Application to the H Atom," Division of Atomic, Molecular, and Optical Physics Meeting, American Physical Society, Monterey, CA, May 22, 1990.

Clarke, A., "Spin Polarized Studies of Epitaxially Grown Fe Thin Films," March '90 Meeting of the American Physical Society Meeting, Anaheim, CA, March 15, 1990.

First, P.N., "An STM System for the Study of Magnetic Materials," Fifth International Conference on Scanning Tunneling Microscopy, Baltimore, MD, July 25, 1990.

First, P.N., "Dispersion of Band Gap States Near Metallic Clusters on GaAs(110)," 17th Annual Conference of the Physics and Chemistry of Semi-Conductor Interfaces, Clearwater Beach, FL, February 1, 1990.

Hart, M.W., "Scanning Electron Microscopy with Polarization Analysis (SEMPA) Studies of Magnetic Microstructure," The 176th Meeting of the Electrochemical Society, Hollywood, FL, October 16, 1989.

Jia, J.-J., "Soft X-Ray Emission Spectra of Krypton in Ion Implanted Materials," March '90 Meeting of the American Physical Society, Anaheim, CA, March 14, 1990.

Lett, P.D., "Observation of Atoms Laser-Cooled Below the Doppler Limit," International Laser Science Conference, Atlanta, GA, October 6, 1989.

Lett, P.D., "Ultracold Collisions: Associative Ionization in a Laser Trap," Light Induced Kinetic Effects Workshop, Isola de Elba, Italy, May 4, 1990.

Lett, P.D., "Investigation of Long Range Molecular States Through Ultracold Collisions," 12th International Conference on Atomic Physics, Ann Arbor, MI, July 31, 1990.

Li, Q., "RIS Studies of Autoionization in Calcium," Fifth International Symposium on Resonant Ionization Spectroscopy and Its Applications, Varese, Italy, September 18, 1990.

Lorentz, S.R., "Elastic Scattering of Spin Polarized Electrons from Optically Pumped Sodium," Division of Atomic, Molecular and Optical Physics Meeting, American Physical Society, Monterey, CA, May 22, 1990.

Madden, R.P., "NIST Analysis of First Round Solar Monitor Intercomparison Data," Solar Monitor Intercomparison Workshop, NIST, Gaithersburg, MD, April 20, 1990.

McClelland, J.J., "Laser Focusing of Atoms: A Particle Optics Approach," 12th International Conference on Atomic Physics, University of Michigan, Ann Arbor, MI, July 31, 1990.

Mueller, D.R., "Soft X-Ray Fluorescence and the Electronic Structure of CuO, $Cu_2O$, $Nd_2CuO_4$, and $Nd_{1.85}CuO_4$," Fifteenth International Conference on X-Ray and Inner-Shell Processes, Knoxville, TN, July 10, 1990.

Mueller, D.R., "A Soft X-Ray Fluorescence Investigation of the Superconducting Oxide $Nd_{1.85}Ce_{0.15}CuO_4$," 177th Meeting of the Electrochemical Society, Montreal, Quebec, Canada, May 8, 1990.

Mueller, D.R., "A Soft X-ray Emission Investigation of the Electronic Structure of $Nd_{1.85}Ce_{0.15}CuO_4$ and $Nd_2CuO_4$ Samples," Poster Presentation at AMSAHTS'90--Advances in Materials Science and Applications of High Temperature Superconductors, NASA/GSFC, Greenbelt, MD, April 4, 1990.

Mueller, D.R., "A Soft X-Ray Emission Investigation of the Electronic Structure of $Nd_{1.85}Ce_{0.15}CuO_4$," March '90 Meeting of the American Physical Society, Anaheim, CA, March 13, 1990.

O'Brien, W.L., "Local Partial Density of States of CoSi and $CoSi_2$ Studied by Soft X-ray Emission Spectroscopy," March '90 Meeting of the American Physical Society, Anaheim, CA, March 14, 1990.

Pan, L., "Convergence of Rayleigh-Schrödinger Perturbation Theory in the Calculation of Multiphoton Processes," 1990 Spring Meeting of the American Physical Society, Washington, DC, April 18, 1990.

Penn, D.R., "Theory of Spin Polarized Metastable Deexcitation Spectroscopy," March '90 Meeting of the American Physical Society Meeting, Anaheim, CA, March 15, 1990.

Stiles, M.D., "Theory of Ballistic Electron Emission Microscopy for $NiSi_2$/Si(111) Interfaces," Scanning Tunneling Microscopy/90 Conference, Baltimore, MD, July 24, 1990.

Stiles, M.D., "Theory of Ballistic Electron Emission Microscopy for $NiSi_2$/Si(111) Interfaces," Physical Electronics Conference, NIST, Gaithersburg, MD, June 13, 1990.

Stiles, M.D., "Theory of Electron Transmission Through Epitaxial Interfaces," 17th Conference on the Physics and Chemistry of Semiconductor Interfaces, Clearwater, FL, February 1, 1990.

Stiles, M.D., "Coulomb Blockade Effects in Transmission Lines," March '90 Meeting of the American Physical Society, Anaheim, CA, March 12, 1990.

Tanuma, S., "Electron Inelastic Mean Free Paths in Solids at Low Energies," American Vacuum Society Meeting, Boston, MA, October 24, 1989.

Tanuma, S., "Electron Attenuation Lengths for Quantitative AES and XPS," Third Topical Conference on Quantitative Surface Analysis, Salem, MA, October 20, 1989.

Watts, R.N., "The Reflectometer at the New and Improved (Institute of) Standards and Technology," First Technical Symposium on Soft X-Ray Projection Lithography Technology, Asilomar, CA, January 15, 1990.

Watts, R.N., "Metrology for X-Ray Projection Lithography," SEMATECH/DOE National Lab Meeting, Austin, TX, July 14, 1990.

Whitman, L.J., "Scanning Tunneling Microscopy of Clean and Cs-covered InSb(110)," Fifth International Conference on Scanning Tunneling Microscopy, Baltimore, MD, July 25, 1990.

Whitman, L.J., "Scanning Tunneling Microscopy of Clean and Cs-covered InSb(110)," 50th Conference on Physical Electronics, NIST, Gaithersburg, MD, June 13, 1990.

Whitman, L.J., "An STM Study of Clean and Cs-covered InSb(110)," March '90 Meeting of the American Physical Society Meeting, Anaheim, CA, March 12, 1990.

Whitman, L.J., "The Chemisorption of Chlorosilanes and Chlorine on Si(111) 7x7," 36th National Symposium of the American Vacuum Society, Boston, MA, October 27, 1989.

Yarmoff, J.A., "Chemisorption of Chlorosilanes on Semiconductor Surfaces," March '90 Meeting of the American Physical Society, Anaheim, CA, March 14, 1990.

Yarmoff, J.A., "The Chemisorption of $PF_3$ on Ru(0001) Studied with Soft X-ray Photoemission and Photo Stimulated Desorption," 36th National Symposium of the American Vacuum Society, Boston, MA, October 25, 1989.

## IX. EDITORSHIPS HELD BY STAFF MEMBERS

Robert J. Celotta

co-editor, Methods of Experimental Physics, Academic Press Series.

Charles W. Clark

Topical Editor for Atomic Spectroscopy, *Journal of the Optical Society of America B*.

Co-editor, Atoms in Strong Fields (Plenum Publishers, New York 1990).

David L. Ederer

Member, Editorial Board, *Review of Scientific Instruments*, (1990-1992).

Thomas B. Lucatorto

Co-editor, The Physics of Electronic and Atomic Collisions (AIP Conference Proc. 205, American Institute of Physics, New York 1990).

Co-editor, Methods of Experimental Physics, Academic Press Series.

Michael H. Kelley

Co-editor, Proceedings of the International Symposium on Correlation and Polarization in Electronic and Atomic Collisions, NIST Special Publication 789 (1990).

Daniel.T. Pierce

Member, Editorial Board, *Journal of Electron Spectroscopy and Related Phenomena*.

Co-editor, Proceedings of the 35$^{th}$ Conference on Magnetics and Magnetic Materials.

# X. TECHNICAL AND PROFESSIONAL COMMITTEE PARTICIPATION AND LEADERSHIP

Charles W. Clark

Member, Executive Committee, Division of Atomic, Molecular, and Optical Physics, American Physical Society.

Member, Collaborative Computational Project 2: Continuum States of Atoms and Molecules, Science and Engineering Research Council (UK).

Chairman, National Academy of Sciences/National Research Council Committee on Line Spectra of the Elements - Atomic Spectroscopy.

David L. Ederer

Member, Executive User Committee of the Advanced Light Source, Berkeley, CA.

Member, User Proposal Review Committee, National Synchrotron Light Source, Brookhaven National Laboratory, Upton, NY.

Lanny R. Hughey

Member, Design Review Board for Title II Vacuum Design of the 6 GeV Electron Storage Ring (APS), Argonne National Laboratory.

Program Committee, Vacuum Design Synchrotron Light Sources Conference, Argonne National Laboratories, November 9-15, 1990.

Robert P. Madden

Member, Optical Society of America Nominating Committee.

Member, Advisory Program Committee for the 75th Annual Meeting of the Optical Society of America.

Member, Council of U.S. Synchrotron Radiation Laboratory Directors.

Member, International Committee of the International Conference on X-Ray and VUV Synchrotron Radiation Instrumentation.

Member, DARPA Advisory Committee for Oversight of the Development of a Synchrotron Source for Lithography.

Member, NSLS Program Advisory Committee, Brookhaven National Laboratories.

Robert P. Madden (continued)

Member, Advisory Committee for the U.S. National Synchrotron Radiation Instrumentation Conference.

Michael H. Kelley

Co-chair, 1991 Annual Meeting of the Division of Atomic, Molecular, and Optical Physics, American Physical Society, Washington, DC.

Member, Scientific Organizing Committee, International Workshop on the Interfaces of Atomic, Molecular, and Surface Physics, Fremantle, Western Australia, February 4-7, 1990.

Jabez J. McClelland

Co-chair, 1991 Annual Meeting of the Division of Atomic, Molecular, and Optical Physics, American Physical Society, Washington, DC.

Daniel T. Pierce

International Scientific Committee, 1990 European MRS Symposium: Magnetic Thin Films, Multilayer, and Superlattices, May 1990.

Program Committee, $34^{th}$ Conference on Magnetics and Magnetic Materials.

Mark D. Stiles

President, Greater Washington Solid State Physics Colloquium Steering Committee.

## XI. SPONSORED SEMINARS AND COLLOQUIA

Amusia, Miron, Leningrad State University, "Correlation Effects in Photoionization," November 13, 1990.

Baer, Tomas, University of North Carolina, "Conformational Analysis by Laser Spectroscopy," October 15, 1990.

Blümel, Reinhold, Max-Planck Institute für Quantenoptik, Garching, FRG, "Trapped Ions and Strongly-Driven Rydberg Atoms -- Test Cases for Classical and Quantum Chaos," January 31, 1990.

Bokor, Jeffrey, AT&T Bell Laboratories, "X-Ray Projection Imaging: An Advanced Lithography for the 1990's," May 2, 1990.

Buckman, Stephen J., Australian National University, "Near-Threshold Vibrational Excitation of $H_2$ by Electron Impact: Resolution of Discrepancies Between Experiment and Theory," October 26, 1990.

Cornel, Eric, MIT, "Single Ion Cyclotron Resonance: Mass Spectroscopy Beyond the Part Per Billion," November 29, 1990.

Corkum, Paul, National Research Council, Ottawa, Canada "Ultrashort Pulse Multiphoton Ionization," February 28, 1990.

Damburg, Robert, Latvian Academy of Sciences, Riga, Latvia, "Is the LoSurdo-Stark Effect an Open Problem?", January 22, 1990.

Garton, W. Reginald, Blackett Laboratory, Imperial College of Science and Technology, London, UK "Terrestrial Lightning," September 4, 1990.

Gay, Jean-Claude, Ecole Normale Superieur, Paris, France, "Elliptical Squeezed States of the Hydrogen Atom and Applications," June 21, 1990.

Gentile, Thomas, MIT, "Microwave Spectroscopy and Two-Photon Rabi Oscillations in Ca Rydberg States," January 17, 1990.

Gryzinski, Michal, Polish Institute for Nuclear Studies, Swierk-Atwock, Poland, "Classical Approach Atomic Process: Low Energy Atomic Collisions and Physical Properties of Palladium-Hydrogen Systems," November 19, 1990.

Hashizume, Tomi, Institute for Materials Research, Tohoku University, Sendai, Japan, "FI-STM And Its Application for the Si(111) and Si(100) Surfaces," July 20, 1990.

Hubert, Alex, University of Erlangen, Erlangen, Germany, "Micromagnetics: Analysis of Systems of Current Interest," October 25, 1990.

Jonson, Mats, Chalmers University, Göteborg, Sweden, "The Globally Adiabatic Region in Quantum Ballistic Transport," December 7, 1989.

Lapiano-Smith, Dawn, SUNY at Stony Brook, "Relaxation and Fragmentation in Small Molecules Following Core Excitations," January 10, 1990.

Lin, Burn, IBM, "A Comparison of Projection and Proximity Printings from UV to X-Ray," April 12, 1990.

Lubell, Michael S., City College of New York, "Polarized e-H Scattering and the Ionization Threshold Law," March 2, 1990.

Matthew, J.A.D., University of York, York, UK, "4f - 4f Excitations in the Rare Earths," April 17, 1990.

Meschede, Dieter, Max-Planck Institute für Quantenoptik, Garching, FRG, "New Experiments for Optical Frequency Synthesis," May 15, 1990.

Moorjani, Kishin, Johns Hopkins University, "Microwave Excitation in High Temperature Superconductors," May 1, 1990.

Morin, Paul, LURE, Orsay, France, "Laser Induced Dissociation of Molecules Probed by Synchrotron Radiation: The Iodine Case," July 6, 1990.

Muller, Harm G., FOM Institute for Atomic, Molecular Physics, Amsterdam, Netherlands, "Making Rydberg Wave Packets and Other Applications of Short Pulse Lasers," November 20, 1989.

Nayfeh, Munir, Loomis Laboratory of Physics, University of Illinois at Urbana-Champaign, "STM-Laser Fabrication of Nanostructures," December 6, 1990.

Nenner, Irene, LURE & CEN, Saclay, France, "X-Ray Photoabsorption Spectroscopy in Molecules: A Powerful Characterization Tool in Chemistry," July 24, 1990.

Nicolaides, Cleanthes, National Hellenic Research Foundation, Athens, Greece, "Structure, Stability and Highly Exothermic Reactions of Exotic Molecular States," October 5, 1989.

Nithianandam, Jayasingh, Naval Research Laboratory, "A Study of Diamond and Tetrahederally Bonded Materials by X-Ray Spectroscopy," May 10, 1990.

O'Brien, William, University of Tennessee, "Ion-Induced Chlorination of Ti," February 20, 1990.

Oepen, H.P., KFA, Juelich, FRG, "Magnetic Microstructure in Ultrathin Cobalt Films," May 4, 1990.

Ostrovskii, Valentin N., Leningrad State University, Leningrad, USSR, "Doubly-Excited States of the Helium Atom in the Dipole Approximation," May 10, 1990.

Ostrovskii, Valentin N., Leningrad State University, Leningrad, USSR, "Closed Classical Trajectories and Quantum Resonances," May 9, 1990.

Parker, Jonathan S., University of Rochester, "Classical and Quantum Above-Threshold Ionization," April 13, 1990.

Rzazewski, Kazimierz, Institute of Theoretical Physics, Polish Academy of Sciences, Warsaw, Poland, "Stabilization of Atoms in Super Intense Laser Fields," June 22, 1990.

Tarrio, Charles, University of Virginia, "Inelastic Electron Scattering at Low Temperatures," December 21, 1990.

Taylor, Kenneth T., Royal Holloway and Bedford New College, United Kingdom, "Atoms and Molecules in Magnetic Fields: New Features of Chaos," December 19, 1990.

Van Zandt, T., Stanford University, "A Spin Polarized Electron Microscopy of Magnetics," September 20, 1990.

Vaterlaus, A., ETC Hönggerberg, Zürich, Switzerland, "Short Pulsed Heating (30ps - 20ns) of the Surface of Magnetic (Fe) and Nonmagnetic (Sn, Ge) Materials Observed by Laser Induced Spin-Polarized Photoemission," December 21, 1989.

Venables, J.A., Arizona State University, "Studies of Surface Diffusion and Crystal Growth by SEM and STM," March 8, 1990.

Watanabe, Takeshi, Tohoku University, Japan, "EXAFS, XPS, and BIS From a Theoretical Viewpoint," April 27, 1990.

Welge, Karl, Universität Bielefeld, Bielefeld, Germany, "Hydrogen Atom Short Pulse Multiphoton Ionization," May 7, 1990.

West, John B., Daresbury Laboratory, England, "Recent Experiments in Atomic and Molecular Science at Daresbury Synchrotron Radiation Source," April 3, 1990.

Yoshino, K., Harvard University, "High Resolution VUV Spectroscopy of Atoms and Molecules," February 2, 1990.

Zimmermann, Peter, University of Berlin, "Photoion and Photoelectron Spectroscopy with Laser and Synchrotron Radiation," July 26, 1990.

## XII. MAJOR CONSULTING AND ADVISORY SERVICES

**L. Randall Canfield**

consulted with Raj Korde of International Radiation Detectors on matters involving semiconductor photodiodes in the far ultraviolet.

consulted with H. Ogawa and D. Judge concerning narrow-bandpass detector systems for solar flux determinations in rocket flight experiments and on a proposal for a satellite solar flux experiment.

**Robert J. Celotta and Daniel T. Pierce**

consulted on the production and detection of polarized electrons with researchers from NSLS (Brookhaven), University of Texas, MIT, Argonne National Laboratory, Naval Research Laboratory, IBM Almaden, University of Clausthal, and CEBAF.

**David.L. Ederer**

consulted with Dr. Natale Ceglio, Lawrence Livermore National Laboratory, on a NIST-BESSY intercomparison of multilayer reflectometry.

**Thomas B. Lucatorto**

consulted with Hampshire Instruments on the design of an x-ray collimator.

**Robert P. Madden**

at the request of the Director of the Earth Science and Applications Division of the Office of Space Science and Applications, NASA, is coordinating an international round-robin intercomparison of solar irradiance monitoring space experiments.

## XIII. SPONSORED WORKSHOPS

Mitchell L. Furst

organized the "Scheduling Meeting for the Users of the Radiometric Instrumentation Calibration Facility at SURF," October 18, 1990, at NIST.

Robert P. Madden

organized the "Solar Monitor Intercomparison Workshop," April 20, 1990, at NIST.

## XIV. PROFESSIONAL DEVELOPMENT OF STAFF

Sayoko Blodgett-Ford

"Phys. 621 - Graduate Laboratory," University of Maryland, College Park, MD. September 4 - December 30, 1990.

"Co-op 098 and 099 - Cooperative Education Program," University of Maryland, College Park, MD, September 4 - December 30, 1990.

"Phys 778 - Seminar in Cosmic Ray Astrophysics," University of Maryland, College Park, MD, September 4 - December 30, 1990.

Charles W. Clark

"Northeast Parallel Architectures Center Training Workshop," Northeast Parallel Architectures Center, Syracuse University, Syracuse, NY, November 15-17, 1989.

Patricia Elspas

"Introduction to Lotus 1-2-3," NIST, Gaithersburg, MD, October 9, 1990.

Mitchell L. Furst

"CTI Cryogenics Cryopump Course," NIST, Gaithersburg, MD, October 9-10, 1990.

Rossie M. Graves

"CTI Cryogenics Cryopump Course," NIST, Gaithersburg, MD, October 9-10, 1990.

Andrew D. Hamilton

"American Vacuum Society Short Course Program," Columbia, MD, May 6-10, 1990.

Lanny R. Hughey

"Comprehensive WordPerfect - Version 5.0," NIST, Gaithersburg, MD, January 9-10, 1990.

"Prime Time Planning", NIST, Gaithersburg, MD, May 8-9, 1990.

Paul D. Lett

"Hazards Review Committee Training Course," NIST, Gaithersburg, MD, October 23, 1990.

Aija E. Roess

"Personnel Management," University of Maryland, University College, June 4 - August 25, 1990.

"Advanced Composition," University of Maryland, University College, September 7 - October 24, 1990.

## XV. AWARDS

**L. Randall Canfield**

R&D 100 Award for "Windowless Silicon Photodiode (Model XUV 100C)," September 1989.

**Jonathan Kerner**

R&D 100 Award for "Windowless Silicon Photodiode (Model XUV 100C)," September 1989.

**John Unguris**

U.S. Department of Commerce Bronze Medal, December 1989.

Sigma Xi Young Scientist Award, May 1990.

## XV. BRIEF RESUMES OF SCIENTIFIC AND TECHNICAL STAFF MEMBERS

**BLODGETT-FORD, SAYOKO:** b. Evanston, IL, 9/21/67. PHYSICS, BS, Coll. William and Mary, summa cum laude, 1988; entered graduate program in physics, Univ. MD, 1/89. Student Trainee - Physical Science, Electron and Optical Physics Div., NIST, 6/90-present. Teaching Assistant, University of Maryland, 1/89-5/90. Physicist, Electron and Optical Physics Div., NIST, 6/89-8/89. Mathematics Aide, Scientific Computing Division, NIST, 6/88-8/89. Theoretical atomic, molecular and Optical Physics.

**CANFIELD, L. RANDALL:** b. Rochester, NY, 1/1/30. PHYSICS, BS, Florida State Univ., 1954. Physicist, NIST, 1963-present. Electronics Engineer Physicist, USAERDL 1958-63; Far UV optical and photoemissive properties, far UV detector radiometry.

**CELOTTA, ROBERT J.**, b. New York, NY, 11/18/43. PHYSICS, BS, City College of NY, 1964; PhD 1969, NY Univ. Physicist, NIST, 1971-present; presently NIST Fellow and Leader, Electron Physics Group, Electron and Optical Physics Div. Postdoctoral Res., Ass., Joint Institute of Lab. Astrophysics, Univ. of Colorado, 1969-71. DAMOP Prog. Comm. 1982-83. Internatl. Conf. on Coherence and Correlation, Organizing Committee Chair, 1981. Internatl. Conf. on the Physics of Electron and Atomic Collisions, Gen. Comm., 1985-89. Rev. of Scient. Instr. Ed. Board, 1982-85. Methods of Experimental Physics, Editor-in-Chief, 1981-. Fellow, American Physical Society. Laser photodetachment, negative ions, electron scattering from atoms, molecules, and surfaces, polarized electron interactions, surface magnetism, and scanning electron and scanning tunneling microscopy.

**CLARK, CHARLES W.**, b. Minneapolis, MN, 9/30/52. MATHEMATICS AND PHYSICS, BA, 1974, magna cum laude, Western Wash. State Coll.; SM 1976 Physics, Univ. Chicago; PhD, Physics, 1979 Univ. Chicago. Chief, Electron and Optical Physics Division 8/90-present. Acting Chief, 11/89-8/90. Physicist, NIST, 3/84-present. Visiting Fellow, Research School of Physical Science, Australian National Univ. 1/86-2/86. Consultant, Princeton Plasma Physics Lab., 7/84-12/89. Physicist, self-employed, 10/83-3/84. NBS-NRC Res. Assoc., 10/81-10/83. Jr. Res. Assoc., Daresbury Laboratory, England, 9/79-10/81. Res. Assoc., Univ. Chicago, 1/79-9/79. Topical Editor, Atomic Spectroscopy, J. Opt. Soc. Am. B, 1986-present. Chairman, NAS/NRC Committee on Line Spectra of the Elements - Atomic Spectroscopy, 1989-present. Adjunct Professor, Institute for Physical Science and Technology, Univ. Maryland 12/90-present. Member, Executive Committee, DAMOP, American Physical Society, 1990. Electronic structure and collisions, the properties of atoms in strong fields, and atomic and molecular phenomena on surfaces in condensed matter.

**CUTKOSKY, ROBERT D.**, b. Minneapolis, Minnesota, 10/24/33; PHYSICS, BS. Mass. Inst. of Tech. 1955; Physicist, NBS/NIST, 1955-present. Fellow, American Physical Society; Fellow, IEEE.

**DRAGOSET, ROBERT A.**, b. Elizabeth, NJ, 10/7/52; PHYSICS, BS, Auburn Univ., 1975; PhD, Univ. Virginia, 1982. Research Physicist, NIST, 1985-present. Res. Assoc., Physics Dept., Univ. Virginia, 82-83; NBS-NRC Res. Assoc., 83-85; Mem: APS, AAAS. Scanning tunneling microscopy.

**EDERER, DAVID L.**, b. Evanston, ILL, 11/20/35. PHYSICS, BS, Univ. Notre Dame, 1958, Ph.D. Physics, Cornell Univ. 1963. NIST Professional Research Staff, 1965-pres. Temporary duty, Advisor to Director of National Measurement Lab. 1989-90; Teacher, School for Continuing Professional Programs, Johns Hopkins Whiting School of Engineering, 1988-89. Visiting Maitre de Recherche, LURE (Laboratoire pour l'Utilsation du Rayonnment Electromagnetique) Orsay, France, 1979-80. NBS-NRC Res. Assoc., 1964-65. Post doctoral research associate, Cornell Univ. 1963-64. Research assistant, Cornell Univ. 1961-63; Teaching assistant, Cornell Univ. 1958-60. Fellow, American Physical Society. Soft x-ray emissions from exotic materials excited by synchrotron radiation. Instrumentation for soft x-ray spectral region. Study of atomic correlations through photoionization of ground state and excited atoms by synchrotron radiation. Measurement of molecular photoionization dynamics through photoelectron spectroscopy and polarized fluorescence. Dynamics of atomic collisions in resonantly excited atomic vapor.

**FRENCH, ROBERT H.**, b. Martinsburg, WV, 10/2/39; ELECTRONICS TECHNOLOGY, AA, 1961, DeVry Technical Institute, Chicago, ILL. Electronic Technician, NIST, 1987-present. Electronic Technician, Harry Diamond Labs 1967-87.

**FURST, MITCHELL L.**, b. New York, NY, 4/27/54; PHYSICS AND EARTH AND SPACE SCIENCE, BS, State Univ. of New York at Stony Brook, 1975; Physics, MS, Univ. Connecticut, 1977; PhD, Univ. Connecticut, 1985. Physicist, NIST, 1987-present. Mem: APS, AVS. Optical physics, UV spectroscopy, VUV radiometry.

**GRAVES, ROSSIE, M.**, b. 11/25/39; Washington, DC; ELECTRONICS TECHNOLOGY, U. S. Air Force Technical School 1962-63, Wichita State Univ. 1964-65; Electronics Technician, NIST 1969-85, 1987-present. Spectrometer calibrations on SURF-II Beamline 2.

**HAMILTON, ANDREW D.**, b. Hempstead, LI, NY, 1/6/36; ELECTRICAL ENGINEERING, BEE 1962, New York Univ.; MEE 1965, New York Univ.; MS Marine Environmental Science 1979, State Univ. of NY at Stony Brook. Electronics Engineer, Synchrotron Ultraviolet Radiation Facility, NIST (formerly National Bureau of Standards) 1988-pres.; Senior Development Engineer, North Atlantic Industries, Hauppauge, NY, 1986-1988. Vice President of Engineering, Stynetic Systems, Inc., St. James, NY, 1981-1988. Associate Staff Oceanographer, SUNY, Stony Brook, NY, 1974-1981. Control of and data acquisition for electron accelerators.

**HUGHEY, LANNY R.**, b. San Bernardino, CA, 12/23/37; PHYSICS, AB, 1961, MA, 1965, Univ. California at Santa Barbara. Physicist, NIST, 1965-present. Data Analyst, UC Lawrence Radiation Laboratory, 1962; Research Assistant, UCSB, 1963-65. Mem: APS, AVS, OSA. UV-XUV optics and radiometry, ultra-high vacuum systems, electron accelerators.

**KELLEY, MICHAEL H.**, b. Abilene, TX, 12/20/50; PHYSICS. BS, Abilene Christian College, 1973; MA Univ. Texas at Austin, 1976; Ph.D., Univ. Texas at Austin, 1979. Research Physicist, NIST, 1983-present. Fulbright Fellowship, Universität Kaiserslautern, West Germany, 77-78; NBS-NRC Res. Assoc., 79-83. Mem: APS, AAAS. Polarized electron scattering, laser optical pumping, electron optical design, digital image processing.

**LETT, PAUL D.**, b. Milwaukee, WI, 8/1/58, PHYSICS, BS, 1980, Marquette Univ.; MA 1982, Univ. Rochester; PhD 1986, Univ. Rochester. Physicist, NIST 1989-present. Postdoctoral position, Laser Cooling Group, National Bureau of Standards, 1986-88. Laser cooling and trapping of neutral atoms, ultracold collisions, generation of spectrally narrow VUV radiation.

**LORENTZ, STEVEN R.**, b. Comanche, OK, 11/06/60; BS, Univ. Oklahoma, 1984; MS, Univ. Oklahoma, 1987; Ph.D., Univ. Oklahoma, 1989; NIST-NRC Res. Assoc. 1989-present. Atomic physics, polarized electron-atom scattering, laser optical pumping of atoms for polarization and alignment.

**LUCATORTO, THOMAS B.**, b. New York, NY, 5/09/37; PHYSICS, BS, City College of New York, 1960; MS, Physics, Columbia Univ., 1964; PHD, Physics, Columbia Univ., 1968. Physicist, NIST 1969-present. Postdoctoral Fellow, Columbia University, 1968-69; Fellow, American Physical Society. Optical physics, VUV physics, laser spectroscopy.

**MADDEN, ROBERT P.**, b. Schenectady, NY, 12/20/28; PHYSICS, BS, Univ., of Rochester, 1950; PhD., Johns Hopkins Univ., 1956. Leader, Far UV Physics Group and Manager, SURF-II, 1961-present. Physicist and Chief, Spectroscopy Section, ERDL, Ft. Belvoir, VA., 1958-61. Fellow, American Physical Society. Fellow, Optical Society of America. Atomic and molecular spectroscopy, optical properties of thin films, spectroscopic instrumentation, UV and VUV radiometry, synchrotron radiation and applications.

**McCLELLAND, JABEZ J.**, b. Middletown, CT, 7/31/54; PHYSICS. BA, Wesleyan Univ., 1976; MA, Univ. of Texas at Austin, 1980; Ph.D., Univ. of Texas at Austin, 1984. Res. physicist, NIST 1986-present. Res. Asst. Univ. of Texas, 1978-84; Fulbright Fellow, Freie Univ. Berlin, 1981-82; Postdoctoral Res. Assoc., NBS 1984-86; Polarized electron-atom scattering, laser optical pumping, orientation and alignment in electron-atom collisions, polarized electron physics.

**McILRATH, THOMAS J.**, b. Dowagiac, MI, 5/10/38; PHYSICS. BS, Mich. State Univ., 1960; Ph.D., Princeton Univ., 1966. Physicist, NIST 1974-present. NATO Postdoc. Fellow, Oxford Univ., 66-67; Res. Fellow, Harvard College Observatory, 67-70; Res. Assoc.,70-73; Lecturer, Dept. Astronomy, Harvard Univ., 70-73; Assoc. Prof., Inst. Phys. Sci. and Tech., Univ. Maryland, 73-81; Prof., 81-present. Consultant, Princeton Plasma Physics Lab., 84-present; Consultant, AT&T Bell Laboratories, 85-present. Fellow, American Physical Society. Fellow, Optical Society of America. X-ray physics, multiphoton processes, laser spectroscopy.

**MUELLER, DONALD R.**, b. Ithaca, NY, 4/22/58; APPLIED AND ENGINEERING PHYSICS, BS, Cornell Univ., 1980; PhD Cornell Univ., 1987. NRC Postdoctoral Res. Assoc., Naval Research Lab, 1987-88; Physicist, NIST 1988-pres; Angle-resolved ultraviolet photoelectron spectroscopy, surface science, soft x-ray emission spectroscopy, soft x-ray fluorescence.

**PENN, DAVID R.**, b. Chicago, IL, 4/3/37; PHYSICS. BS, Univ. of Chicago, 1958; MS, Univ. of Chicago, 1959; Ph.D., Univ. of Chicago, 1965; Research Fellow, Argonne National Laboratory, 1965-66; NSF Postdoctoral Fellow, Atomic Energy Research Establishment, Harwell, England, 1966-67; Assist. Prof. of Physics, Brown Univ., 1967-72; Visiting Assist. Prof., Univ. of Chicago, 1971; Visiting Assist. Prof., Univ. of California at Berkeley, 1971-72; Physicist, NIST, 1972-present. Mem: APS. Secondary electron polarization, electron energy loss in solids, interaction of electrons with surfaces, magnetism, high temperature superconductivity.

**PIERCE, DANIEL T.**, b. Los Angeles, CA, 7/16/40; PHYSICS, BS, 1962, Stanford Univ.; MA 1966 Wesleyan Univ.; PhD 1970, Stanford Univ. Physicist, NIST 1975-pres. Research staff Swiss Federal Inst., of Tech., Zürich 1971-75. Prof. Tri-Chandra College, Kathmandu 1962-64. Editorial Board, Rev. Sci. Inst. 1985-88. Editorial Board, J. Electron Spectrosc. and Related Phenom. 1986-. International Colloquium on Magnetic Films and Surfaces Organizing Committee, 1985-. Executive Committee, Surface Science Division of American Vacuum Society 1984-88, Chairman 1988. Chairman, 1988 Gordon Conference on Electron Spectroscopy. Program Committee and Publications Co-Chair, 1990 Magnetism and Magnetic Materials Conference. Fellow, American Physical Society. Research interests: electronic structure of solids and surfaces, surface magnetism, spin polarized electron-surface interactions, sources and detectors of spin polarized electrons, scanning electron and tunneling microscopy, thin films and low dimensional systems.

**SALOMAN, EDWARD B.**, b. New York, NY, 5/30/40; PHYSICS, AB, Columbia Univ., 1961; MA, Columbia Univ., 1962; PhD., Columbia Univ., 1965. Physicist, NIST, 1972-present. Res. Asst., Columbia Rad. Lab., 1959-1965; Teaching Asst, Columbia Univ., 1961-1962; Lecturer, Columbia Univ., 1962-1963; Res. Physicist, Columbia Rad. Lab., 1965-1966; Asst. Prof. Physics, Brown Univ., 1966-1972; Consultant, Brown Univ., Mat. Sci. Prog., 1972. Mem: APS, OSA, AAAS. Atomic data calculations and compilations for resonance ionization spectroscopy; relativistic ab-initio calculation of atomic and ionic energies and oscillator strengths; laser spectroscopy of autoionizing atomic states in electric fields; studies of atomic and molecular states around the ionization limit in the presence of electric fields using synchrotron radiation; XUV absorption spectroscopy using synchrotron radiation; x-ray absorption cross section data compilations; soft x-ray optics characterization; XUV detector radiometry; use of synchrotron radiation as an absolute radiometric source.

**STILES, MARK D.**, b. Philadelphia, PA. 1/07/59; PHYSICS, MS/BS, Yale Univ., 1981; Ph.D., Cornell Univ., 1986. Physicist, NIST 1988-present. Postdoctoral AT&T Bell Labs., 86-88. Mem: APS. Theoretical condensed matter physics, gas-surface scattering dynamics, electronic structure, electron transport in materials.

**STROSCIO, JOSEPH A.**, b. Providence, RI, 10/05/56, PHYSICS, BS, 1974, MS, 1980, Univ. of Rhode Island; MS, 1983, Cornell Univ.; Ph.D. 1986, Cornell Univ. Physicist, NIST, 1987-pres.; Postdoctoral Research Associate, IBM T.J. Watson Research Center, 1985-87. Research interests in the physical and chemical properties of surfaces using electron and laser probes. Current research in scanning tunneling microscopy/spectroscopy with applications in low dimensional microstructures and thin films,surface magnetism, and applications in surface transport studies of small microstructures.

**UNGURIS, JOHN**, b. Dietz, West Germany, 11/25/50; PHYSICS, BS, Carnegie-Mellon Univ., 73, Ph.D., Univ. of Wisconsin, 80. Physicist, NIST, 82-present. NBS-NRC Res. Assoc., 80-82. Surface and thin film magnetism, electron microscopy, electron-solid interactions.

**WACLAWSKI, BERNARD J.**, b. Dickson City, PA, 6/24/32; PHYSICS, BS, Pennsylvania State Univ. 1959; MS Pennsylvania State Univ. 1962. Physicist, NIST, 1963 - pres. Photoelectron spectroscopy, high-resolution energy-loss spectroscopy, electron microscopy, surface and thin film magnetism.

**WATTS, RICHARD, N.**, b. Waco, TX, 2/27/57; PHYSICS, BA, Rice Univ., 1979; MS,, Physics, Univ. of Michigan, 1981; PhD, Physics, Univ. of Michigan, 1986. Physicist, NIST, 1989-present. Postdoctoral Res. Assoc., State Univ. of New York at Stony Brook, 1986-87; NIST-NRC Res. Assoc., 1987-89. Atomic and optical physics, ultra-cold atoms, VUV physics, laser spectroscopy.

**WHITMAN, LLOYD J.**, b. 9/20/60; New Brunswick, NJ; PHYSICS, BS, Brown Univ., 1982; MS, Cornell Univ. 1985; PhD., Cornell Univ., 1988. NAS-NRC Res. Assoc., NIST, 1989-pres. Surface physics and chemistry, scanning tunneling microscopy/spectroscopy.

**WOODEN, WILLIAM H.**, b. 6/26/29; Weldon, NC; ELECTRONICS TECHNOLOGY, U. S. Navy Technical School. Electronics Technician, NIST, 1976-present. Aviation Electronics Technician, U. S. Navy, 1950-75. SURF-II operations.

| NIST-114A (REV. 3-90) | U.S. DEPARTMENT OF COMMERCE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY | 1. PUBLICATION OR REPORT NUMBER NISTIR 4553 |
|---|---|---|
| | | 2. PERFORMING ORGANIZATION REPORT NUMBER |
| | **BIBLIOGRAPHIC DATA SHEET** | 3. PUBLICATION DATE MAY 1991 |

4. TITLE AND SUBTITLE

Technical Activities 1990
Electron and Optical Physics Division

5. AUTHOR(S)

C.W. Clark

| 6. PERFORMING ORGANIZATION (IF JOINT OR OTHER THAN NIST, SEE INSTRUCTIONS) | 7. CONTRACT/GRANT NUMBER |
|---|---|
| U.S. DEPARTMENT OF COMMERCE<br>NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY<br>GAITHERSBURG, MD 20899 | 8. TYPE OF REPORT AND PERIOD COVERED |

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (STREET, CITY, STATE, ZIP)

Electron and Optical Physics Division
Center for Atomic, Molecular and Optical Physics
National Measurement Laboratory

NIST
Gaithersburg, MD 20899

10. SUPPLEMENTARY NOTES

11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

This report summarizes technical activities of the NIST Electron and Optical Physics Division during Fiscal Year 1990. These fall into five general areas: soft x-ray radiometry, operation of the SURF-II synchrotron storage ring; electron microscopy and basic surface physics; soft x-ray emission studies; and multiphoton processes. A listing is given of calibration services, publications, talks, and other relevant activities of the Division's staff.

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)

electron physics; multi-photon processes; optical physics; SEMPA, scanning tunneling microscopy; synchrotron radiation.

| 13. AVAILABILITY | | 14. NUMBER OF PRINTED PAGES |
|---|---|---|
| X | UNLIMITED | 71 |
| | FOR OFFICIAL DISTRIBUTION. DO NOT RELEASE TO NATIONAL TECHNICAL INFORMATION SERVICE (NTIS). | |
| | ORDER FROM SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, DC 20402. | 15. PRICE A04 |
| X | ORDER FROM NATIONAL TECHNICAL INFORMATION SERVICE (NTIS), SPRINGFIELD, VA 22161. | |

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