Lawrence Livermore National Laboratory

Science & Technology Review

June 2011

Postdocs Energize Science

Also in this issue:

Could Comet Impacts Generate Life?

Fabricating a Ribbon of Optical Light

Improved Imaging for Aviation Security

About the Cover

Renewing its talented workforce has been a key to Lawrence Livermore's success and longevity, and the Postdoc Program, described in the article beginning on p. 4, is a vital component for recruiting new scientists and engineers to the Laboratory. Successful candidates, all recent recipients of a doctoral degree, have demonstrated expertise in a scientific or engineering field pertinent to the Laboratory's mission and are enthusiastic about working in a highly collaborative environment. Postdocs conduct basic or applied research and have an opportunity to sharpen their scientific expertise. On the cover are current Livermore postdocs (from left): Jennifer Matzel, Saad Khairallah, Eric Wang, and Andrea Kritcher. Behind them is a screen shot from Khairallah's simulation designed to study the behavior of hydrogen.

Cover design: Daniel S. Moore

About *S&TR*

At Lawrence Livermore National Laboratory, we focus on science and technology research to ensure our nation's security. We also apply that expertise to solve other important national problems in energy, bioscience, and the environment. *Science & Technology Review* is published eight times a year to communicate, to a broad audience, the Laboratory's scientific and technological accomplishments in fulfilling its primary missions. The publication's goal is to help readers understand these accomplishments and appreciate their value to the individual citizen, the nation, and the world.

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Contents

S&TR Staff

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Feature

3 **Postdocs Vital to Our Future Workforce**
Commentary by Tomás Díaz de la Rubia

4 **Training a New Generation of Research Scientists**
Postdoctoral researchers sharpen Livermore's scientific and engineering expertise while boosting creativity, enthusiasm, and teamwork.

Research Highlights

13 **Life from Outer Space**
Low-angle comets striking Earth could have created the first amino acids and left them behind.

16 **A New Shape for Optical Fiber Lasers**
A multidisciplinary team at Livermore is designing a new ribbonlike fiber for reliable, efficient laser light.

19 **Preventing Terror in the Skies**
Advanced x-ray computed tomography techniques for detecting a broad range of explosives will help improve aviation security.

Departments

2 The Laboratory in the News

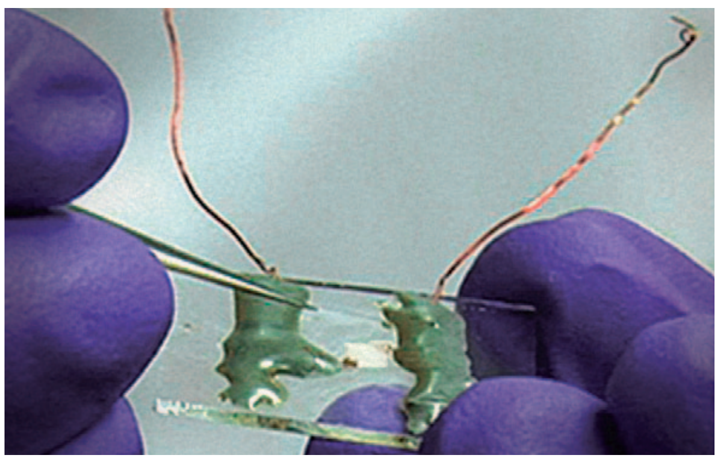
22 Patents and Awards

25 Abstract

Valuable Clues from Old Objects in the Solar System

A research collaboration involving Livermore scientists has found that calcium-aluminum-rich inclusions (CAIs), some of the oldest objects in the solar system, formed far from the Sun and later fell back into the midplane of the solar system. Findings from this study may lead to a greater understanding of how our solar system—and possibly others—have evolved.

CAIs formed some 4.57 billion years ago, millions of years before the planets began to take shape. Because CAIs are enriched with the lightest oxygen isotope relative to planetary materials, they may provide a record of the oxygen composition of the solar nebular gas in areas where they grew. The collaboration, led by researchers at the National Aeronautics and Space Administration's Johnson Space Center, studied a specific CAI from a sample of the Allende carbonaceous chondrite meteorite, which fell to Earth in 1969 and is an abundant source of CAIs. Using NanoSIMS (a nanometer-scale secondary-ion mass spectrometer), the Livermore team examined the rims surrounding CAIs in the Allende sample and measured the concentration of oxygen isotopes in each inclusion. Results showed that late in a CAI's evolution, it was in a nebular environment distinct from where it originated. This later environment was similar to the environment in which the building materials for terrestrial planets originated.



These findings imply that CAIs formed from several oxygen reservoirs, likely located in distinct regions of the solar nebula. The research also indicates that the inclusions had contact with nebular gas, either as solid condensates or as molten droplets. The collaboration, which included researchers from the University of California at Berkeley and the University of Chicago, published its results in the March 4, 2011, issue of *Science*.

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A Batteryless Chemical Detector

A research team led by materials scientist Yinmin (Morris) Wang in Livermore's Physical and Life Sciences Directorate has developed the first generation of detectors using one-dimensional semiconductor nanowires that do not need external batteries. The nanosensor (shown above) takes advantage of a unique interaction between chemical species and semiconductor nanowire surfaces to stimulate an electrical charge between the two ends of nanowires or between the exposed and unexposed nanowires. The highly sensitive device can quickly distinguish various molecules and chemical species and determine their concentration levels.

Working with colleagues from the University of Shanghai for Science and Technology, the Livermore team ran experiments on two platforms—a zinc oxide and a silicon nanosensor—using an ethanol solvent as a testing agent. In the zinc oxide sensor, the electric voltage between the two nanowire ends changed when a small amount of ethanol was placed on the detector. "The rise of the electric signal is almost instantaneous and decays slowly as the ethanol evaporates," says Wang. In tests with more than 15 solvents, the team observed different voltages for each type. The silicon nanosensor showed a similar response to the various solvents, although the voltage decay rate differed from that of the zinc oxide sensor.

Because the new detector does not require an external power source, its development could be the first step in making a chemical sensor that is easy to deploy on a battlefield. According to Wang, the team must next test the sensors with more complex molecules such as those from explosives and biological systems. Results from this work appeared in the January 4, 2011, issue of *Advanced Materials*.

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Carbon Aerogels Designed for Energy Applications

Laboratory research on advanced carbon aerogels for energy applications was featured in the March 2011 issue of *Energy and Environmental Science*. Carbon aerogels are a unique class of high-surface-area materials derived by solgel chemistry in which the liquid component of a polymer gel has been replaced with a gas. Because of their high surface area, electrical conductivity, environmental compatibility, and chemical inertness, carbon aerogels are promising materials for many energy-related applications from hydrogen and electrical storage to desalination and catalysis.

(continued on p. 24)

Commentary by Tomás Díaz de la Rubia

Postdocs Vital to Our Future Workforce

AMONG the most energetic people at Lawrence Livermore are postdocs, new doctoral scientists and engineers who are just beginning promising careers. We depend on a vigorous Postdoc Program to bring new skills and knowledge to the Laboratory as well as a fresh perspective to our work. Postdocs bring their ideas, enthusiasm, and passion while providing a vital link to the academic world. It is good to see the Laboratory's postdoc population grow from 112 two years ago to 177 today.

Every year, we receive far more applications for postdoc positions than we can fund. As described in the article beginning on p. 4, we look for candidates with strong scientific or engineering research skills, an established publication record, and a desire to work in a multidisciplinary environment. The most promising candidates are invited to the Laboratory for interviews and to present a seminar on their doctoral research.

Livermore postdocs perform research alongside some of the top experts in the world. They present and publish research that advances knowledge in both basic and applied research and contribute to the continuing scientific and technological success of the Laboratory. Postdocs also receive career encouragement and advice from senior scientists who serve as mentors. A valuable part of the Postdoc Program is the opportunity to develop professional skills, such as writing grant proposals and peer-reviewed research papers and presenting research results at national and international conferences.

Every summer, our postdocs showcase their current scientific research results at a poster symposium. The symposium gives postdocs an opportunity to gain feedback from senior Laboratory scientists on their work, and it helps to promote interactions between postdocs and the general Laboratory community.

Postdocs are also an essential element of our strategy for recruiting and developing our workforce. Faculty members at the world's greatest universities send some of their best graduates to the Laboratory for postdoc training, and we look to these young researchers as a major source of talent for our future workforce.

By any measure, postdocs value their experience at Livermore. In fact, surveys conducted by *The Scientist* have ranked the Laboratory among the top workplaces for postdocs internationally. It is also gratifying that so many postdocs desire to make Lawrence Livermore their permanent home once they have completed their appointment. Currently, more than 60 percent of the Laboratory's postdocs are retained as staff. We encourage those who leave for other positions—whether at another national laboratory, academic institution, or private industry—to remain part of the extended Laboratory community. Many former postdocs who do not stay nevertheless become important research collaborators or otherwise remain "ambassadors" for Lawrence Livermore in the greater scientific community.

My strong feelings about Livermore postdocs are based on more than observations and surveys. In 1989, I joined the Laboratory as a postdoc in materials science. My supervisor said my job was to do science and become famous. After six months, he asked me to take the lead on writing a paper describing research that had begun before I arrived at Livermore, but that I had been heavily involved with first as a graduate student and then as a postdoc. I experienced great difficulty at first, but with others' help, we soon published the paper. I went on to do much more research of which I am still proud. As for becoming famous, I'll let history be the judge of that. Today, I see my role as helping other postdocs achieve their full potential as scientists working at an institution that offers unparalleled opportunities for advancing scientific knowledge.

The postdoc experience can be one of the most rewarding chapters in an academic or research career. I'm pleased that so many postdocs have told me their experience at Lawrence Livermore has been extremely valuable in advancing their careers. A vigorous Postdoc Program has proven to be immeasurably beneficial for the Laboratory, as well.

■ Tomás Díaz de la Rubia is deputy director for Science and Technology.

Training a New Generation of Research Scientists

Livermore's postdoctoral researchers gain invaluable experience while strengthening the Laboratory's technical expertise.

Bioscientist Kris Kulp (far right) reviews experimental results with three Laboratory postdocs (from front to back): Miranda Sarachine, Bryan Hudson, and Ben Stewart.

ACHIEVING a Ph.D. in a scientific or engineering field symbolizes the pinnacle of higher education, but it rarely marks the end of training. The sheer amount of technical knowledge required and the myriad challenges involved in conducting pioneering research in many fields demand advanced training beyond the doctoral degree. Such training is particularly valuable when it is acquired under the mentorship of a senior researcher and offers access to advanced computational and experimental facilities such as those at Lawrence Livermore.

For the Laboratory, historically bent on attracting the nation's top talents in science and engineering, having a strong program that sponsors postdoctoral researchers, or "postdocs," for two to three years has proven invaluable. What began as a small, informal effort conducted independently by various research directorates has grown substantially during the past decade, especially in the last few years. Livermore's Postdoc Program now provides much greater coordination and oversight and operates with strong encouragement from Department of Energy and Lawrence Livermore senior managers.

In 2009, 112 new doctoral degree recipients, among the most promising scientific researchers in the nation and the world, were given the opportunity to pursue research at Livermore. Two years later, that number has grown to 177. An allied program, the Lawrence Postdoctoral Fellowship Program, founded in 1997, typically accepts two to four participants annually. (See the box on pp. 6–7.)

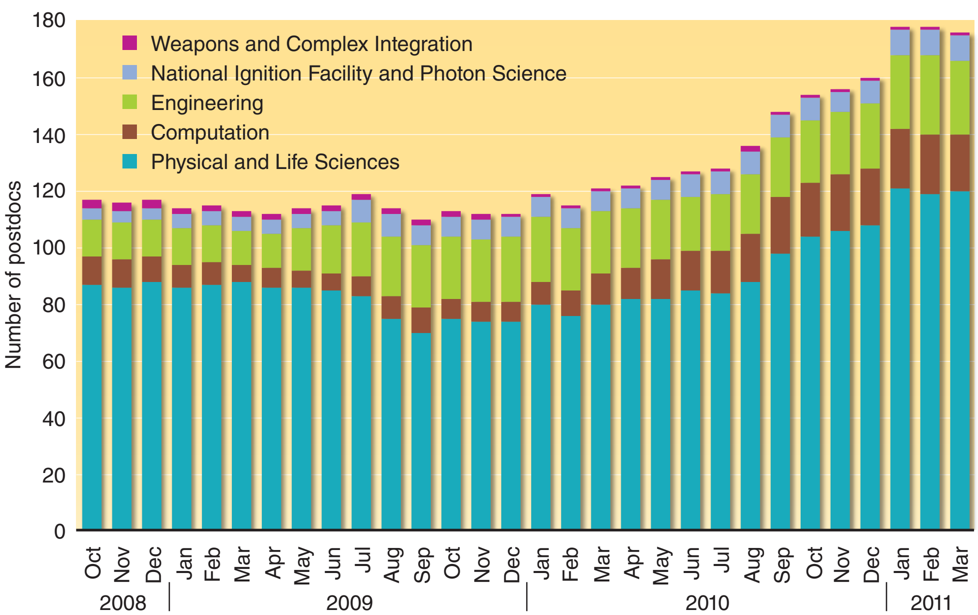
"Postdocs bring to the Laboratory many of the most recent advances taking place in academic departments at top universities worldwide," says bioscientist Kris Kulp, director of the Institutional Postdoc Program Board, which oversees the Livermore program. "These scientists and engineers are essential for maintaining the intellectual capabilities we need." While working at the Laboratory, postdocs make significant contributions to basic and applied research of national interest, from investigating dense plasmas of ions to elucidating the mechanics of climate change. "Postdocs add to the breadth and depth of Livermore's scientific capabilities," Kulp says, "and they help inspire established research teams with their creativity and enthusiasm."

Young Ph.D.s learn about the program from advertisements in scientific journals, the Laboratory's career Web sites, scientific conferences, and faculty who are affiliated with Livermore scientists. Many applicants hear about the program while attending one of Livermore's summer institutes for both undergraduate and graduate students.

Postdocs are selected for their scientific expertise, publishing record, and enthusiasm for working in the Laboratory's highly collaborative environment. Their positions offer a competitive salary, fringe benefits, and travel opportunities. Successful candidates are hired for one or two years, depending on the program, and terms can be extended up to three years—an opportunity most postdocs choose to take. About one-third of the applicants selected are non-U.S. citizens.

During their tenure, postdocs conduct research and sharpen their scientific expertise in their chosen field. Every postdoc is assigned a mentor, a senior scientist or engineer who guides the research and helps the postdoc acquire the skills necessary to advance his or her career. These skills include developing research plans, writing proposals, publishing results, and presenting their findings at national meetings. Perhaps most importantly, these young researchers have an extended opportunity to establish collaborations both within and outside the Laboratory.

Chemist John Knezovich, director of Livermore's University Relations Program, oversees collaborations between the Laboratory and the academic community



Lawrence Livermore has significantly increased the number of postdoc positions since 2008, as shown in this graph of the month-by-month postdoc population.

In addition to its historic postdoctoral program, the Laboratory also supports the Lawrence Postdoctoral Fellowship Program, known informally as the Lawrence Fellowships. Initiated in 1997, the program is a tribute to Nobel laureate and Laboratory cofounder Ernest O. Lawrence. The highly competitive program provides recipients with three years of scientific freedom at Livermore to pursue experimental, theoretical, or computational projects of their own design.

Lawrence Fellowships are awarded to candidates who have exceptional talent, established track records in scientific pursuits, and the potential for significant achievements. Fellows are free to work on projects and with mentors of their choice. This freedom, coupled with the Laboratory's interdisciplinary atmosphere, permits many fellows to investigate other scientific fields. On completing the fellowship's term, recipients may choose to stay at the Laboratory as one of their career options.

A committee with representatives from the Laboratory's mission-related organizations chooses the Lawrence Fellows each year. An applicant pool of a few hundred is reduced to six individuals, who then participate in a two-day interview. Two to four of those six individuals are selected for fellowships. (See *S&TR*, November 2002, pp. 12–18.) Particularly talented applicants not chosen as Lawrence Fellows are frequently offered traditional postdoctoral fellowships or staff positions.

"We expect Lawrence Fellows to bring something new to the Laboratory and take us in new directions," says Livermore chemist John Knezovich, who directs the University Relations Program. Indeed, fellows have produced remarkably creative research during their tenure. For example, Knezovich points to chemist Aleksandr Noy and physicist Olgica Bakajin. While working as Lawrence

In E. O. Lawrence's Image

Fellows, they built a versatile hybrid platform that uses lipid-coated nanowires. Mingling biological components in electronic circuits could enhance biosensing and diagnostic tools, advance neural prosthetics such as cochlear implants, and even increase the efficiency of future computers.

In 2010, Noy, Bakajin, Francesco Fornasiero, and Sangil Kim received an R&D 100 Award for filtration membranes composed of carbon nanotubes aligned on a silicon chip the size of a quarter. Developed in partnership with Porifera, Inc., in Hayward, California, with early support from Livermore's Laboratory Directed Research and Development Program, the nanotechnology could make water desalination more efficient and cost effective. (See *S&TR*, October/November 2010, pp. 12–13.) The two former Lawrence Fellows, now career scientists at Livermore, have taken entrepreneurial leaves of absence to work with Porifera, where Bakajin is the chief technology officer and Noy is the chief science officer. Noy is also an associate adjunct professor at the University of California at Merced.

Physicist Andrea Kritcher, shown here with a laser optic at the Laboratory's Jupiter Laser Facility, is in the second year of a Lawrence fellowship. Her work involves characterizing fusion targets and conducting research on nuclei–plasma interactions.

Second-year Lawrence Fellow Andrea Kritcher graduated from the University of California at Berkeley in nuclear engineering. She also interviewed for and was offered a staff position with the Laboratory as well as a conventional postdoc position, but she accepted the Lawrence Fellowship because of the unusual freedom the award affords. "For some researchers coming out of graduate school, it's very valuable to have an opportunity to develop more fully as a research scientist before taking a staff position," she says.

Kritcher has two Livermore mentors: physicist Siegfried Glenzer, with whom she began working as a graduate student, and physicist Lee Bernstein. In one of her projects, she is using x-ray Thomson scattering to characterize fusion targets for ignition experiments at the National Ignition Facility (NIF), in which 192 laser beams will compress and heat the hydrogen isotopes deuterium and tritium to the point of fusion.

"We're diagnosing the compression-phase temperature and density conditions of these implosion capsules," Kritcher says. "We want to achieve low temperature and high density to reduce entropy and enable efficient capsule compression to the ultrahigh densities needed for ignition." Kritcher has conducted initial experiments using the OMEGA laser at the University of Rochester's Laboratory for Laser Energetics. "I feel lucky to have this opportunity," she says. "Scientists hope to have ignition on NIF within the next couple of years, and some people have waited their entire careers for this event."

Kritcher is also looking at how nuclei interact with dense plasmas. She is planning experiments on the OMEGA laser to study nuclei–plasma interactions in thulium and osmium. She adds, "These basic science experiments are relevant to NIF-type plasmas as well as astrophysics."

to strengthen science teaching and help develop the future scientific and engineering workforce. Knezovich worked as a Laboratory postdoc in the early 1980s, one of only 12 at the time. More recently, he says, "We've built an organization around the postdocs and are paying attention to them as a group."

Pipeline for Staff Positions

Knezovich notes that besides invigorating research programs, postdoctoral appointments represent an important pathway toward filling new career positions. "The Postdoc Program is a critical component of our strategy for attracting world-class scientific talent," he says. "It's a significant part of our workforce hiring process." Historically, about half of the appointees have converted to staff positions at the end of their tenure. In 2010, that number rose to 62 percent.

"Our goal is to provide an experience that prepares them well for any job they may have in the future, either at Livermore, another national lab, academia, or industry," says Kulp. "If they don't stay, we want them to maintain a relationship with the Laboratory." Some who find positions in academia, for example, become collaborators in various research programs and recommend their graduate students apply for postdoc positions at Livermore.

Many postdocs receive support from a specific research project, typically sponsored by the Laboratory Directed Research and Development (LDRD) Program, which applies internal research and development funds to potentially high-payoff projects at the forefront of science. Positions may also be supported by external sources such as the Department of Energy's Office of Science. "The Department of Energy and its National Nuclear Security Administration expect us to invest in the future of our workforce," says Knezovich, "and LDRD funding is an excellent means to that end."

Marisa Pedretti, a postdoc in the Physical and Life Sciences Directorate, describes her research to physicist Chris Hagmann at the 2010 Institutional Postdoc Poster Symposium. The daylong symposium is an annual event, allowing postdocs to discuss their research with Livermore scientists and engineers.

In addition to funding provided by research projects, the Laboratory supports time for postdocs to devote to professional development and networking. Examples include conducting research that is more general in nature but not funded by a project; writing papers and proposals; and attending seminars, conferences, and workshops. (See the box on p. 9.)

PLS Home to Most Postdocs

Postdocs work in one of Livermore's mission-related organizations: Physical and Life Sciences (PLS), Computation, Engineering, Global Security, Weapons and Complex Integration, or National Ignition Facility and Photon Science. The majority of them find a home in PLS, where about 120 postdoctoral fellows conduct research in physics, chemistry, life sciences, earth science, and materials science.

In the last two years, the postdoc population in PLS has increased about 73 percent, from 70 to more than 120. Geochemist Annie Kersting, director of the Glenn T. Seaborg Institute, oversees the Postdoc Program for PLS. Kersting meets regularly with postdocs to make sure they are on track with their research goals as well as focused on their careers.

"Postdocs bring new scientific skills to the Laboratory and make many important scientific contributions to Livermore's programs," she says. The decision to offer a postdoc a staff position is determined by the postdoc's skill set and achievements during the fellowship as well as the funding outlook for programs needing that person's expertise. "Whether they stay on or not, we want them to maximize their time here and prepare for a career as an effective researcher."

Geologist Jennifer Matzel converted to a staff position in 2010, following a three-year term as a postdoc. After obtaining a Ph.D. in geology and geochemistry from Massachusetts Institute of Technology, Matzel accepted a postdoc position with the Berkeley Geochronology Center and the University of California at Berkeley.

Taking Care of Postdocs

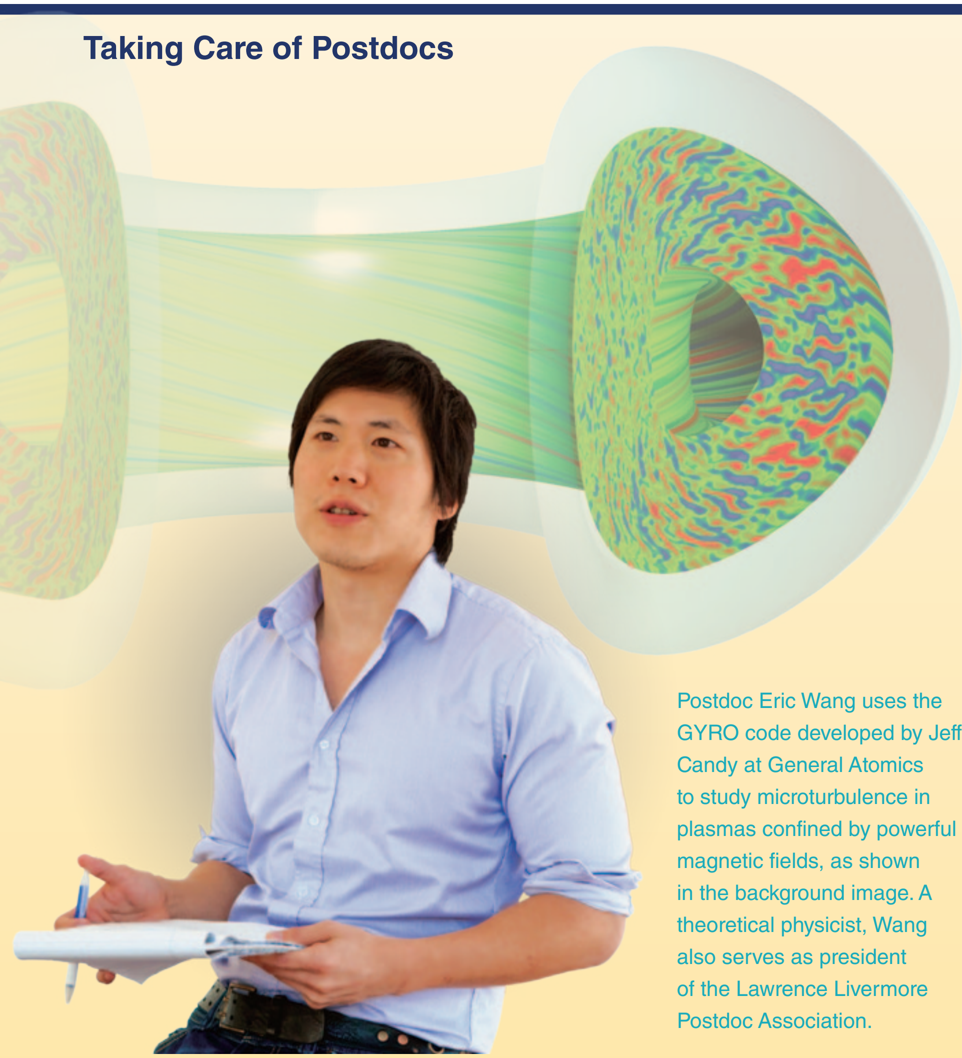
"The Laboratory is committed to providing a rewarding experience for our postdocs," says Kris Kulp, head of Livermore's Institutional Postdoc Program Board, which evaluates the quality and effectiveness of the program. The board is composed of representatives from all Livermore organizations that sponsor postdocs as well as the Strategic Human Resources Management Directorate.

The board fosters professional development activities throughout the year. Each year, the board holds a one-day postdoc workshop that focuses on career development. The board also sponsors the Lawrence Livermore Postdoc Association (LLPA), which organizes informal social activities for the young scientists and engineers. A monthly brown-bag seminar series addresses topics that help postdocs better understand the Laboratory, with question-and-answer sessions featuring senior managers such as Director George Miller. Once a year, all postdocs present results from their work at a daylong poster symposium, where they can meet and talk with Laboratory scientists about their current research.

The Laboratory's mission-related organizations also sponsor activities for their postdocs. For example, the Physical and Life Sciences Directorate holds semi-monthly seminars that feature talks from postdocs, allowing the presenters to practice giving general talks to scientists not in their immediate field of research. The directorate also offers awards each year for best research and best mentor. Other organizations might devote seminars to career development topics, such as how to write a proposal or search for a new job, and reviews of major Livermore programs and initiatives. Occasionally, past postdocs who are now on the Laboratory's staff provide insights from their experiences.

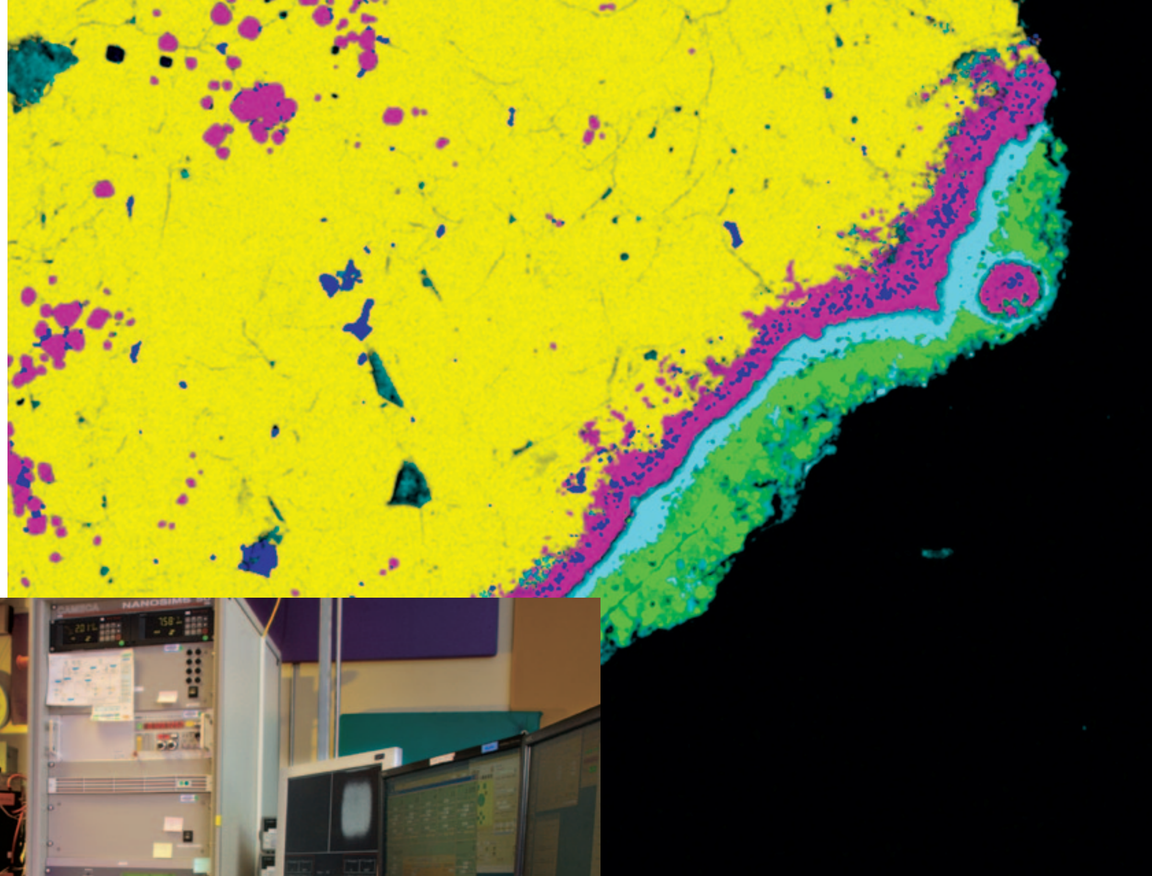
LLPA is run entirely by the current postdocs with the goal of fostering a community environment for the new researchers. The association organizes monthly lunches, an annual summer barbecue, and regular social gatherings (movie nights and happy hours). The LLPA Handbook also provides advice for living in the San Francisco Bay Area and navigating the Laboratory. The handbook recommends places to live, resources for finding rentals, and information on local stores, utilities, and transportation options.

The current LLPA president is Eric Wang, a theoretical physicist in the third year of his postdoc term. "We do our best to welcome new members, put on social events, and provide career guidance," he says. He adds that the association meets regularly with the board to discuss questions, concerns, and successes.



Postdoc Eric Wang uses the GYRO code developed by Jeff Candy at General Atomics to study microturbulence in plasmas confined by powerful magnetic fields, as shown in the background image. A theoretical physicist, Wang also serves as president of the Lawrence Livermore Postdoc Association.

Wang's research focuses on simulating microturbulence in tokamak plasmas. Scientists hope that tokamaks, which use magnetic fields to confine a plasma, will one day provide abundant energy through continuous fusion reactions. "If we can control microturbulence, we'll have much steeper temperature gradients," says Wang. "A fusion reactor would then be much smaller and cheaper to develop." Wang received a Ph.D. in plasma physics from the University of California at Los Angeles, where his adviser was collaborating with Livermore physicist Bill Nevins. Wang is one of six postdocs working in the Laboratory's Fusion Energy Sciences Program.



Livermore geologist and former postdoc Jennifer Matzel is part of a research team examining calcium-aluminum-rich inclusions in samples of the Allende carbonaceous chondrite meteorite, which fell to Earth in 1969. The compositional x-ray image (above) shows the rim and margin of an inclusion that is about 4.6 billion years old. Studies such as this one are helping researchers better understand how a solar system forms.

While there, she heard two Livermore chemists speak about nuclear forensics and decided to investigate postdoc opportunities at the Laboratory.

At Livermore, Matzel studied dust particles brought back by the Stardust space mission and samples collected from meteorites. For this research, she used a nanometer-scale secondary-ion mass spectrometer (NanoSIMS), an instrument designed to measure the elemental and isotopic concentrations of very small particles. Matzel examined the particles' isotopic composition, looking in particular for "daughter" products of an isotope of aluminum with a half-life of about 700,000 years. Information obtained from the analysis is helping scientists better understand how the solar system formed billions of years ago.

As a staff member, Matzel is continuing her cosmochemistry research and working in the field of nuclear forensics. In particular, she is studying boron isotopes found in graphite obtained from nuclear reactors. "The isotopes tell us about the reactor's history," she says, adding that her current activities are especially multidisciplinary. "My work involves biology, nuclear forensics, cosmochemistry, and geochemistry, so I'm learning about many new fields."

Her husband, Eric Matzel, is a seismologist at Livermore. She notes that the diverse scientific programs at Livermore make it an attractive research institution for two-career couples.

Engineering Builds Success

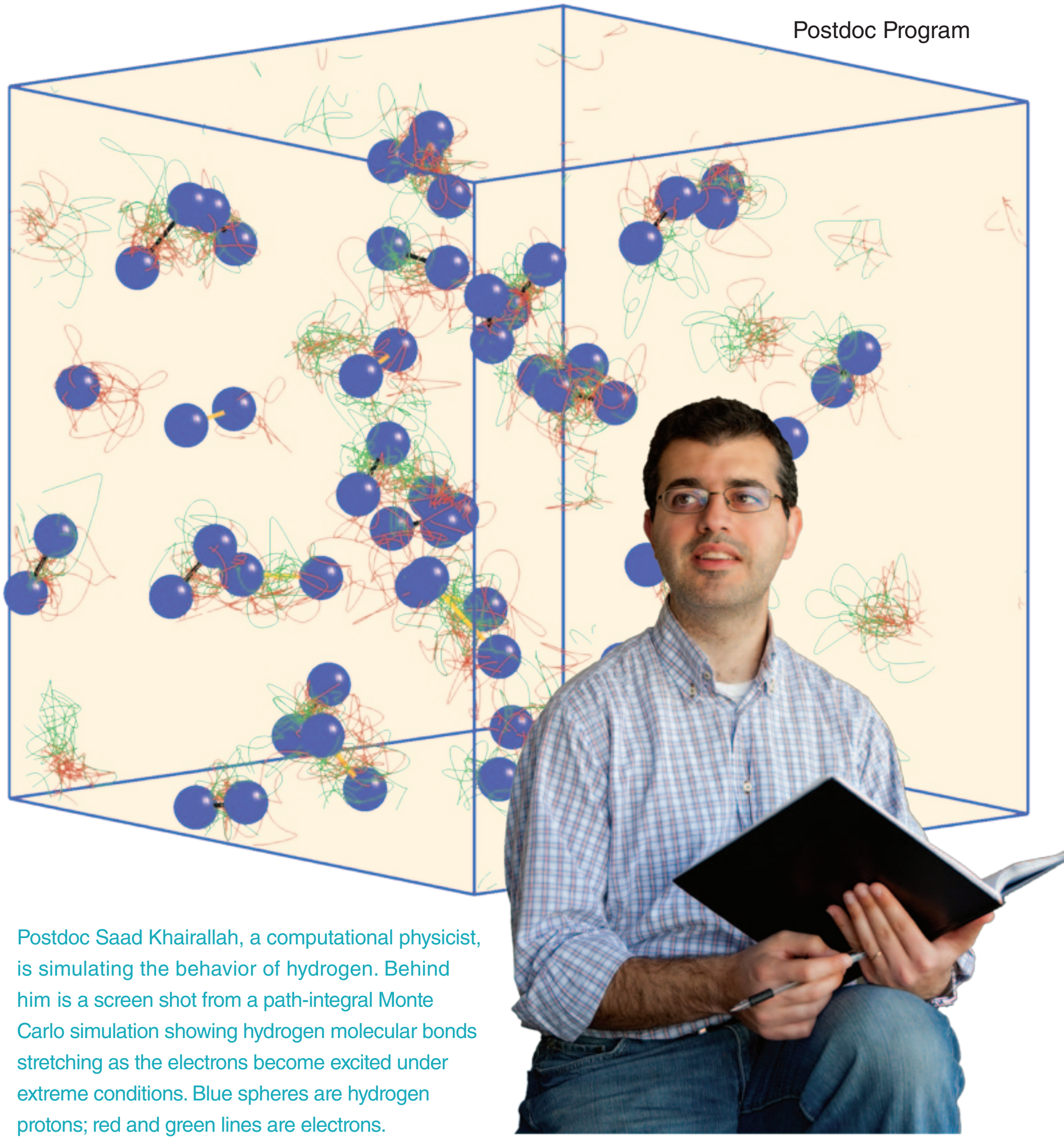
Diane Chinn, division leader for Engineering Technologies, oversees the Postdoc Program for the Engineering Directorate. "There's a certain kind of engineering postdoc who wants to work at a national lab," says Chinn. "Typically, that person is looking to apply a narrow area of expertise. This candidate may toy with the idea of academia or be interested in industry, but those options may not offer a postdoc much say over which projects to work on."

As with other directorates, Engineering advertises, recruits on major university campuses and at national conferences, and encourages applicants through its relationships with many professors. The efforts have paid off handsomely. A few years ago, Engineering employed only one to three postdoc engineers, but in 2011, 27 are on the job.

"Postdocs have a narrow and deep understanding of their fields," Chinn says. "They bring us engineering technology out of universities that is state of the art." LDRD funding pays about one-third of Engineering's postdoc salaries. The remainder is a combination of institutional and programmatic funding.

Candidates for Engineering's postdoc openings face a similar vetting process to that in other directorates, which includes traveling to Livermore for an interview and presenting a seminar on their graduate research. Occasionally, managers recognize that a strong candidate is better suited for a staff position than a postdoc fellowship.

Up to 70 percent of applicants offered postdoc positions agree to join Livermore. Chinn says the high percentage is a telling indicator of the Postdoc Program's strength because many engineering candidates receive offers from other institutions. About 50 percent of the postdoc engineers eventually convert to staff positions at the conclusion of their third year. Those who leave usually go on to jobs at a university or in industry. Wherever the former postdocs land, their mentors strive to maintain relationships and encourage collaborations.



Postdoc Saad Khairallah, a computational physicist, is simulating the behavior of hydrogen. Behind him is a screen shot from a path-integral Monte Carlo simulation showing hydrogen molecular bonds stretching as the electrons become excited under extreme conditions. Blue spheres are hydrogen protons; red and green lines are electrons.

Computation Doubles Its Postdocs

In the past two years, the Computation Directorate has nearly doubled its number of postdocs, from to 12 to 22. "The Postdoc Program is our primary means of attracting new staff into research positions," says Jeff Hittinger, the directorate postdoc advocate and a computational scientist at the Center for Applied Scientific Computing (CASC). Hittinger notes that there is a tremendous amount of competition among employers for new Ph.D.s in computer and computational science. However, few places offer Livermore's breadth of research—from computational physics and applied mathematics, to data mining, visualization, computer architectures, and high-performance computing—along with ready access to some of the world's most powerful supercomputers.

While the LDRD Program supports many Computation postdocs, a significant number are funded through programs sponsored by the Office of Advanced Scientific Computing Research in the Department of Energy's Office of Science. For example, the Scientific Discovery through Advanced Computing Program, known as SciDAC, is aimed at solving the computational challenges involved in developing future energy sources, studying global climate change, designing new materials, improving environmental cleanup methods, and advancing physics.

Third-year CASC postdoc Saad Khairallah, a computational physicist, graduated with a Ph.D. in condensed-matter physics from the University of Illinois. His thesis adviser was David Ceperley, a former Livermore researcher. Khairallah was accepted into the Postdoc Program after meeting his current mentor, Erik Draeger, at a scientific conference.

Draeger, a computational physicist, had also been a postdoc before joining the Livermore staff.

Khairallah is involved in three research efforts. First, he is helping develop new algorithms for path-integral Monte Carlo calculations to simulate the behavior of hydrogen from first principles. Results from this work will have important applications to National Ignition Facility experiments, astrophysics research, and simulations of the physical processes that occur during a nuclear weapon detonation.

"Although hydrogen is the simplest element in nature, it is nevertheless challenging to fully predict its properties," says Khairallah. "Achieving this capability would influence many areas of research because hydrogen makes up roughly 74 percent of the elemental mass of the universe. If I were not at Livermore, I could not have done such computationally intensive work."

Khairallah is also part of a large team effort that is led by Livermore physicist Frank Graziani and includes collaborators from other national laboratories. The project involves large-scale molecular-dynamics simulations of high-energy-density plasmas. Khairallah notes that his experience as a Livermore postdoc has been good. "People here value postdocs and listen to them," he says.

Finally, he is exploring a computational technique called nudged elastic band that is designed to show at the atomic level the path a physical system takes as it transitions to a final state after undergoing, for example, a chemical reaction. "We are asked to think about new algorithms to take advantage of petascale and exascale computing," says Khairallah, "and I believe the nudged elastic-band technique is a great candidate for the new generation of machines."

Future Scientific Leaders

Physicist Heather Whitley is another former postdoc who converted to a staff position following a three-year term at Livermore. Whitley, who received a Ph.D. from the University of California at Berkeley, notes that scientific fields are constantly evolving and that knowledge and techniques learned in one field can often be applied to another, particularly in the Laboratory's multidisciplinary environment. She says, "We all bring different expertise to the table. Hopefully, we all learn to listen to each other."

Livermore managers overseeing the Postdoc Program expect the program to continue to thrive and grow, as scientific fields cross traditional boundaries. "Postdocs do great research," says Kersting. "They are a talented bunch of up-and-coming scientists, and we're very happy to have them here."

—Arnie Heller

Key Words: Institutional Postdoc Program Board, Lawrence Postdoctoral Fellowship Program, Postdoc Program, postdoctoral research, University Relations Program.

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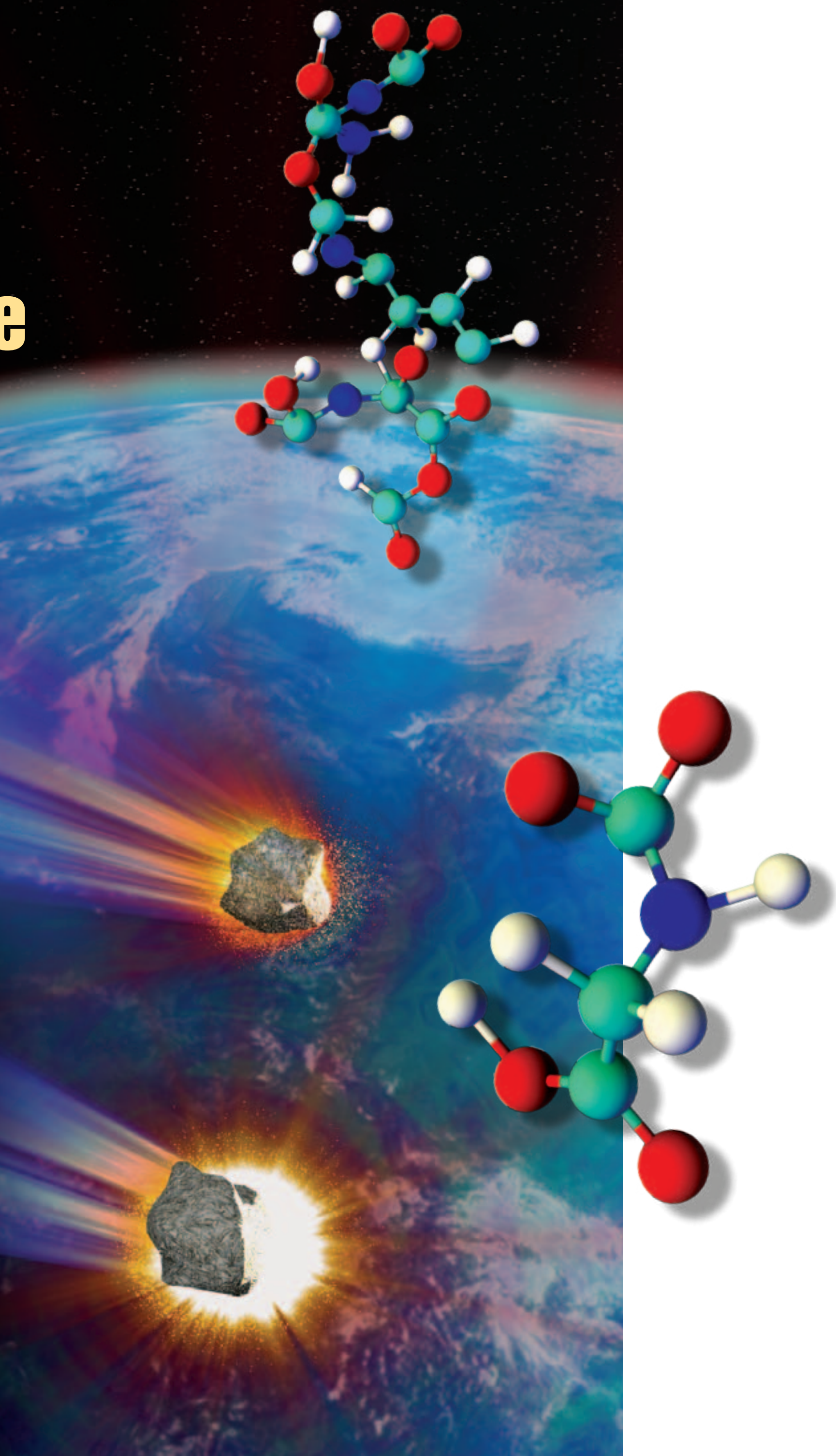
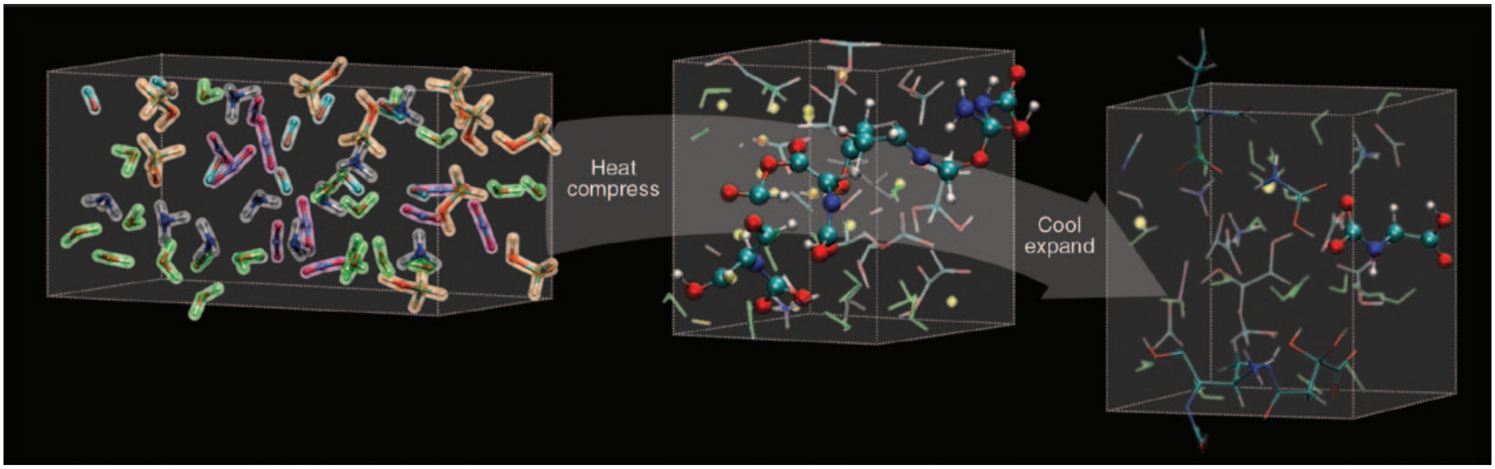
Life from Outer Space



BACK before life as we know it began on Earth—3 to 4 billion years ago—comets were regular visitors. Because of the high temperatures generated when a comet directly strikes Earth, scientists have thought it unlikely that such impacts left much behind, certainly not the materials that would bring about the origins of life. But computational simulations by a team at Lawrence Livermore indicate that a different outcome is possible. "Comets contain methanol, water, carbon dioxide, carbon monoxide, and ammonia, among a few other molecules, which are precursors to amino acids," says Nir Goldman, a physical chemist in the Laboratory's Physical and Life Sciences Directorate. "If a comet struck Earth at a low enough angle, shock waves within it could have yielded amino acids—the building blocks of life—and left them behind."

Origins-of-life research initially focused on the production of amino acids from organic materials already present on Earth. Although the actual composition of the planet's early atmosphere is unknown, the current view is that it consisted primarily of carbon dioxide, nitrogen, and water. Shock-heating experiments and calculations show that the organic molecules

In this rendering, a prototypical comet composed of methanol, water, carbon monoxide, ammonia, and carbon dioxide crashes into Earth. (Rendering by Kwei-Yu Chu.)



Computer simulations show (left) the molecular makeup of a comet before it strikes Earth, (middle) the long chains of carbon–nitrogen bonds created by the heating and compression that occur on impact, and (right) a long chain breaking apart to form complexes that contain glycine, a protein-building amino acid.

required to produce amino acids could not be synthesized in such an environment, leaving researchers with the question: where did amino acids—and the proteins and larger life forms that grow from them—come from?

Life on Ice

Comets, roaming through the freezing universe, are icy objects, ranging from less than 2 to about 56 kilometers in diameter, on average. As they pass through Earth's atmosphere, they are heated externally but remain cool inside. When a comet hits Earth, the resulting shock wave generates sudden, intense pressures and temperatures up to tens of thousands of kelvins. Such extreme conditions could affect chemical reactions within the comet before it interacts with the ambient planetary environment. The consensus had been that the intense heating from the impact would destroy any potential life-building molecules.

To study comet impacts in more detail, the Livermore team, which includes Laurence Fried, William Kuo, Amitesh Maiti, and former Laboratory employee Evan Reed, now at Stanford University, conducted computer simulations in which a comet strikes Earth at an angle of up to 24 degrees from the horizon. Results show that a glancing blow such as this one would generate significantly lower temperatures. "Under those conditions, organic materials could potentially be synthesized within the comet's interior during shock compression," says Goldman, who leads the project team. "Once the compressed material expands, stable amino acids might survive interactions with the planet's atmosphere or ocean. These processes could result in concentrations of prebiotic organic species from materials that originated in the outer regions of space."

Amino Acid Synthesis Revealed

The team explored amino acid synthesis in a shock-compressed astrophysical ice mixture using quantum molecular-dynamics simulations. Quantum simulations can offer an accurate reproduction of shock compression, greatly facilitating experimental design and theory. These calculations predict activity at the electronic scale, allowing scientists to examine processes occurring at dimensions of less than 1 nanometer (one-billionth of a meter). Information at this level of detail can help researchers interpret experimental results and design future experiments.

Each shock-compression simulation ran for about 10 picoseconds (10-trillionths of a second), the approximate time it takes a shock wave to traverse a single ice grain in a comet. Even with the enormous capabilities available at Livermore's Terascale Simulation Facility, the researchers needed several months of computing time to calculate the first set of results. They found that a high degree of chemical reactivity occurred during the simulation, and aside from small amounts of water and ammonia, almost none of the starting materials remained at higher pressures and temperatures. The simulated reactions produced long, chainlike molecules with sequences of carbon–nitrogen bonds, which are required for both amino acids and proteins to synthesize. Says Goldman, "The quantity and complexity of carbon-nitrogen-bonded oligomers grew rapidly as the simulated pressure and temperature increased."

The team ran the simulation for an additional 30 picoseconds to observe the shock-compressed material as it cooled and expanded to atmospheric conditions. During this time, the carbon-nitrogen-bonded oligomers broke into simpler pieces, one of which was a precursor to the amino acid glycine. The expansion also produced hydrogen cyanide and formic acid, both of which are precursors to amino acid and complex organic synthesis. In other words, the team's results indicate that comets impacting Earth could have produced life-building molecules, which leads to the enticing thought that our progenitors just might have come from outer space.

Physical chemist Nir Goldman is leading a computational research project at Livermore to simulate the materials that are synthesized when a comet impacts Earth.

Recent simulations have extended the timescales for shock compressions and expansions to nearly a full nanosecond, or a billionth of a second. These longer periods, Goldman notes, "will allow us to determine the chemical equilibrium products that can be produced during this type of impact event."

A Broader View

Livermore's Laboratory Directed Research and Development Program funded the initial work on this project. With support from the National Aeronautics and Space Administration's Astrobiology Program, the team is now exploring an array of scenarios, including a more direct cometary impact, resulting in even higher pressures and temperatures, and astrophysical ice mixtures with different chemical compositions. Perhaps the most exciting possibility to be considered is whether cometary impacts might have generated life on different celestial bodies, such as Jupiter's moon Titan, whose atmosphere has a density similar to that of Earth's.

"One interesting aspect of this work," says Goldman "is how applicable it is to the Laboratory's mission. Much of Livermore's research examines situations in which high pressures and temperatures are at work and result in novel chemical reactions. By learning more about chemistry under extreme thermodynamic conditions, we are making important contributions to many program areas around the Laboratory."

—Katie Walter

Key Words: amino acid chains, cometary compression, low-angle comet, molecular-dynamics simulation.

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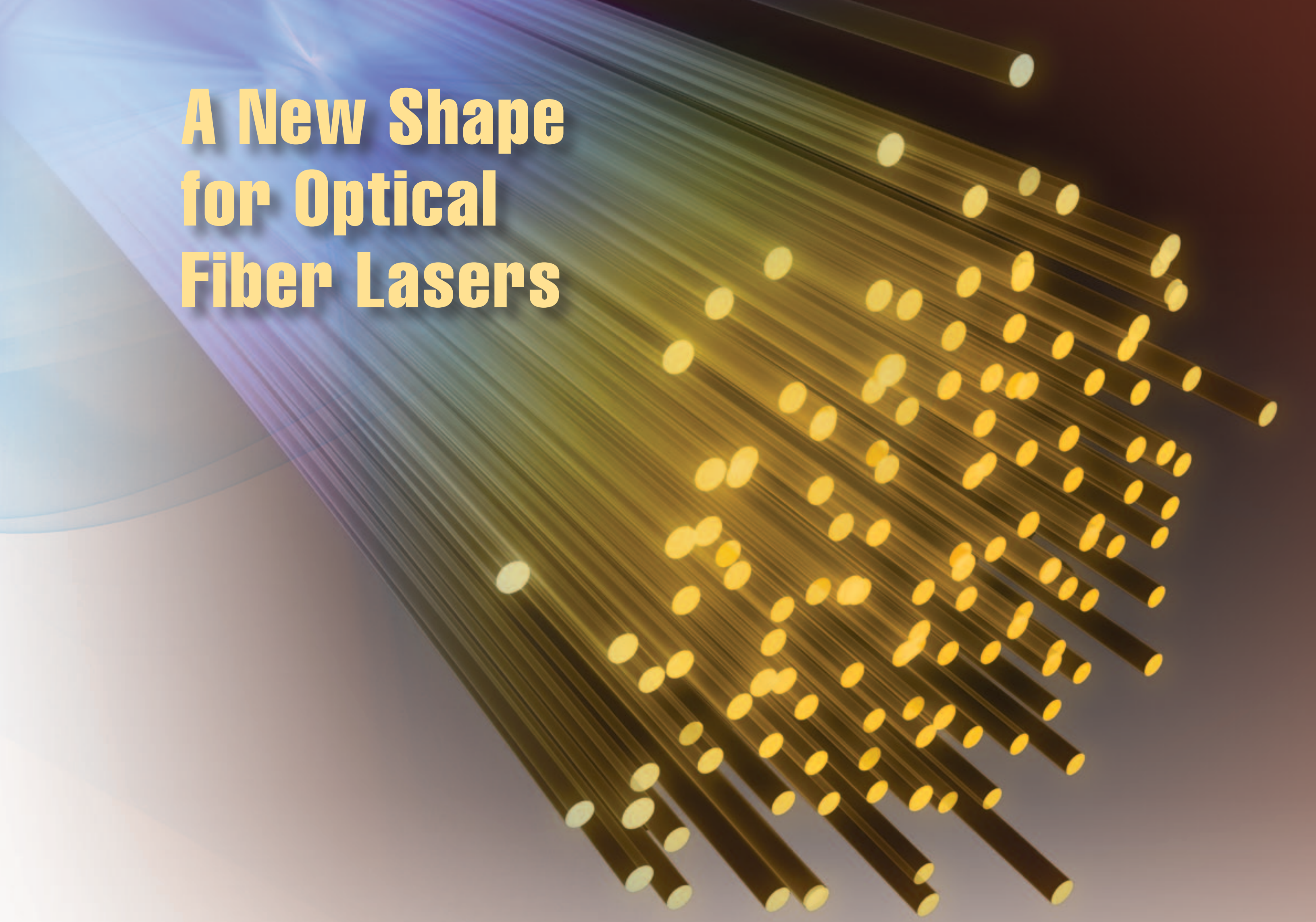
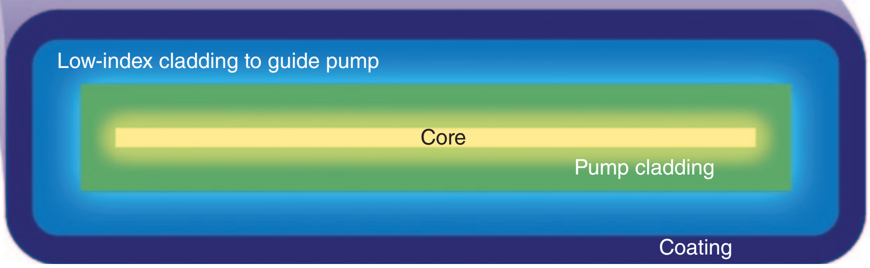
A New Shape for Optical Fiber Lasers



FIRST developed in the 1970s, thin, flexible, and transparent optical fiber revolutionized the telecommunications industry, acting as the structure for carrying electromagnetic waves from point to point. Because of its large bandwidth and immunity from electromagnetic interference, optical fiber has largely replaced copper wire for transmitting data over long distances—across the country, for example.

An optical fiber can also be made into a laser by mixing rare-earth ions into the fiber's glass structure and pumping those ions with a separate laser diode, such as the diodes that generate the light in a laser pointer. Fiber lasers can take this concept a step further, combining the power of many inexpensive laser diodes into a single coherent beam. The fibers are especially well suited for scaling up high-power, continuous-wave lasers that emit a steady stream of photons. Commercial laser systems have reached average powers of 10 kilowatts, high enough to cut and machine metal parts for the automotive and heavy-equipment industries.

Because fiber lasers are compact and reliable and their beams can be focused to extremely small, diffraction-limited spots, they have also found a niche in scientific applications. In this area, however, their performance is limited. They work well for tasks in which energy is spread evenly over time—the metaphorical equivalent of slowly pushing a tack into a board with your thumb—but not for applications that require energy bursts—akin to hitting a nail with a hammer. That's because the fiber's small cross section lets it amplify pulses to levels that damage the fiber itself.



The ribbon-shaped optical fiber being developed at Livermore has a wider cross section than the traditional round fibers used by the telecommunications industry.

Computational modeling at Livermore suggests that fiber lasers cannot generate more than 30 to 40 kilowatts of power—about 10 million times the power of a typical laser pointer. While this output is more than enough to cut intricate patterns into blocks of steel, it falls short by a factor of 100 of the power needed for alternative-energy schemes the Laboratory is pursuing.

Attempts to exceed the fundamental limit using round optical fiber lead to damaging nonlinear and thermal effects. One such effect is thermal lensing, during which the beam intensifies as it amps up, focuses, and then damages the fiber. Another is stimulated Raman scattering, in which power is lost as it is being extracted. Raman scattering describes the inelastic scattering of a photon that creates or annihilates an optical phonon.

Research groups worldwide are working to surpass this limit with existing fiber lasers, but most of them are extending fabrication techniques developed for the telecommunications industry. By departing from that approach, a multidisciplinary team led by Livermore physicists Jay Dawson and Mike Messerly has been inspired to change the structure of optical fiber to create light that is compact, reliable, and efficient.

The team's studies show that the root of the fundamental limit lies in the fibers' round structure. "We can't get the needed output with the basic circular geometry," says Dawson. "Instead, we've stepped back to reexamine all of the factors that prevent scaling further." In addition to Dawson and Messerly, the team includes Arun Sridharan, Amber Bullington, Graham Allen, Craig Siders, Ray Beach, Regina Bonanno, and Chris Barty, all from the National Ignition Facility (NIF) and Photon Science Principal Directorate, as well as Paul Pax, John Heebner, and Henry Phan from the Engineering Directorate.

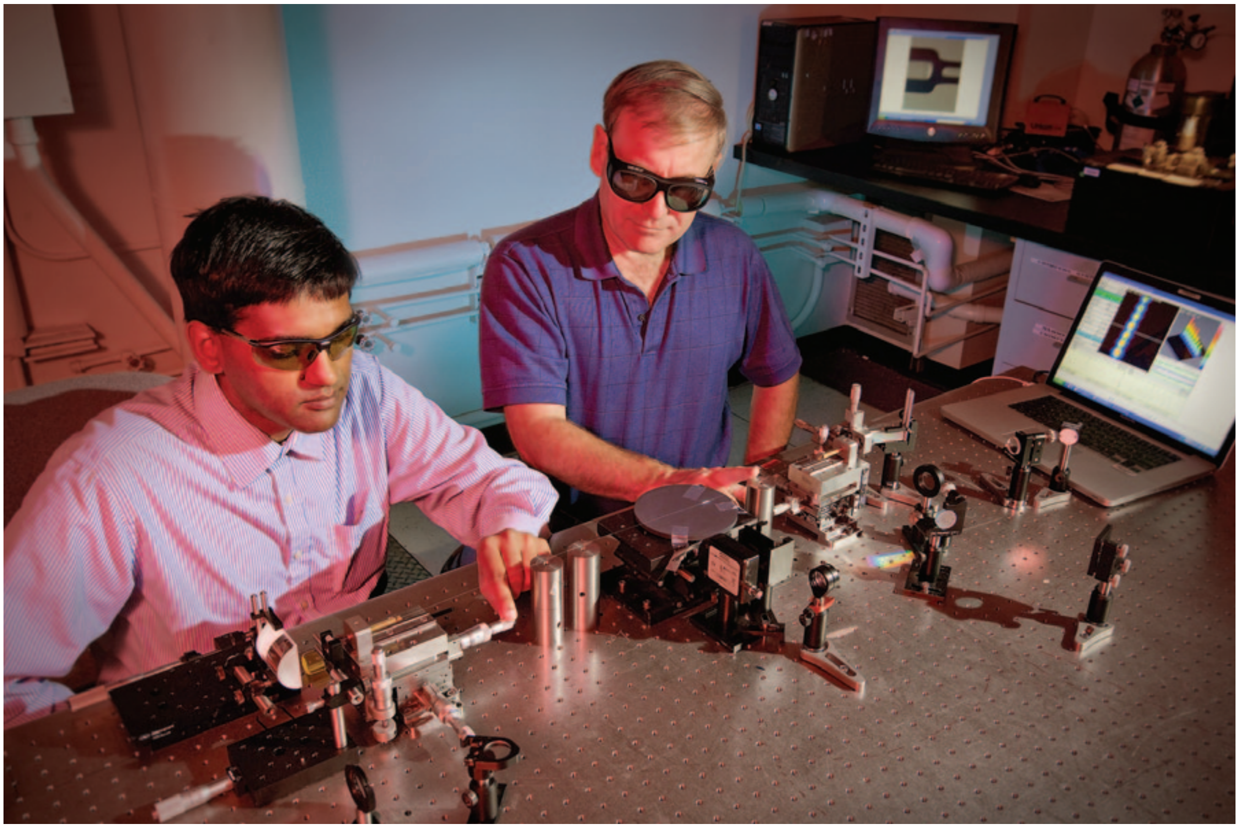
Current industrial-grade fiber lasers tend to produce beams with diameters of a few tens of micrometers at a distance of 1 meter. Diffraction-limited or "single-mode" fiber lasers designed with a focusing optic can produce comparably sized beams at a distance of 1 kilometer. These lasers offer excellent efficiency in converting electricity to highly directional photons, plus they are easy to use and have a wide range of operating wavelengths. The key to scaling to higher powers and pulse energies lies in solving the technical challenges associated with fabricating a ribbonlike fiber.

Light Bending

Beach was the first to publish the concept and construction of a ribbonlike fiber. "The analogy is not perfect," says Messerly, "but the comparison helps illustrate the difference between the two structures. In traditional round fiber, light doesn't stay guided when the fiber is bent. It's like trying to bend an aluminum bar. Ribbon fibers spread that bar into a sheet, like aluminum foil, a smarter geometry for bending." The ribbonlike structure can be bent along the thin axis, and because of its width, it can still carry lots of power.

With funding from the Laboratory Directed Research and Development Program, the Livermore team is not only creating a comprehensive model of the ribbon-fiber structure, or waveguide, but also is developing new fabrication techniques. They will then construct and test a pulsed laser system demonstrating all the critical physics for a ribbon fiber that can scale beyond 30 kilowatts and a few millijoules.

"Our goal is to develop ribbon fiber lasers that can amplify light beams to powers well beyond the fundamental limits," says Heebner. "Accomplishing this goal would make fiber lasers competitive with traditional solid-state lasers and introduce many advantages—compact geometries, robust alignment, and improved thermal management to name a few." To access the higher powers, the team is designing the ribbon-fiber structure so that it preserves beam quality. "Although the highest order mode is predicted to be the most robust while in the amplifier, it is beneficial to inject and extract light in the fundamental mode so it can be easily reshaped into a clean output beam," Heebner says. "We are exploring a number of methods for converting the beam between these modes. Doing this will enable high-average-power light extraction with high beam quality." If successful, these compact, high-average-power light sources will facilitate new applications such as extreme ultraviolet sources, laser machining, and advanced materials processing.



Livermore scientists (left) Arun Sridharan and (right) Jay Dawson couple laser light into a higher order mode of a rectangular core optical fiber.

More Than a Model

The team is constructing an 8-meter-tall tower for "drawing," or fabricating, various optical fiber structures on demand. Dawson says, "During the earlier research, Beach and his team had no fabrication capability, and their vendors needed almost two years to produce a sample fiber. In that time, we'll have completed the draw tower, giving us the capability to fabricate these fibers onsite." Dawson is encouraged by what's proving possible. "When Mike [Messerly] took a weeklong course at the University of Bath, he and a fellow student fabricated a complex structure in their first few days."

For nearly a decade, the Livermore group has been working on fiber laser systems for robust injection-seed systems for high-energy lasers such as NIF's Advanced Radiographic Capability (see *S&TR*, December 2010, pp. 12–18), monoenergetic gamma-ray source (see *S&TR*, April/May 2011, pp. 15–17), and Mercury laser system. The team is strengthened by its multidisciplinary nature, providing expertise in computer modeling, beam propagation, thermal effects, and material processing of glass as well as laser physics, optics, and engineering. The research also benefits from collaborations with the University of Southampton, the University of Michigan, and the Air Force Academy. Dawson says, "As a national lab, we can often take more risks than a private company that has to turn a profit quickly, giving us the time to evaluate new design options."

The project's ultimate goal is to achieve a full-physics demonstration of a ribbon-fiber amplifier, which will lead to future research opportunities. The team will also make the technology available to other Department of Energy laboratories and for industrial and defense applications. The researchers believe that industry will recognize the benefits of the path they've taken and, once the concept is proven, will make prudent infrastructure investments. Success could mean that next-generation concepts for laser-based particle accelerators—something only talked about today—could be realized.

—Kris Fury

Key Words: optical fiber, ribbon-fiber laser.

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Preventing Terror in the Skies

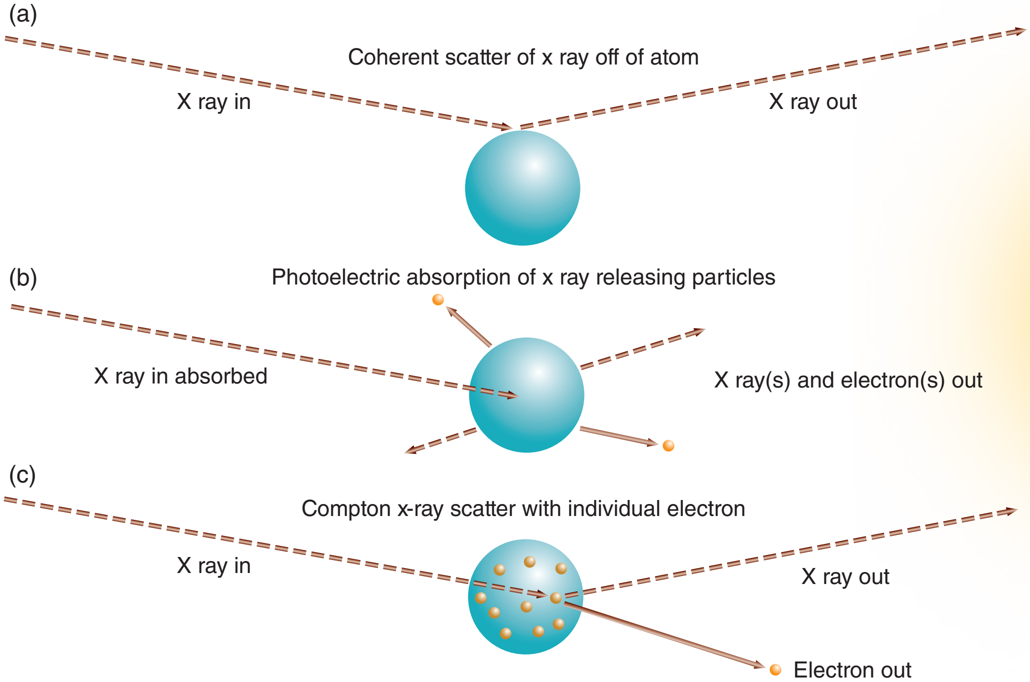
Explosives detection technologies, such as these x-ray computed tomography machines, scan baggage to determine whether dangerous objects are hidden inside. (Courtesy of [left] Reveal Imaging and [right] Safran Morpho.)

AIR travel is a popular mode of transportation. Each year, more than 600 million people board U.S. flights for business or pleasure. A coordinated terrorist strike on commercial airlines could have a detrimental effect on air travel and might cripple the nation's economy. The Transportation Security Administration has worked diligently to enhance security at airports and on flights so that people and cargo can continue to move freely.

Today, all passengers and every piece of checked or carry-on luggage are screened before they are permitted on an aircraft. X-ray systems and walk-through metal detectors allow security personnel to identify dangerous metal objects, such as guns and knives. Explosives detection technologies use x-ray computed tomography (CT) and other techniques to screen for explosives hidden in luggage and cargo destined for transport on passenger flights as well as on the people boarding the aircraft.

One challenge with scanning for explosives is that some nonthreatening materials share similar characteristics with actual threats, leading to false positives or false alarms. When an alarm is generated, security personnel must review the scan images to "clear" the alarm or manually verify the bag's contents, which can increase labor costs and lead to time delays.

To further improve aviation security, the Department of Homeland Security (DHS) Science and Technology Directorate is funding research to deploy advanced explosives detection technologies that can more accurately discriminate between a wide



At the energies used to scan luggage, three basic processes contribute to x-ray attenuation at the atomic level. X rays can be (a) deflected, (b) completely absorbed, or (c) partially transferred to an electron that is ejected from an atom in the object. The contribution that each process makes to the measured linear attenuation coefficient depends on the x-ray energy used and an object's density and elemental composition.

range of explosives and nonthreat materials. Toward this end, a team in Livermore's Engineering Directorate is evaluating the diagnostic performance of next-generation explosives detection technologies and providing recommendations to the Transportation Security Administration.

Materials Revealed

The Livermore project focuses on CT-based applications. First developed for the medical field as a method for diagnosing disease, x-ray CT has become instrumental in various industrial applications. Explosives detection equipment that incorporates CT uses a broad-spectrum x-ray beam to capture projections of an object, in particular, the objects inside a piece of luggage. CT applies complex reconstruction algorithms to the projections to produce a three-dimensional representation of the luggage and its contents. Automated threat-detection algorithms process the images to analyze the data and flag potential threats for further review. Transportation security officers can then examine these images and the relevant data to determine whether further interrogation is needed.

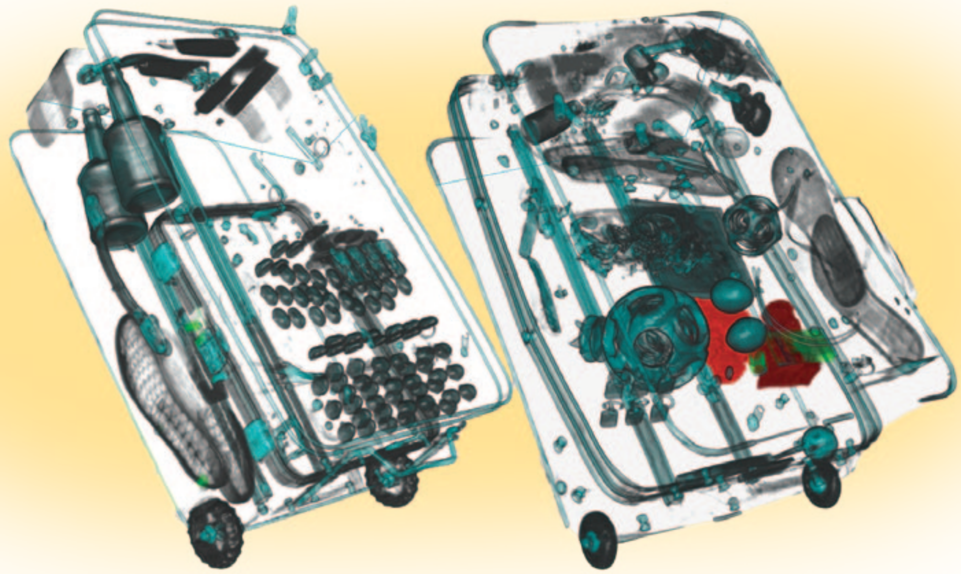
Harry Martz, who leads the Livermore explosives detection project, is an expert in CT systems, having spent more than 20 years working on CT technologies that support the Laboratory's national security missions. "Our objectives include creating a database of the x-ray properties of explosive threats and nonthreats, performing research and development on advanced CT algorithms to ensure that they produce precise reconstructions, and investigating new source and detector hardware to enhance the performance of existing or next-generation technologies," says Martz. "We are also exploring methods to further improve the performance of threat-detection algorithms as passenger loads continue to increase."

An Energetic Response

Images obtained from current CT-based explosives detection systems provide estimates of the linear attenuation coefficients and other features of the items inside luggage. "These attenuation coefficients depend strongly on a material's density and elemental composition and on the x-ray source and detector used to measure them," says Martz.

The Livermore scientists are evaluating reconstruction and automated threat-detection algorithms to determine how to improve these methods for use in advanced dual-energy techniques. In this detection scheme, the detector measures the linear attenuation coefficients of materials at two energy spectra, one low and the other high. The two measurements provide a stronger basis for interpreting an object's elemental composition and density, thus improving the system's detection capabilities with fewer false alarms.

At the energies used to scan luggage, x-ray attenuations are determined by three kinds of interaction processes occurring between the x rays and the object. In coherent scattering, incident x rays are deflected by atoms in an object, whereas in the photoelectric effect, they are completely absorbed. With Compton scattering, the x-ray energy is partially transferred to an electron that is then excited or ejected from an atom. "Current detection techniques combine the first two processes into a single parameter," says team member Jerel Smith. "By measuring



Computed tomography systems produce two- and three-dimensional digital images showing the contents of a bag. Transportation security personnel can review such an image to determine if a threat is present or to clear a false alarm. Areas highlighted in red indicate potential threats. (Courtesy of Safran Morpho.)

all three interactions, we may be able to obtain a more precise signature of the types of atoms within an object and thus more effectively identify specific explosive materials."

As part of the research effort, Smith and Livermore scientist Travis White are using the Laboratory's high-performance computers to model the three interaction processes. "With these models, we can artificially adjust the physics parameters, such as x-ray spectra, to improve our understanding of materials and object characterization," says White. With that knowledge, the researchers can evaluate the algorithms used in existing explosives detection systems and reconfigure the codes for enhanced performance.

Reconstruction algorithms process the projections from CT systems and correct for imperfections in the image quality. In some cases, artifacts, or errors introduced as part of the processing and reconstruction, compromise the image quality. Artifacts such as beam hardening, rings, and streaks can compound the problem. Improved reconstruction algorithms would reduce artifacts in CT images and enhance segmentation to more clearly define objects and their boundaries, increasing threat detection while decreasing the false-alarm rate and thus reducing the intervention required by security personnel.

Automated threat-detection algorithms analyze the CT images and extract relevant characteristics such as x-ray attenuation, density, effective atomic number, and mass of different materials in a scanned bag. The system then compares data generated by the algorithms with values of known explosives to classify each material as either a threat or a nonthreat. To improve the results produced in such comparisons, the Livermore team is redesigning the algorithms to better interpret the complex data, including multiple energy measurements. The researchers are also developing an expanded database of explosives properties to serve as a reference for the algorithms that process the CT data. The database will also be useful for other researchers working in this field, whether they are at other laboratories, government agencies, or academic institutions or with current or potential industrial partners. These improvements should allow explosives detection technologies to more accurately differentiate threats from nonthreats and thus enhance detection capabilities, reduce false-alarm rates, and increase the system's operational efficiency.

Lending a Hand

All explosives detection technologies must be certified by the DHS Transportation Security Laboratory before they are installed in airports. Ultimately, the research performed at Livermore and the resulting modifications to existing technologies will allow the DHS Science and Technology's Explosives Division, through the Transportation Security Administration, to deploy more efficient detection systems.

"We are advancing the technologies used at airports to screen for dangerous materials," says White. Thanks to Livermore's expertise in material characterization and high-performance computing, airport security personnel are becoming better equipped to stay one step ahead of the nation's adversaries, keeping airline passengers safer in an increasingly hostile world.

—Caryn Meissner

Key Words: automated threat-detection algorithm, aviation security, explosives detection, linear attenuation coefficient, Transportation Security Administration, x-ray computed tomography (CT).

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Patents and Awards

In this section, we list recent patents issued to and awards received by Laboratory employees. Our goal is to showcase the distinguished scientific and technical achievements of our employees as well as to indicate the scale and scope of the work done at the Laboratory.

Patents

Optically Initiated Silicon Carbide High Voltage Switch
George J. Caporaso, Stephen E. Sampayan, James S. Sullivan, David M. Sanders
U.S. Patent 7,893,541 B2
February 22, 2011
An improved photoconductive switch has a substrate made of silicon carbide or another wide-bandgap material, such as gallium arsenide, and field-grading liners. The liners are composed preferably of silicon nitride formed on the substrate adjacent to the electrode or substrate perimeters for grading the electric fields.

Gain Media Edge Treatment to Suppress Amplified Spontaneous Emission in a High Power Laser
Lloyd A. Hackel, Thomas F. Soules, Scott N. Fochs, Mark D. Rotter, Stephan A. Letts
U.S. Patent 7,894,496 B2
February 22, 2011
In this method for suppressing amplified spontaneous emission or parasitic oscillation modes in a laser, one or more peripheral edges of a solid-state crystal or ceramic laser gain media are roughened and then bonded to an electromagnetic absorbing material adjacent to the entire outer surface of the roughened laser gain media. The apparatus can thus effectively suppress amplified spontaneous emission, parasitic oscillation modes, and residual pump energy.

Lateral Flow Strip Assay
Robin R. Miles, William J. Benett, Matthew A. Coleman, Francesca S. Pearson, Shanavaz L. Nasarabadi
U.S. Patent 7,901,623 B2
March 8, 2011
This apparatus has a lateral flow strip with a receiving portion, a sample collection unit, and a reagent reservoir. Saliva or buccal cells from an individual are placed in the sample collection unit, which is then immersed in the reagent reservoir. When the tip of the lateral flow strip is immersed in the reservoir, the reagent–sample mixture wicks up into the strip to perform the assay.

Slit Disk for Modified Faraday Cup Diagnostic for Determining Power Density of Electron and Ion Beams
Alan T. Teruya, John W. Elmer, Todd A. Palmer
U.S. Patent 7,902,503 B2
March 8, 2011
A diagnostic system for characterizing an electron or ion beam includes an electrical conducting disk made of refractory material and a Faraday cup positioned to receive the beam. The disk has at least one slit between its circumference and center. One portion of the disk is in radial alignment with the center, and another portion deviates from this alignment. When an electron or ion beam is directed onto the disk, it is translated so that it enters the slit where it can be diagnostically characterized.

Portable Convertible Blast Effects Shield
John W. Pastrnak, Rocky Hollaway, Carl D. Henning, Steve Deteresa, Walter Grundler, Lisle B. Hagler, Edwin Kokko, Vernon A. Switzer
U.S. Patent 7,905,168 B2
March 15, 2011
A rapidly deployable, portable, convertible blast effects and ballistics shield includes a set of two or more tapered telescoping rings connected to each other so that the shield can be collapsed for storage and transport or extended to form an expanded inner volume. One upright configuration provides blast effects shielding, for example, against blast pressures, shrapnel, or fireballs. A second configuration shields against ballistics such as incoming weapons fire or shrapnel. The telescoping rings are made of a high-strength material such as a composite fiber and matrix material that can substantially inhibit blast effects and prevent projectiles from passing through the shield. When telescopically extended, the rings are secured to each other by the friction fit of adjacent pairs in the set.

Optical Fiber Having Wave-Guiding Rings
Michael J. Messerly, Jay W. Dawson, Raymond J. Beach, Christopher P. J. Barty
U.S. Patent 7,907,810 B2
March 15, 2011
In this waveguide, a cladding region with a substantially uniform refractive index surrounds a waveguiding region that has an average index close to the index of the cladding. The waveguiding region also contains a thin ring or series of rings whose index or indices differ significantly from the index of the cladding, thus enabling the structure to guide light.

False Alarm Recognition in Hyperspectral Gas Plume Identification
James L. Conger, Janice K. Lawson, William D. Aimonetti
U.S. Patent 7,916,947 B2
March 29, 2011
In this method for analyzing hyperspectral data, a hyperspectral imager collects a first set of data from a scene during a no-gas period and analyzes the data using one or more gas-plume detection logics. The gas-plume detection logic is executed using a low detection threshold so that each occurrence of an observed hyperspectral signature is recorded. The method generates a histogram for all occurrences of observed signatures and uses it to determine a probability of false alarm for these occurrences. At some other time, the method collects a second set of hyperspectral data. This second data set is then analyzed using one or more of the gas-plume detection logics, which generates a probability of false alarm and determines if any gas is present.

Awards

The **American Society of Civil Engineers** presented the **2011 Karl Emil Hilgard Hydraulic Prize** to **Gokhan Kirkil** and his coauthors for their paper, "Detached Eddy Simulation Investigation of Turbulence at a Circular Pier with Scour Hole." A civil engineer in Livermore's Physical and Life Sciences Directorate, Kirkil was the lead author for the 2009 paper, which was published in *Journal of Hydraulic Engineering*. The annual award honors the authors who have published a paper of superior merit that deals with a problem of flowing water, either in theory or practice. Papers are judged on the basis of the subject matter and the method of presentation. Founded in 1852, the American Society of Civil Engineers represents more than 140,000 members worldwide and is the oldest national engineering society in the U.S.

Crystal Jaing, a molecular biologist in the Laboratory's Physical and Life Science Directorate, was inducted into the **Alameda County Women's Hall of Fame**, one of 11 women to be honored in 2011. Jaing is a codeveloper of the Lawrence Livermore Microbial Detection Array, which can simultaneously identify thousands of known viruses and bacteria within 24 hours. She was recognized for her work in science.

Ben Santer, an expert in the climate change research community, has been named a **Fellow** of the **American Geophysical Union** (AGU), a worldwide scientific community that advances the understanding of Earth and space for the benefit of humanity. Santer has worked in the Laboratory's Program for Climate Model Diagnosis and Intercomparison (PCMDI) for nearly 20 years, and is a frequent expert witness at congressional hearings on the science of climate change.

"Ideally, governments will use the best-available scientific information to make rational decisions on appropriate policy responses to the climate change problem," says Santer. "My colleagues and I have the job of providing that information. The AGU fellowship gives me encouragement to continue PCMDI's research into the nature and causes of climate change, and to continue explaining what we do, what we've learned, and why our work matters." He credits his success to the exceptional scientists he has collaborated with at the Laboratory. "The best reward (award) is working together with great colleagues." Only one in a thousand members is elected to AGU fellowship each year. Santer is one of six Livermore researchers who have been so honored.

The Laboratory in the News *(continued from p. 2)*

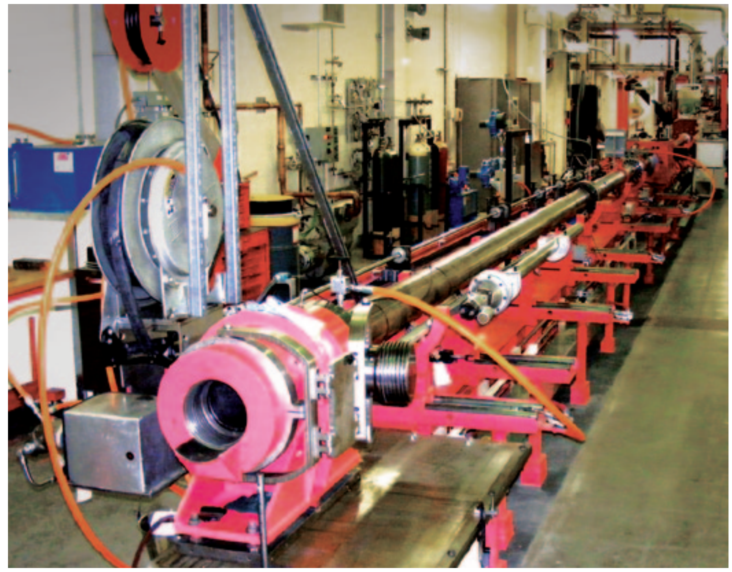
In one Livermore project, researchers are developing carbon aerogels that improve the storage capacity of electrical double-layer capacitors. In these devices, charge is stored in the form of ions that accumulate on the aerogel's surface, creating an intermediate type of capacitor between batteries and electrostatic capacitors. Such capacitors are an ideal complement to batteries when a device has a peak power demand above the base level because they extend battery life.

Carbon aerogels are also important in capacitive deionization, a desalination method in which ions are removed from electrolytes (seawater or brackish water flowing between electrode pairs) to create a clean water source. Livermore researchers first used carbon aerogels in a capacitive deionization system in the 1990s. Since then, they have found that by adjusting the pore-size distribution in carbon aerogels, they can reduce ionic transport losses while maintaining a high capacitance and thus improve the system's energy efficiency.

Another promising energy application for carbon aerogels is their use as electrode materials and catalyst support in proton-exchange membrane fuel cells. The advantage in this application is that an aerogel's surface area, pore size, and pore volume can be tailored independently. In addition, the three-dimensional morphology of carbon aerogels reduces the electrode's electric losses, thus improving electrical conductivity for the fuel cell.

Contact: Juergen Biener (925) 422-9081 (biener2@llnl.gov).

New Research Capability for High Explosives Facility



The Laboratory's High Explosives Applications Facility (HEAF) has activated a new high-velocity research gun (above right) for shock physics research. Such guns are used to study the behavior of materials under sudden high pressures and temperatures. The new gas gun, which operates in two stages, can launch a projectile to velocities of 8,000 meters per second. (In comparison, a typical rifle bullet travels about 1,000 meters per second.) This speed gives it the ability to generate precise one-dimensional shock waves up to several million atmospheres of pressure.

In a two-stage gas gun, the first stage uses gunpowder and a piston to compress a light drive gas, typically hydrogen, to very high pressures. A rupture disk releases the drive gas into a smaller diameter launch tube holding the experimental projectile. The launch tube guides the projectile to the end of the gun where the target chamber contains a target connected to diagnostic instruments outside the chamber.

One mission of HEAF's two-stage gun is to prove out experimental methodologies and diagnostics prior to testing actinides at the Joint Actinide Shock Physics Experimental Research (JASPER) Facility at the Nevada National Security Site (formerly known as the Nevada Test Site). An actinide is one of 15 chemical elements in the actinide series of the periodic table. The elements in this series are radioactive and release energy when activated through nuclear reactors and nuclear weapons. Earlier this year, the Stockpile Stewardship Program used the HEAF gas gun to conduct a joint experiment in which Livermore and Los Alamos national laboratories participated in diagnostics development for upcoming experiments at JASPER.

Contact: John J. Scott (925) 422-8720 (scott8@llnl.gov).

Abstract

Training a New Generation of Research Scientists

Livermore's Postdoc Program, which offers research opportunities to new doctoral degree recipients, has grown substantially. In 2009, the program sponsored 112 postdoctoral researchers. In 2011, that number grew to 177. An allied program, the Lawrence Postdoctoral Fellowship Program, typically accepts two to four participants annually out of hundreds of well-qualified applicants. Postdocs are vital to renewing the intellectual capabilities of a research institution such as Lawrence Livermore. They bring with them many of the most recent advances taking place in academic departments at top universities worldwide. Candidates are selected for their scientific expertise, publishing record, and enthusiasm for working in Livermore's highly collaborative environment. During their tenure, postdocs conduct basic or applied research that is published in peer-reviewed journals. This work offers them an opportunity to sharpen their scientific expertise in their field, present their research at national meetings, and gain experience in writing proposals. Every postdoc is assigned a mentor, a senior scientist or engineer who is responsible for guiding the postdoc's research and helping that person acquire the skills necessary to advance his or her career. About half of the Laboratory's postdocs convert to a staff position at the end of their terms. Some who leave for other positions collaborate with Livermore researchers or recommend the Laboratory to their graduate students or colleagues.

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