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# ADVANCED LIGHT SOURCE REPORT

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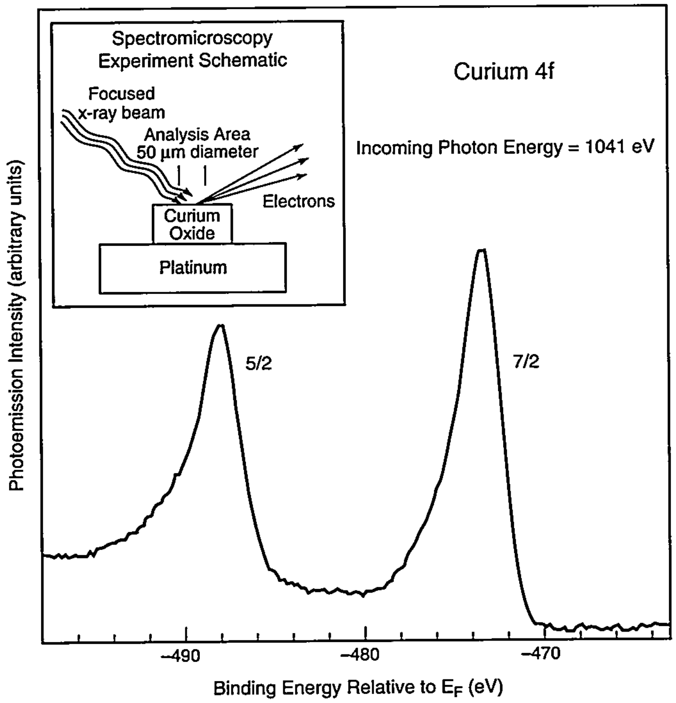
Lawrence Berkeley Laboratory / University of California


# New Tool Delivers New Science

The exceptional science already emerging from the user program at the ALS shows that the promises of "unique research opportunities" and "experiments not possible anywhere else" made at the inception of the ALS are indeed coming true. In less than a year of beamline operations, the ALS has produced numerous high-quality results and achieved an enviable level of performance. Since the beginning of 1994, the ALS has operated for 92% of its scheduled hours, an outstanding achievement for a new machine.

The ALS' ability to deliver the brightest light in the world in the ultraviolet and soft x-ray regions of the spectrum has attracted a who's who of synchrotron research to the experiment floor. These users have produced a variety of scientifically significant results during the ALS' first year of operation, a few of which are highlighted in this article. Another opportunity to hear about new science at the ALS is to attend the upcoming ALS Users' Association Annual Meeting on October 20–21 at Lawrence Berkeley Laboratory.




***This curium-248 photoelectron spectrum represents the successful result of a "proof of principle" experiment using ultra-ESCA at the ALS to collect data from extremely small radioactive samples. This capability could prove valuable in applications such as the analysis and evaluation of contaminated soils in nuclear waste sites because the amount of material needed to carry out the experiment has such a minuscule level of radioactivity. The labels 5/2 and 7/2 refer to the total angular momenta (j) of the orbitals from which electrons were emitted to form the corresponding peaks.***

## Spectromicroscopy of Nanogram Samples

Beamline 7.0, the state-of-the-art undulator beamline designed by the ALS, is providing users with a quantum leap forward in performance compared to anything else in the world. One of the first groups ready to take advantage of the high flux and small spot size (less than 50 μm) this beamline can deliver was a research team which included members from the beamline's spectromicroscopy participating research team, in collaboration with scientists from LBL's chemical sciences and materials sciences divisions, using an x-ray photoelectron microscopy endstation. Placed in the enviable position of having to choose among the multitude of possibilities this beamline offers, they focused their initial efforts on a "proof of principle" experiment using curium oxide to demonstrate the usefulness of ultra-ESCA (electron spectroscopy for chemical analysis) for characterizing minute radioactive samples. The ESCA process involves irradiating the surface of a sample with x rays and measuring the energies of the photoelectrons emitted from the surface as a result (see inset in figure). The resulting spectrum of electron energies gives the chemical composition of the sample, as well as structural and chemical bonding details.

Ultra-ESCA, pioneered by a research group led by Brian Tonner of the University of Wisconsin, uses ESCA with extremely small samples or small areas of samples. The x rays in the curium experiment illuminated less than 5 ng of material, with a level of radioactivity considerably lower than that of a household smoke detector. The ability to collect data from such small samples, providing a safer alternative to other techniques which require working with larger amounts of material, will prove useful for many applications such as analyzing soil from contaminated waste sites as part of ongoing bioremediation studies. One of the team's next priorities is the development of imaging ultra-ESCA. Whereas the current technique provides information for an entire 50 μm spot at once, imaging ultra-ESCA will provide two-dimensional, sub-micron-resolution maps of a sample's surface, with chemical information for each location.

## In This Issue

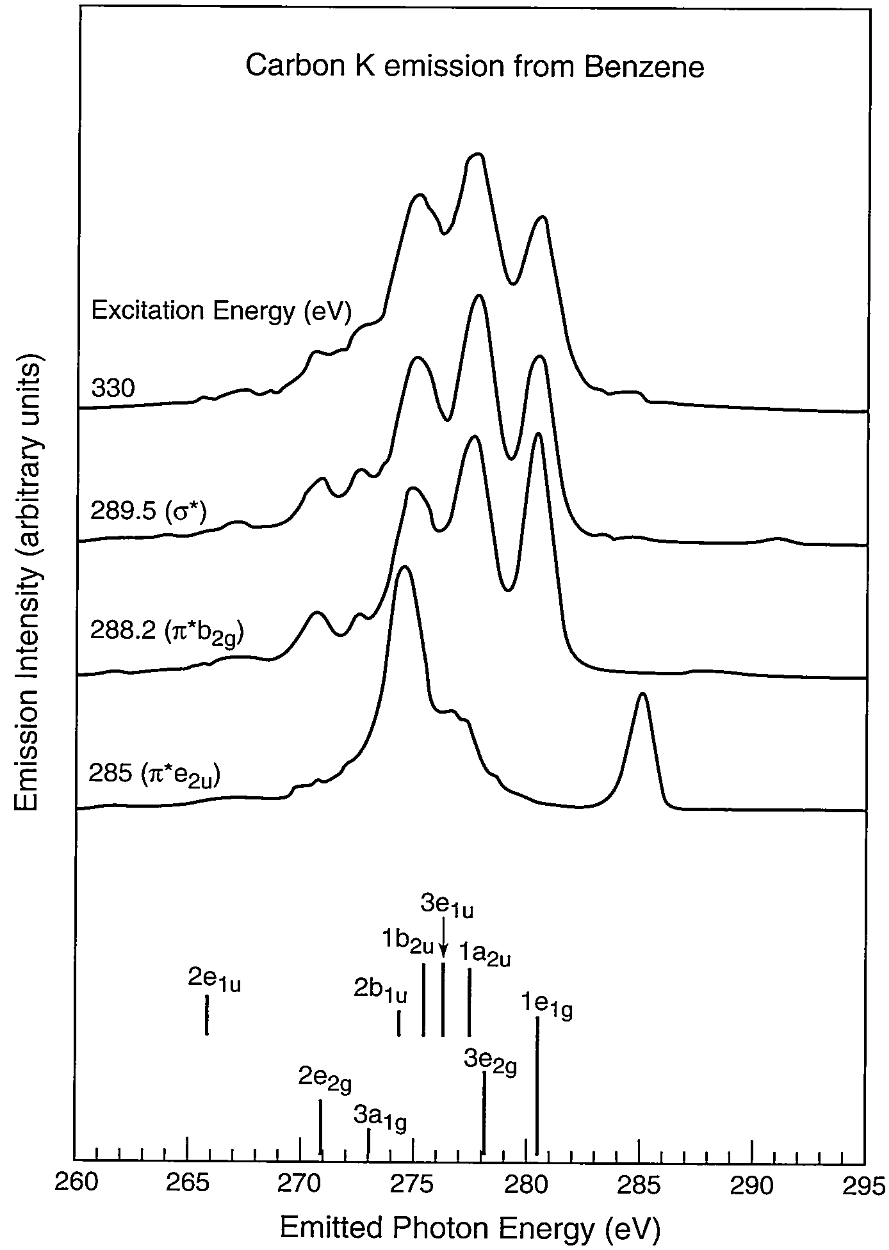
## A Symmetry-Selective View of Benzene

Another center of activity on Beamline 7.0 has been a series of experiments by Joseph Nordgren of Uppsala University in the field of resonant inelastic x-ray scattering (RIXS) spectroscopy. Recently, he and his research team have used RIXS to study benzene with respect to the symmetries of its molecular orbitals. In the experiment, the core-level electrons of the carbon atoms in a thin film of benzene were excited by x rays with selected energies below the energy required to ionize (remove electrons from) the atoms. As a result, the excited electrons moved from their core levels to unoccupied molecular levels with much higher energies, and other electrons from occupied states with somewhat lower energies dropped down to fill the core holes, emitting their lost energy in the form of fluorescent x rays.

The key to understanding the results of the experiment is that the RIXS process takes place in one step, not in the usual two-step fashion with excitation and emission taken as separate processes. The one-step, two-photon nature of the RIXS process makes it highly symmetry-selective; that is, if the incoming x rays excite a core electron to an orbital with a particular symmetry, the electrons that drop in energy to fill the core hole will have the same symmetry. This discovery came from comparing the energies of the incoming photons with the energies of the fluorescent photons. A difficulty with this type of experiment is that orbitals with similar energies often have different symmetries. To distinguish among the different symmetries, Nordgren's experiment had to resolve fluorescent photon energies differing by as little as 0.5 eV—a resolution unattainable at the present flux requirements by most x-ray research facilities but well within reach at the ALS.

The fact that the RIXS process is highly symmetry-selective means that selectively excited soft x-ray emission spectroscopy can be used to study a symmetric molecule like benzene with respect to the symmetries of the different molecular orbitals. For example, the two main types of orbital symmetry in benzene (gerade and ungerade, symbolized as g and u) can be separately studied. Nordgren's group is also investigating substituted benzenes, where the symmetry is lowered by the substitution of atoms of different elements at one or more sites in the molecule, so core electrons at defined sites can be selectively excited. Since the x-ray emission process is highly localized, scientists can study the local electronic structure around one particular atom of a molecule.

Nordgren's experiments are using a spectrometer he designed for soft x-ray fluorescence spectroscopy which consists of a rotatable analysis chamber equipped with a grazing incidence multi-grating spectrometer. By rotating the analysis chamber, it is possible to detect photons emitted at various angles with respect to the horizontal plane (plane of polarization of the synchrotron radiation).




***This figure shows a comparison between a non-resonant x-ray fluorescence spectrum (top curve) generated far above the ionization energy for benzene and several RIXS spectra. Each of the resonant spectra is labeled with the symmetry of the orbital to which a core electron would be excited by the incoming x-ray energy. Below the spectra, the labels on the vertical lines represent the molecular orbitals from which electrons dropped to fill core holes. Each line's position shows the corresponding orbital's energy, and a line's length gives a relative idea of how many p-type (angular momentum = 1) electrons came from the orbital. The symbols for each orbital denote its symmetry. The bottom two spectra, when compared to the $1e_{1g}$ line, show an example of symmetry selection: a peak corresponding to the $1e_{1g}$ line appears in the $\pi^*b_{2g}$ spectrum (g symmetry), but not in the $\pi^*e_{2u}$ spectrum (u symmetry).***

# DISCLAIMER

## Industry Profits from Microprobe's Sensitivity

The high elemental sensitivity of the x-ray fluorescence microprobe on Beamline 10.3 has proved useful for many kinds of applications during its first year of operation—including measuring the concentrations of metal in organic material taken from contaminated wetlands to help develop effective bioremediation strategies, studying high-strength ceramic materials, and providing the answer to "Why is this solar cell defective?" to a mystified manufacturer. The microprobe, developed by LBL's Center for X-Ray Optics, takes advantage of the high brightness and low emittance of the ALS beam to achieve an elemental sensitivity of $10^{-15}g/\mu m^2$ and a spatial resolution approaching 1 μm.

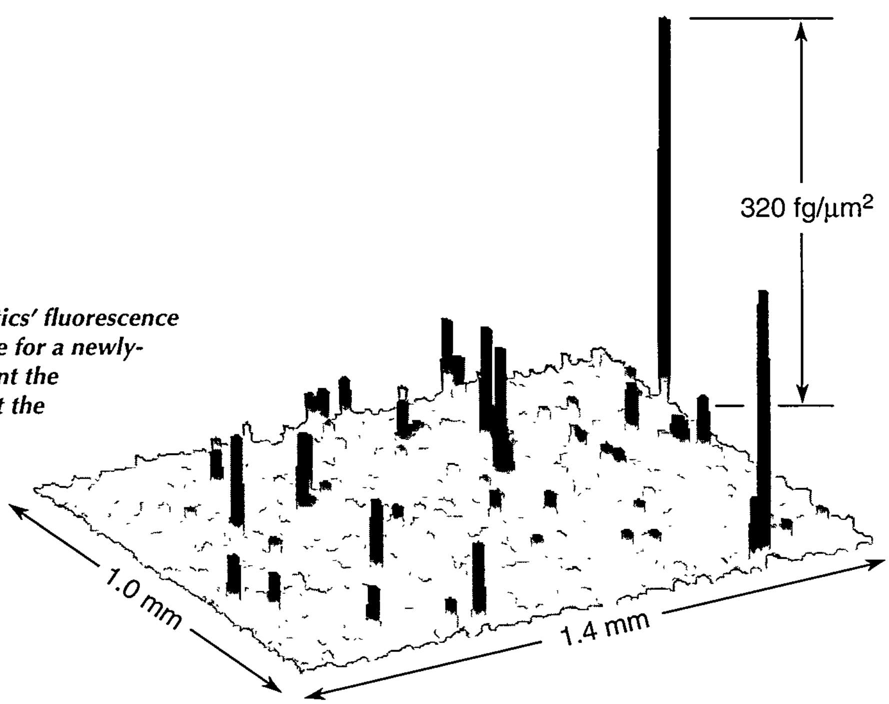
The solar cell manufacturer solicited the help of the beamline research team to find out why their previously successful fabrication process had begun turning out non-functional photovoltaic cells. The fluorescence microprobe is able to detect trace elements in a bulk sample, whereas techniques involving electron photoemission are sensitive only to the elements on the surface. This capability, along with the high sensitivity and spatial resolution of the microprobe, were essential in completing the solar cell analysis. The team's scan of the defective solar cell revealed the amount and distribution of extremely small quantities of iron impurities present at and below the surface that were probably introduced during fabrication and led to the cell's failure.

## A New Way to Probe Band Structure

The Beamline 8.0 participating research team has made many contributions to new science at the ALS during 1994. One recent achievement is their observation that certain features in the resonant fluorescence spectra of some materials arise from a one-step (coherent) fluorescence process, a discovery that has revealed a new way to probe band structure. Band structure, a key predictor of a material's behavior, is the relationship between the two most important parameters for describing electronic states in a solid: energy and crystal momentum (a description of electron momentum defined in the context of crystalline structures).

In soft x-ray fluorescence (SXF), photons are used to excite an electron from an atom's core energy level to a higher energy level, and a second electron from an intermediate energy level drops to fill the resulting hole in the core energy level. The energy lost by the second electron is radiated as a fluorescent photon with an energy determined by the atom and its molecular environment. In *resonant* fluorescence experiments, the energies of the incoming photons are close to the minimum energy required to remove core electrons (called the core ionization threshold), rather than considerably above the ionization threshold as in much previous fluorescence work. The high brightness of the ALS is a strong asset in high-resolution SXF experiments because it excites strong fluorescence even from elements which do not fluoresce well under many conditions and because it reduces the time required for scans from hours (at many other sources) to minutes.

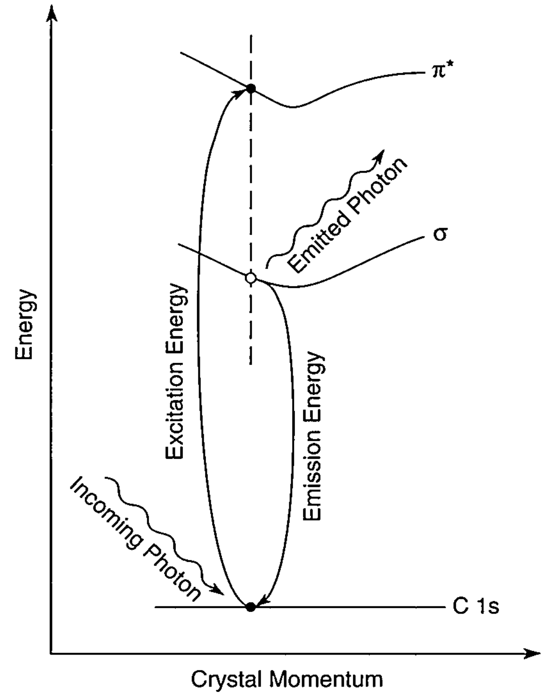
The graphite experiment showed that for coherent fluorescence, produced by resonant techniques, the state to which the first electron is excited and the state from which the second electron drops must have the same crystal momentum (i.e., crystal momentum is conserved). By making small variations in the incoming photon energies, Beamline 8.0 researchers excited electrons to states with differing crystal momenta and observed corresponding shifts in the fluorescence spectra peaks. The shifts were in excellent agreement with the graphite band structure predicted by theory (see accompanying figure), thus demonstrating the potential of resonant SXF for examining the momentum-resolved electronic structure of complex materials, including those for which calculated band structures are not available.



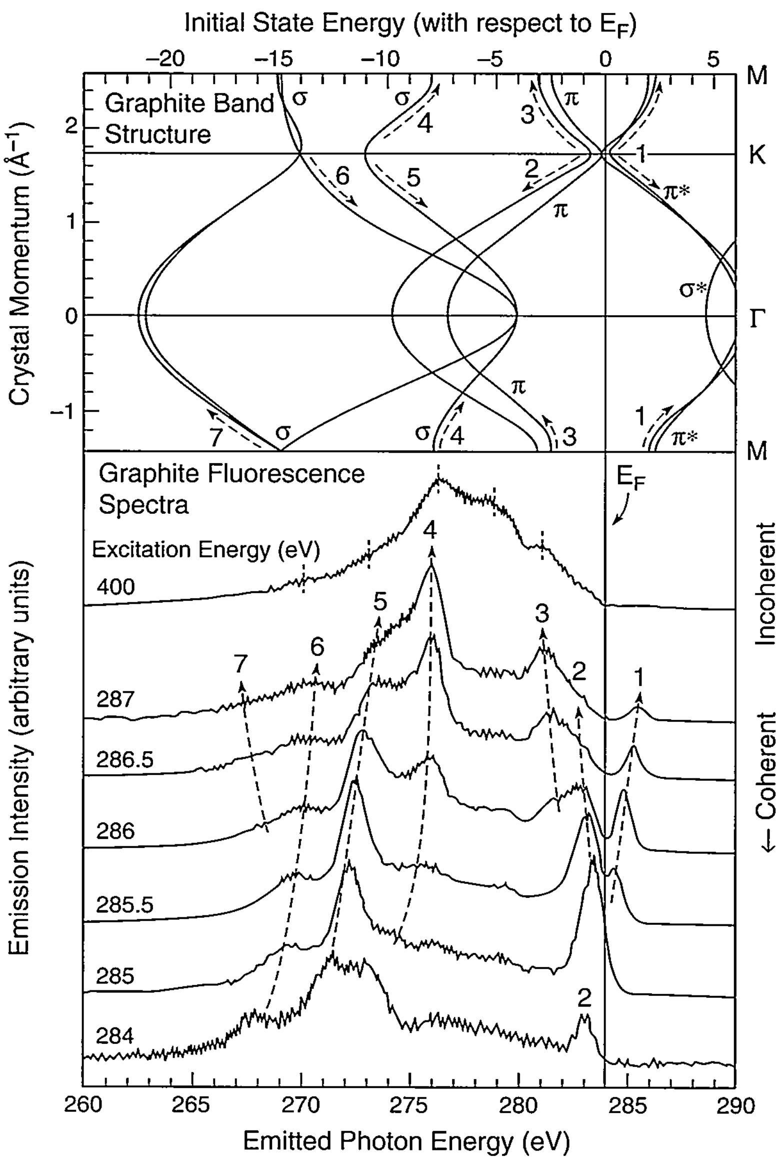

***This image, produced on the Center for X-Ray Optics' fluorescence microprobe beamline, revealed the cause of failure for a newly-manufactured silicon solar cell. The peaks represent the amount of iron in the defective cell, and show that the iron had settled along the boundaries of the individual crystals in the polycrystalline silicon wafer, interfering with the solar cell's performance.***

The utility of SXF also stems from its ability to analyze polycrystalline samples, rather than the hard-to-obtain single crystals used in angle-resolved photoemission experiments, and to obtain element-specific information from materials composed of many elements.

The graphite experiment was conducted by John Carlisle, Eric Shirley, and Louis Terminello, all of Lawrence Livermore National Laboratory, and Tom Callcott and J.J. Jia of the University of Tennessee, using the University of Tennessee soft x-ray emission spectrometer endstation.




*This figure shows why spectral peaks shift when the excitation energy changes slightly. When a core electron is excited with a given excitation energy, the band structure determines the possible value(s) of crystal momentum (shown as horizontal position in this diagram) for the electron's excited state, and the electron which drops to fill the core hole must have the same crystal momentum as the excited electron (dotted vertical line). A slightly lower excitation energy in this case would result in a lower emission energy, representing a shift of the same type as that labeled by arrow #4 in the larger figure.*




*The lower panel shows fluorescence spectra taken on undulator Beamline 8.0 from highly-oriented pyrolytic graphite at several different excitation energies. The upper curve is a non-resonant spectrum at 400 eV excitation energy. The lower curves are resonant fluorescence spectra, with excitation energies near the ionization threshold for graphite. The gradual displacements of fluorescence peaks with increasing excitation energy are labeled 1–7 with arrows; these arrows correspond to those in the upper panel which shows the mathematically derived band structure for graphite. The symbols M, K, and Γ refer to points of symmetry in the band structure; $E_F$ is the Fermi energy.*

# Neville Smith Named Scientific Program Head

LBL Director Charles V. Shank has appointed Neville Smith as the first Scientific Program Head of the ALS. In this position, Smith will be responsible for the development of the scientific program, which includes promoting the unique ALS capabilities to the user community and to potential new user groups, as well as overseeing user services and administration. Specific duties include supervising the user program, chairing the newly formed Program Advisory Committee, acting as scientific representative of the ALS, and ensuring that the operation of the ALS meets user and scientific goals, including those of industrial participants.

*Neville Smith is the new ALS scientific program head.*

Smith comes to the ALS after a 25-year career at AT&T Bell Laboratories, where he gained an international reputation for his work in the application of photoemission to the investigation of solids and surfaces. He obtained his university education at Cambridge, gaining a B.A. from Queens' College in 1963 and a Ph.D. at the Cavendish Laboratory in 1967. After a post-doctoral appointment working with photoemission pioneer William Spicer at Stanford University, Smith became a member of the technical staff at Bell Laboratories in Murray Hill, NJ, in 1969.

During his career, Smith has specialized in the use of synchrotron radiation for photoemission, first becoming an early user at the old Tantalus storage ring, which preceded Aladdin at the University of Wisconsin Synchrotron Radiation Center, and later establishing beamlines on the UV ring at the National Synchrotron Light Source. At Tantalus, he developed angle-resolved photoemission as a tool for mapping band structures. More recently at the NSLS, he has been in the forefront of spin-polarized photoemission and soft x-ray absorption spectroscopy with circularly polarized synchrotron radiation. In 1991, Smith received the American Physical Society's Davisson-Germer Prize in surface physics for his contributions to momentum-resolved photoemission spectroscopy.

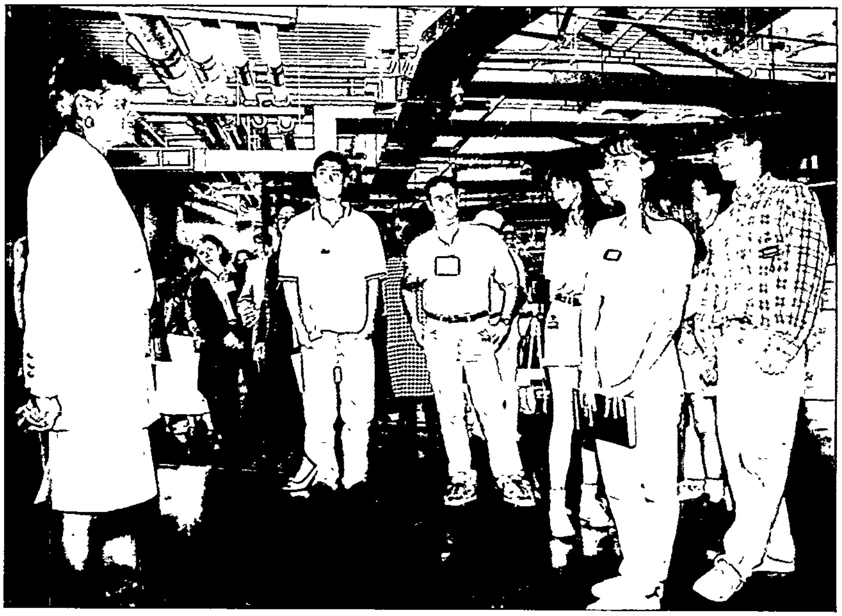
Smith's connection with the ALS began in 1987, when he was a member of the ALS Users' Executive Committee. When his term expired, he became chair of the ALS Program Review Panel, which reviewed all proposals to form participating research teams (PRTs) and thereby played an important role in the early development of the ALS scientific program. In June, the Program Review Panel was recast as the Program Advisory Committee, chaired by Smith, to provide a broader range of oversight than its predecessor. The Committee will serve as a "board of directors" working through ALS Director Brian Kincaid to advise the LBL Director on current ALS operations, allocation of facility resources, strategic planning, budget development, and other major issues. It is also responsible for reviewing proposals for establishment of new participating research teams (PRTs) and monitoring progress and performance of approved teams.

One of Smith's main tasks at present is developing a formal proposal process for independent investigators wishing to perform experiments at the ALS. This process will be in place by late fall. Among his other activities are establishing spin-polarized photoemission and photoemission microscopy experiments at the ALS and working as one of the principal investigators involved in a cooperative agreement with IBM to study magnetic materials with applications for high density storage.

**The ALS is now soliciting proposals from scientists who wish to conduct research at the facility as independent investigators during 1995.**
**To receive instructions for submitting a proposal, please contact Elizabeth Saucier, ALS User Administrator**
**Lawrence Berkeley Laboratory**
**MS 80-101, Berkeley, CA 94720**
**Tel: (510) 486-6166**
**Fax: (510) 486-4960, Email: ECSaucier@lbl.gov.**

# Special Events

*The ALS was honored by a visit from U.S. Department of Energy Secretary Hazel O'Leary during a meeting with her Scientific Advisory Board held at LBL on June 30. After receiving an introduction to the ALS given by Director Brian M. Kincaid, the Secretary enjoyed the opportunity to talk with several of the students involved in research projects at the ALS to share ideas on how their work experience benefits their academic studies and pursuit of science as a career.*



*Robert Dynes, a member of the University of California's President's Council on the National Laboratories, looks at recent results from an LBL/Jet Propulsion Laboratory collaboration on micromachining during the Council's tour of the ALS in May. Assisting Dynes is Chantal Khan-Malek of LBL's Center for X-Ray Optics, who is a member of the research team.*

*Special guests at the opening reception for an exhibit of student artworks featuring the ALS were Iran Thomas, Department of Energy Office of Basic Energy Sciences, and Professor Joseph Slusky, University of California at Berkeley Department of Architecture. The paintings and drawings originated from an evening art session held at the ALS as part of a visual arts course given by Professor Slusky, and were displayed in the lobby of the ALS as part of a special exhibit sponsored by David Attwood of LBL's Center for X-Ray Optics. The highlight of the reception was a talk given by Iran Thomas entitled "Creativity in Art and Science."*

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# ALS Update: Highlights of Beamline and Operations Activity

The fabrication, testing, and commissioning of new beamlines and the development of new techniques to improve user operations continue to be the chief focal points of ALS activity. The success of these efforts depends on the cooperation of many groups within the ALS and between the ALS and the beamline research teams, working together to produce high-quality results and performance. Some of the highlights of recent months include the installation of the third undulator, three new beamlines in operation, and several improvements in machine operations.

## Beamline 6.1 Successfully Commissioned

The research team connected with Beamline 6.1 had reason to celebrate on August 5 as light entered the beamline and reached the endstation on the first attempt. After an initial beamline commissioning period of a few weeks, the endstation's high-resolution zone plate microscope, expected to achieve spatial resolutions of 300-500 Å, will take its first images of test samples. Researchers using this beamline will be able to analyze samples 1-10 μm thick in transmission mode, and to alternate easily between visible-light and x-ray microscopy.

Beamline 6.1 will be dedicated to high-resolution microscopy for biology and materials science applications. An important aspect of the biological experiments will be analysis of contrast mechanisms, preparation techniques, and methods of mitigating the effects of radiation. Werner Meyer-Ilse (LBL's Center for X-Ray Optics) is spokesperson for the Participating Research Team (PRT) operating the beamline.

## Beamline 9.0.1 Sees The Light

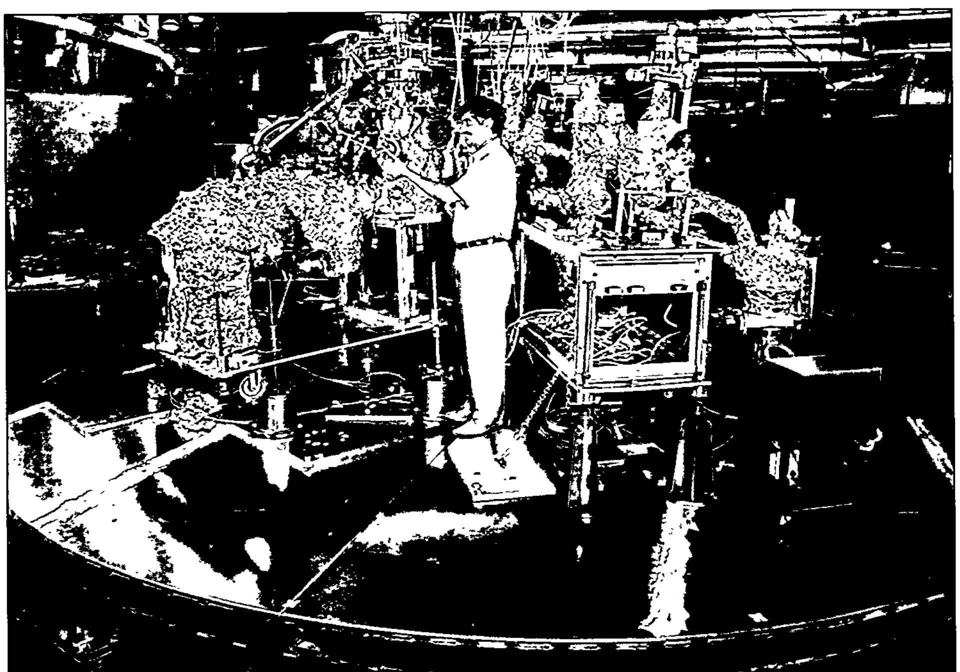
Beamline 9.0.1, dedicated to atomic and molecular physics, saw its first light on August 17, and within 20 hours light was passed through all of the optical elements to the end of the beamline, a remarkable achievement. Initial measurements show the spot size at the sample to be 33 μm vertical by 650 μm horizontal, and indicate the beamline will meet the performance specifications with a flux of $> 10^{12}$photons/sec at a resolving power of 10,000. The high spectral resolution available from this undulator beamline will provide new capabilities for obtaining higher resolution data than is available from atomic and molecular physics experiments carried out at other facilities, greatly enhancing scientists' ability to expand our understanding of electronic structure.

The beamline will serve three branchlines, one semi-permanent endstation for "at wavelength" testing of optics for extreme ultraviolet (EUV) lithography run by Jeffrey Bokor (U.C. Berkeley) and two endstations that will be shared by members of the atomic physics community. Optimizing the beamline for a particular experiment has proved to be a particularly easy task thanks to the excellent functional design of the beamline layout and components. Initial users of the shared stations will include Denise Caldwell (University of Central Florida) and Manfred Krause (Oak Ridge National Laboratory) for photoelectron spectroscopy of chlorine and methane, and Nora Berrah (Western Michigan University) for electron time-of-flight experiments to study electron correlation in helium.

## Beamline 9.3.2 Begins Operations

The start of operations for Beamline 9.3.2 began in June when light passed through the beamline to a photoionization gas cell, and measurements taken during the initial commissioning period showed the resolving power was close to 8,000 at higher photon energies. The major components of the beamline were moved to the ALS from Beamline 6-1 at Stanford Synchrotron Radiation Laboratory (SSRL), and modified to make best use of the high brightness and low emittance of the ALS, where the monochromator is expected to have a higher throughput for spectroscopy and microscopy by more than an order of magnitude compared to its performance at SSRL. In addition, Beamline 9.3.2 allows selection of either linearly or circularly polarized light, a first at the ALS.

The beamline endstation has a movable platform that accommodates two experimental chambers and enables the photon beam to be directed to either experiment chamber without breaking the vacuum. At present, one of the chamber sites is outfitted with an angle-resolved photoemission spectrometer



***Zahid Hussain, a member of the Beamline 9.3.2 participating research team, makes an adjustment to the angle-resolved photoemission spectrometer newly installed on the beamline endstation's rotatable platform.***

(ARPES), and the other holds a photoionization gas cell used for commissioning the beamline. Other experiment chambers can also be installed in the two platform positions; two already planned for use in the near future include an applied materials chamber for analytical industrial applications (now under construction) and an advanced photoemission spectrometer (APES). The installation and commissioning of the beamline was supervised by ALS scientist Zahid Hussain, and the beamline's PRT is led by Charles Fadley (U.C. Davis and LBL).

## PRISM Endstation Commissioning Underway

George Castro of IBM's Almaden Research Center and members of Brian Tonner's research group from the University of Wisconsin have been busy during the last few months commissioning their new state-of-the-art Paraxial-Ray Imaging Spectromicroscope (PRISM) endstation on Beamline 7.0. Initial tests of the x-ray photoelectron emission microscope (X-PEEM) constituting the front end of PRISM show a chromatic-aberration-limited resolution of 2000 Å; addition of the energy filter and projector forming PRISM's back end is expected to improve that figure to a few hundred angstroms. The microscope, designed for IBM by a group led by Brian Tonner, will be moved to Beamline 8.0 this fall.

PRISM creates an image by irradiating a sample with x rays of one energy (for example, near an absorption edge for an element of interest), and measuring the quantity and kinetic energy of electrons emitted from each part of the sample within the selected field of view. Researchers can also use PRISM to construct a spectrum for each pixel in an area by taking a series of images using different incoming photon energies, thereby obtaining information on local chemical or magnetic states. PRISM is particularly suited to analyzing fragile samples, such as the thin polymer films used on computer disks, which are quickly destroyed by conventional electron microscope techniques.

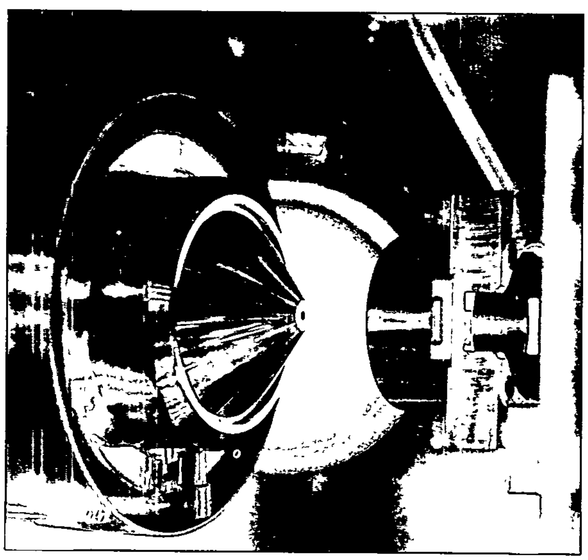
## Third Undulator Delivers Unmatched Performance

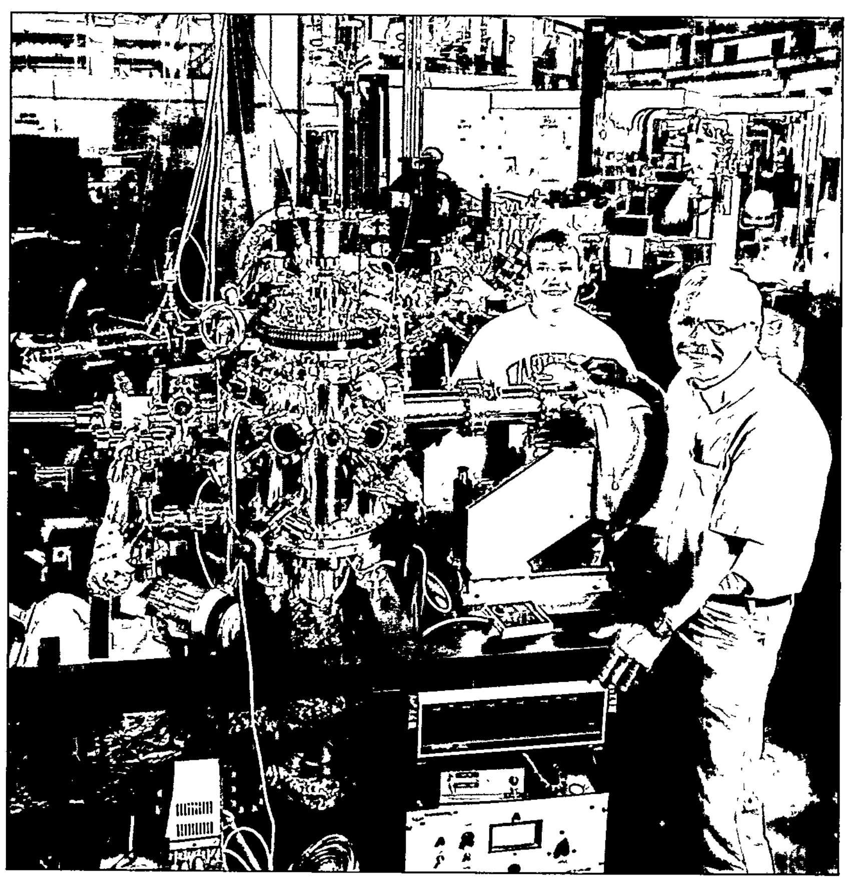
The latest in the series of insertion devices designed for the ALS, an 8-cm-period undulator (U8), was installed in sector 9 of the storage ring during the May-June shutdown, and measurements of the undulator light taken during its initial operation show a phenomenal level of performance. By late August, the undulator was delivering high-quality beams of extreme brightness to user experiments.

An ALS-designed transmission grating spectrometer (TGS) was placed in Beamline 9.0 to measure the spectrum of the undulator beam and provide a confirmation of its performance. The TGS spectra revealed sharp peaks at the 3rd and 5th harmonics, and a total of about 100 harmonics at the smallest undulator gap. These measurements indicate that the U8 is essentially perfect in its conformity to design specifications. The U8 undulator will produce light at photon energies from about 5.5eV to 1100 eV, initially for Beamline 9.0.1 and early next year for Beamline 9.0.2.

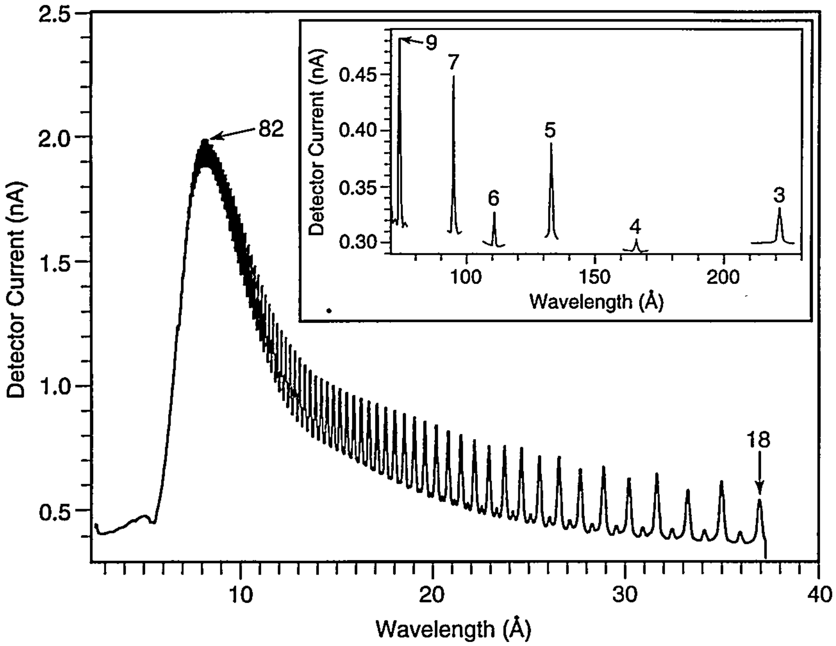
## Progress in Operations

The accelerator physics and operations teams have made several major advances in the areas of beam orbit correction, beam stability, and compensating for the effects of undulators on the beam in the past several months. They have also faced the task of assessing the extent and location of damage caused by unexpected events such as the earthquake on June 26 and the momentary power surge on August 12 caused by a ground fault at U.C. Berkeley. In both cases, the ALS staff re-established beam to user experiments with minimal delay.





*Tim Droubay of University of Wisconsin, Milwaukee, and George Castro of IBM's Almaden Research Center have led the commissioning efforts for the newly-constructed PRISM endstation on Beamline 7.0. The photo above is an inside view of PRISM, showing the conical electron lens and, to its right, a cylinder surrounding the sample.*




***Spectrum of the 8-cm-period undulator taken by the TGS, showing harmonics from the 3rd to the 82nd (and beyond) at a value of K = 5.24 (25 mm gap).***

*Implementing user control of undulator gaps*

ALS users can now independently adjust the gap of their beamline's undulator knowing the change will not disturb the beam delivered to other experiments; this marks an important milestone in the ALS' commitment to being a user-oriented, user-friendly facility. The new "feed-forward" algorithm making this possible was developed by measuring the effects on the electron and photon beams caused by changing the undulator gaps, and calculating the necessary changes to the local corrector magnets to compensate for those effects. Measurements show that the feed-forward mechanism holds beam position distortions under 30 µm for all adjustments, and refinements in progress should make that figure less than 20 µm (a standard already reached with the new 8-cm-period undulator installed in sector 9).

*Expanding range of operating conditions*

The ALS has successfully tested and demonstrated its ability to run at 1.3 GeV and in two-bunch mode in response to user requests for these operating conditions. The 1.3 GeV operations test, motivated by the need of some users to run undulator experiments using photon energies below the normal range, proved successful on the first attempt. Less than an hour of fine-tuning was required by the accelerator physics group to bring the beam current up to 300 mA with an estimated lifetime of 11 hours, comparable to normal operations levels.

*Reducing multibunch-mode instability*

Tests of a new feedback system to damp longitudinal oscillations in multibunch operation, and thus narrow the energy spread of electrons in the storage ring, are slated to begin in October. The system will be used for suppression of multi-bunch instabilities that cause a small energy spread in the electron beam at high current and a consequent spectral broadening of the undulator third and fifth harmonics. The design and testing of the feedback systems is being carried out in collaboration with Stanford Linear Accelerator Center and LBL's Center for Beam Physics.

## Dry-Tent Technique Shortens Shutdown

A new vacuum technique developed by ALS mechanical technicians substantially reduced the length of the May-June shutdown by obviating the need for baking out *in situ* sections of accelerator and beamline vacuum chamber that had been brought up to atmospheric pressure, a 1–2 week process formerly necessary during shutdown time to remove contaminants from ultra-high vacuum (UHV) components.

The successful demonstration of the "dry tent" (or dry hood) technique on a variety of vacuum joints means that the ALS can schedule future shutdowns to be shorter than previously thought necessary, thereby increasing the time the facility is available to users (see accompanying photo). When machine operations resumed after the shutdown, it took only two days to achieve a storage-ring beam lifetime of 14 hours at 200 mA beam current, the same as it had been before the shutdown. The dry tent technique not only permitted rapid restoration of the storage-ring vacuum and beam lifetime but also reduced to five weeks what would have otherwise been an eight-week shutdown.

In addition to the introduction of the dry-tent technique, the success of the shutdown was due to careful long-term planning and a pre-shutdown schedule during which two-day maintenance periods were incorporated into the weekly operations schedule in order to carry out electrical work required by the new installations. Using the knowledge gained during this shutdown will help reduce even further the length of future shutdowns, thus maximizing beam delivery to ALS users.

***Technician Ed Wong demonstrates the dry tent technique, developed at the ALS by John Thomson of the Mechanical Technicians Group. When workers are ready to connect a new (pre-baked) UHV section to an existing UHV chamber, they erect a dry tent made of clear vinyl over the point of connection. Dry, filtered air is forced down inside the tent over the union point from above. Dry nitrogen, cleaned by a gas purifier, is introduced into both the new pre-baked UHV component and the existing UHV chamber, and end caps are then removed from the UHV components, allowing the nitrogen to flow out. All work inside the dry tent is carried out through penetration ports by technicians wearing double surgical gloves.***

The *Advanced Light Source Report* is published periodically at Lawrence Berkeley Laboratory for members of the Advanced Light Source Users' Association and other interested persons.

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# REMINDER

Please plan to attend the Annual Meeting
of the Advanced Light Source
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