Science & Technology REVIEW

January/
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U.S. Department
of Energy's
Lawrence Livermore
National Laboratory

Building on a Vision for the Laboratory

Carl Haussmann
(1924–1998)

Also in this issue:

- The B Factory, the BaBar Detector, and the Big Bang
- Livermore's Laughlin Wins Nobel Prize for Physics

About the Cover

Carl Haussmann’s career at Lawrence Livermore spanned 45 years. Loved and revered by several generations of Laboratory scientists and engineers, Haussmann was a leader of great energy and vision. He helped originate and guide the programs that brought Lawrence Livermore to preeminence as a provider of the most advanced science and technology in the national interest. His lasting contributions to Livermore's weapons design, computations, and laser programs as well as his devotion to making the Laboratory environment conducive to the finest research achievements are the subject of this month’s feature article, which begins on p. 4.

Cover design: George Kitrinos

About the Review

Lawrence Livermore National Laboratory is operated by the University of California for the Department of Energy. At Livermore, we focus science and technology on assuring 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 10 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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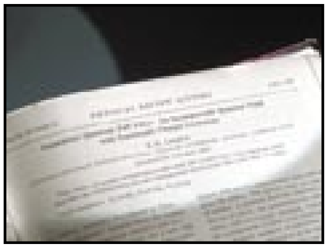

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The Laboratory in the News

Genome project reaches milestone

Martha Krebs, Director of the Department of Energy's Office of Energy Research, announced in late October that the DOE-sponsored Joint Genome Institute (JGI) had surpassed its ambitious goal of sequencing 20 million base pairs of DNA for fiscal year 1998. "This achievement marks an unprecedented tenfold increase in production output over the previous year," said Krebs.

JGI, established in 1996, is a consortium of scientists, engineers, and support staff from Lawrence Livermore, Lawrence Berkeley, and Los Alamos national laboratories. JGI has assumed a key role in the international Human Genome Project's effort to determine all 3 billion base pairs that comprise the human genome. This worldwide project, the largest biological undertaking in history, promises untold opportunities to understand the basic molecular underpinnings of life and to improve human health.

JGI's goal in 1999 is to sequence an additional 70 million base pairs. By 2000, researchers hope to be sequencing at least 100 million base pairs each year.

The initial goal of the Human Genome Project was to complete the full sequence of the human genetic code by 2005. The new timetable calls for completing a "working draft" by the end of 2001 and a full sequence by 2003.

Details of the accelerated production schedule appear in the October 1998 issue of the journal *Science*.

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B Factory accelerator dedicated

On October 26, 1998, Energy Secretary Bill Richardson presided over the official startup of the B Factory at DOE's Stanford Linear Accelerator Center (SLAC) in Menlo Park, California. The $177-million facility is a collaborative effort of three Department of Energy laboratories—SLAC and Lawrence Livermore and Lawrence Berkeley national laboratories—working in concert with scientists and engineers from nine countries. Richardson noted that "The root of [the B Factory's] success is partnership, and one of the partnerships is between three of our premier national laboratories."

Karl van Bibber, the Livermore physicist who oversaw the Laboratory's contributions to the project, shared Richardson's sentiments. He noted that during the project, the three laboratories operated as a "superlab,"working in seamless partnership.

The B Factory is a massive particle physics research instrument that scientists will use to investigate what happened a few trillionths of a second after the creation of the universe by the so-called Big Bang to cause a preponderance of matter over antimatter.

Close to 200 Livermore physicists, engineers, and technicians from disciplines ranging from particle physics to electroplating participated in the B Factory project. Livermore's primary contributions to the project include the construction of the 26 high-power radiofrequency cavities essential to maintaining the accelerator's operation. Livermore personnel were also responsible for designing and fabricating approximately 1,000 distributed ion pumps necessary for operation of the accelerator's high-energy electron storage ring.

For additional information about the B Factory and Lawrence Livermore's contributions to it, see the January/February 1997 *S&TR*, pp. 4–13 (available on the World Wide Web at *http://www.llnl.gov/str/01.97.html*). See also the article beginning on p. 12 of this issue of *S&TR*.

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Lab, partner developing glucose sensor

Lawrence Livermore researchers in partnership with MiniMed Inc. of Sylmar, California, are adapting laser technology used for fusion research to the treatment of diabetes. The Laboratory and MiniMed have signed a three-year cooperative research and development agreement (CRADA)—funded in part by a $2-million grant from the National Institute of Standards and Technology's Advanced Technology Program—to develop glucose sensor technologies to aid in controlling diabetes.

Livermore scientists and MiniMed researchers have been working together on new glucose-sensing technologies since 1996. MiniMed currently makes and markets in Europe a radio-controlled pump device that is implanted in the abdomen and allows a diabetic to forgo the multiple daily shots of insulin usually needed to control blood sugar levels. But to find out if insulin should be released and how much, patients must still draw their own blood and test the sugar level.

The glucose sensor project aims to make that part of the process automatic. Stephen Lane, leader of the glucose sensor project at Livermore, wants to develop an implantable monitor that measures the amount of light reflected from tissue. The more glucose in the tissue, the brighter the reflected light. The monitor system envisioned by Lane and his colleagues borrows laser technology used for fusion research at Livermore's Nova laser.

The glucose sensor would allow diabetics with a pump implant to receive the precise amount of insulin exactly when they need it without pin-prick testing. Those without a pump implant would receive a radio reading from the glucose sensor on a Dick Tracy–style wrist gizmo to let them know when an insulin injection is needed.

When used together, the two devices would essentially become an artificial pancreas—the organ that controls blood sugar levels.

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Carl Haussmann—Mover and Shaper

IN the lobby of the building that serves as administrative hub for this Laboratory, among the plaques honoring past directors, there hangs one with the following inscription:

> *Innovator, physicist, technologist, communicator, architect, planner, humanist, pragmatist, optimist, mentor, champion.*

All these descriptors define one man, someone who—although never a director—was instrumental in building the Laboratory and making it the innovative institution it is today: Carl Haussmann.

Carl's sudden passing last July gave me an opportunity to reflect on his many contributions and the unique role he played in his 45 years at Livermore. His acumen about the place and role of the programs at Livermore was unparalleled. Carl described himself as a "large-scale applied science guy," a man of action, someone who liked to start up new projects and think long-term.

The feature article of this issue of *Science & Technology Review* commemorates Carl's life by recalling his legacy at the Laboratory. Carl played not a single role at the Laboratory but—as you might infer from the impressive list above—many roles in a wide range of areas, including weapons and high-end computing, lasers, and site planning.

Carl and others helped set a solid course for Livermore's weapon designs during the Cold War. His ideas for designing and miniaturizing high-yield thermonuclear weapons were revolutionary for the time. In the Laboratory's current efforts in support of DOE's Stockpile Stewardship Program, we can also trace Carl's hand. For instance, Carl always believed in the future of numerical modeling. He was an unabashed champion of the supercomputer, even in its earliest stages. Now, in the Accelerated Strategic Computing Initiative, we see proof of Carl's conviction that computers would continue to grow in capabilities and serve as important tools for weapon designers.

Computers were one of Carl's passions. "Growing" programs was another. A prime example of that occurred in the early 1970s when Carl took a collection of laser experiments scattered throughout the Laboratory and brought them together. He breathed life into the vision of a unified laser program, and then, when the vision lived, personally recruited the best and the brightest to manage and nurture it. From today's vantage point—with the National Ignition Facility becoming reality, atomic vapor laser isotope separation well on its way to commercialization, and the plethora of innovative laser technologies pouring forth from the program—we can gaze back to the program's beginning and see Carl's imprint.

Carl also championed a number of other Laboratory efforts: the Military Research Associates Program and the Laboratory's site planning efforts—which earned him the affectionate sobriquet Father of the Trees—as well as the innovative technologies that emerged from Livermore's O Program for the Defense Advanced Research Projects Agency. In addition to growing programs and growing trees, Carl had a remarkable knack for growing people. An excellent mentor, he delighted in people who could generate ideas, and he knew how to lead people of intellectual brilliance and unbounded energy. He channeled that intellect and energy and encouraged those around him to push the envelope and think in revolutionary terms.

Carl was a man with an eye to the future, someone who was always considering the next step, weighing the next challenge. He helped bring the Laboratory from its early beginnings to where it is today, at the forefront of scientific research for the nation's good. He was a builder of programs, a man who took visions and dreams and made them real.

We miss him.

■ Bruce Tarter is the Director of Lawrence Livermore National Laboratory.

Leading the Best

Carl Haussmann helped to revolutionize nuclear warhead design, build Livermore's renowned laser program, and create an environment conducive to world-class research.

SCIENTIST, manager, and self-proclaimed "meddler," Carl Haussmann made an indelible impression on generations of Livermore employees. In an age of increasing specialization and narrowing focus, Haussmann made lasting and creative contributions to a variety of programs, including weapons, lasers, and site planning. In times of constrained funding when it was difficult to see beyond the next fiscal year, Haussmann could seemingly see decades ahead. Indeed, some say his most important gift was his visionary leadership. It was with fond remembrance that Laboratory employees honored Carl Haussmann's passing last year and his 45 years of service to the nation and the institution he loved.

U.S. Army Captain Carl Haussmann arrived in 1953 as the Laboratory's second military research associate with the standard assignment to acquire in-depth exposure to nuclear weapons and other defense-related programs. Haussmann already possessed

and the Brightest

exceptional skills and experience—a solid academic background in physics; experience as a nuclear weapons supervisor at Sandia Base, New Mexico, and Killeen Base, Texas; and member of the team that helped Princeton University's John Wheeler calculate the explosive power of the first hydrogen bomb. Not surprisingly, Haussmann was assigned to the Livermore thermonuclear test program, where he quickly became, in the words of former Livermore Director Roger Batzel, "a major spark plug for the entire weapons program" (Figure 1).

By 1956, Haussmann was already in management, and Livermore had proven itself with several nuclear explosives designs successfully tested in Nevada and the Pacific (Figure 2). Subsequently, the breakthrough designs for the Polaris warhead for the first submarine-launched ballistic missile brought the Laboratory the special attention of the top managers of the Department of Defense and the Atomic Energy Commission (AEC).

The Polaris story began in 1956 at a much-publicized meeting held at Woods Hole, Massachusetts. U.S. Navy representatives told Los Alamos and Livermore weapons experts that their planned ballistic missile–launching submarines required a much smaller and lighter warhead than was currently available. Edward Teller, who represented Livermore, boldly projected that Livermore could develop small thermonuclear warheads to be carried by a solid-fueled missile.

Haussmann's group was assigned the task of fulfilling Teller's pledge to the Navy, pursuing what some had deemed impossible. Haussmann was characteristically unintimidated by the challenge. "Polaris gave us a goal and a high-priority one at that," he recalled later.

"Carl had great respect for his brilliant cohorts at the Lab," says longtime colleague Lyle Cox, "yet he believed he could add to their strengths as a leader, and he took pride in leading them" (Figure 3). Indeed, during the Polaris development effort, Haussmann demonstrated an ability to recognize and act on the big picture, says former Livermore Director John Nuckolls. Nuckolls also notes that Haussmann was a wonderful complement to top Livermore creative theoreticians because "he could turn great ideas into reality."

Livermore's teams of extraordinary thermonuclear and fission weapons experts tapped the nation's growing computer resources (see the box on p. 8) to successfully reduce the size of strategic warheads while maintaining the required explosive power. In a note to Laboratory Director Bruce Tarter, Haussmann discussed the high-profile project: "We worked our way toward Edward Teller's technical and time-scale goals, utilizing

Figure 1. Carl Haussmann quickly established himself as one of the most respected leaders in Livermore's weapons program.

Figure 2. Haussmann traveled to the Pacific for key Livermore tests. Pictured are Haussmann (fourth from the right) with visiting University of California Regents and key Livermore managers such as E. O. Lawrence (to the left of Haussmann) and Herb York (second from right), at the time Livermore's Director.

several successive FBM [Fleet Ballistic Missile] payload iterations, ever introducing better materials. The introduction of the (conceptually) penultimate design . . . did not receive instantaneous approval. I remember Harold Brown saying 'It takes more than a French curve and a compass to design a warhead.'"

The innovative Livermore design for Polaris was first validated in 1958 during Operation Hardtack in the Pacific, only a few months before nuclear testing was halted by an international moratorium. Nuckolls notes that the final design even surpassed Teller's bold promise to the Navy.

In 1960, the first Polaris submarine armed with warheads designed at Livermore took to sea, ahead of the most optimistic schedule. "Polaris was critically important to the stability of the nuclear deterrent," says Nuckolls. "Submarines could not be destroyed by a first strike; Polaris provided a secure second-strike force." The design improvements reflected in the Polaris warhead were adopted in most subsequent U.S. strategic nuclear weapons (Figure 4).

From 1962 to 1968, Haussmann served as associate director of the Laboratory's new Military Applications Program, the interface between Livermore's design and engineering divisions and the military services. "In this role, Haussmann was also extremely successful," Nuckolls says.

The early contributions of Haussmann and others at Livermore set a solid course for future Livermore weapon designs. Over the next decades, until the end of the Cold War, Livermore scientists and engineers worked to assure the nation's stockpile with increasingly sophisticated tests at the Nevada Test Site, new generations of diagnostic instruments, and computer codes running on ever-more powerful supercomputers.

Shining a Light on Lasers

Haussmann's notable tenure as a weapons program manager was matched by his enormous contributions as associate director for Laser Programs (1971 to 1975). During this period, he built up the program and provided it with strong direction (Figure 5) and top managers.

It is no exaggeration that Haussmann created the milieu within which two far-reaching decisions were made in the

Figure 3. Haussmann took great pride in managing and leading Livermore physicists, including some of the best theoretical minds. From the left are physicists Dick Adelman, Haussmann, Jim Frank, and Mel Harrison.

Figure 4. The first test of the Navy's Polaris submarine-launched missile in 1960. Livermore's breakthrough design for the Polaris warhead is largely credited with helping to discourage a Soviet first strike.

1970s: the choice of solid-state lasers for Livermore's laser fusion program and the atomic vapor method for laser separation of isotopes, particularly uranium, for use in weapons and nuclear power plants. These two options proved in the long run to be by far the most effective, both technically and economically.

Almost since the first laser flashed in 1960, Livermore had been exploring the potential of lasers, looking primarily at their application to weapons and other military uses. By the late 1960s and early 1970s, scientists in the burgeoning laser field were studying different types of lasers for producing energy from laser fusion.

In 1971, Laboratory Director Michael May asked Haussmann to take charge of the Laboratory's fragmented laser efforts. With that request, May played to Haussmann's strong suit as a visionary and "big-picture guy" who enjoyed making things happen quickly and effectively.

Haussmann moved swiftly to focus Livermore's laser work. With a few phone calls and visits to the head of the AEC's Division of Military Application, he committed Livermore to building Shiva, the first large laser fusion facility in the country. Haussmann sought out James Schlesinger, head of the powerful AEC, who agreed to support the development of lasers. Lasers were still experimental, but the scientific community and a few well-informed national leaders recognized the role that lasers could play in research germane to nuclear weapons.

Committing to a huge project such as Shiva was only part of the big picture. Livermore needed to expand its staff of laser experts if it was going to deliver on Shiva. After an audit of laser expertise around the country, Haussmann brought in John Emmett and Bill Krupke to define and run the new program. Both had already been responsible for advanced laser research, at the Naval Research Laboratory and Hughes Aircraft, respectively.

Says Nuckolls, "I'm sure Haussmann thought that one of the most important things he did was bringing in John Emmett to lead the laser program." With Haussmann's assistance, a diverse group of highly qualified newcomers was recruited, so that by 1974, some 260 personnel were working in Livermore's laser program.

According to Bill Krupke, "From the beginning, Haussmann was committed to creating an entire program, not just to building a laser. He wanted Livermore's laser effort to be all-encompassing, to include theorists, computational modelers, facility designers, testing engineers, as well as diagnostics experts. He felt that the end users of the facility should be involved in Shiva's development so that all parties would share a common commitment to its success."

Nuckolls recalls that Haussmann equated that success with achieving extremely difficult fusion goals. Haussmann brought together in one place experts from throughout the Laboratory to complement new hires for the design, development, and construction of the new laser. Having diverse disciplines "live together," a method inspired by E. O. Lawrence's multidisciplinary team approach to the management of big science projects, proved effective for getting the laser program up and running quickly and onto a very successful track.

Focusing on Shorter Wavelengths. Various types of lasers were being studied by the early 1970s for inertial confinement fusion: carbon dioxide, neodymium glass, hydrogen fluoride, and atomic iodine lasers. Basic considerations of plasma physics, coupled with Livermore computer calculations, indicated to Laboratory scientists that delivering the laser energy to the target at shorter wavelengths was extremely important.

Figure 5. Haussmann shown in the mid-1970s with a disk laser, one of the technologies for the Cyclops laser.

With this requirement in mind, in 1972 Livermore selected the neodymium-doped glass (Nd:glass) laser for its inertial confinement fusion program. The Nd:glass laser had the shortest wavelength at 1,050 nanometers (nm), the potential for frequency doubling to produce even shorter wavelengths, and by far the greatest ability to produce high peak power.

Livermore's earliest lasers for nuclear fusion experimentation, developed under Haussmann's leadership, were Janus, Cyclops, and Argus, each producing higher and higher peak power and output energy. All of these lasers operated at a 1,050-nm wavelength. But experimentation with the more powerful Shiva laser indicated that even a 1,050-nm wavelength was not short enough to produce effective implosions. So researchers at the University of Rochester developed the way to efficiently convert 1,050-nm output to 532- and 355-nm wavelengths, a technology adopted for Livermore's Nova laser in 1984 (Figure 6).

At about the same time that Livermore made its solid-state laser decision, the scientific community was exploring ideas for separating isotopes with lasers. Livermore focused its attention primarily on uranium and plutonium because of the relatively high cost of these isotopes and their relevance to Laboratory missions. Livermore researchers ultimately selected the atomic vapor method using a dye laser pumped by a copper vapor laser to selectively excite, photoionize, and separate isotopes of choice.

John Emmett, who succeeded Haussmann as associate director of Laser Programs in 1975, recalls, "Carl was willing to let go, but he was always there when I needed him. He was a unique person at Livermore. He was committed to creating the future and made it possible for younger people to carry the organization forward. What finer mentor could a person expect to have?"

Meddling with a License

After leaving the laser program, Haussmann was named as one of two associate directors at large, a position he likened later to having "a license to meddle." His zeal for landscaping, which made him famous as Livermore's Father of the Trees, was part of a larger vision of changing the former military base into a campuslike environment more amenable to research excellence.

According to Chuck Meier, a Livermore retiree who worked closely with Haussmann, "He said that an improved site would provide a more efficient working environment as well as give it a more aesthetic quality that would be more conducive to attracting and retaining top employees." With Director May's approval, Haussmann commissioned the landscape

The Bet on Supercomputing that Paid Off

From his earliest days at Livermore, Carl Haussmann was instrumental in obtaining and applying ever-more powerful computers for nuclear weapon design efforts. Former colleagues say the source of Haussmann's confidence in computers as an essential tool was almost certainly his work with physicist John Wheeler at Princeton University. As part of Operation Matterhorn, Haussmann did thermonuclear calculations on the precommercial version of the Univac, a machine designed by famed physicist John Van Neumann.

Not surprisingly, Livermore weapons managers first assigned Haussmann to work on thermonuclear explosion calculations for early Livermore warhead designs, using the Laboratory's two card-programmed calculators. Group leader Chuck Leith found Haussmann a "quick learner and very energetic." Shortly after his arrival, Lawrence Livermore's first supercomputer, the Univac-1, was delivered, and Haussmann performed calculations using that machine as well (see figure below).

Haussmann helped to develop codes as well as use them to verify new weapon designs. Judged by today's standards, the early codes were crude, in part because they were one dimensional; Haussmann often found it necessary to extrapolate computer data with both intuition and hand calculations.

Former Laboratory Director John Nuckolls says, "Carl was a great champion of the supercomputer. We became known as the 'computer lab' in the early days." Much of that reputation can be attributed to Haussmann's conviction that the capabilities of the early machines would grow rapidly and serve as increasingly important tools for weapons designers.

"Working on the thermonuclear weapons program for the first decade, I had a need and an opportunity to vigorously support both a good stable of supercomputers and numerical modeling," Haussmann later said. "I always made sure we had the money to get the maximum quantity and quality of those computers in that era. Betting on supercomputers and supercomputer utilization has never let me down."

During the first decades, Livermore helped advance the nation's fledgling computer industry by contracting for and purchasing the most advanced machines. The computers supplied by manufacturers were often acquired early in their development and had little support software. As a result, Livermore became expert in software development, from numerical approximation algorithms to operating systems.

Even after Haussmann left the weapons program in the late 1960s, he had a strong influence on the supercomputer industry. He helped lead the development of the S-1 supercomputer for the Navy in the 1980s, a machine that incorporated several advances. An outgrowth of the program was SCALD (Structured Computer-Aided Logic Design), a graphics-based program to drastically reduce the time to design computers. The program has been used successfully by several Silicon Valley computer firms.

The Laboratory's first supercomputer, the Univac-1, arrived in 1953 and was immediately put to use performing thermonuclear explosion calculations.

architecture firm of Royston, Hanamoto, Beck & Abey to develop a long-range site master plan, later known as the Royston Plan.

The Royston Plan provided the basis for an orderly development of the site. The plan demonstrated an understanding of Livermore's needs and wants by posing, among other questions, this rhetorical one: "Should a great laboratory continue to be controlled by a road system and flying field adapted for training aviators in World War II?"

Before the founding of the Laboratory in 1952, the site had been a ranch, then a naval air station, and then the proposed location of the Atomic Energy Commission's Materials Testing Accelerator (MTA). In the early years, groups of employees were housed close together in existing barracks and other facilities, to promote communication and unity of mission. As the Laboratory grew, new facilities were built in north–south, east–west blocks adjacent to previously developed areas. The result: dense overdevelopment along the southwest perimeter of the site and a grid design with poor traffic flow and dead-end streets, all compounded by security area barriers.

The Royston Plan replaced the grid system with a curvilinear design based on a loop road system (Figure 7). The loop roads partitioned the site into large parcels of land that were shaped differently enough to allow flexibility for future development. The roads also eliminated many intersections and provided better access to buildings while reducing driving distances.

The plan also advocated using plants and trees for aesthetics; to define spaces, such as pedestrian and bicycle paths, parking lots, and groups of buildings; and to provide shade, dust control, and protection against wind and glare. Haussmann was passionate about increasing the number of trees on site. He brought in some from his own yard, and one year, he got the California Conservation Corps to plant some three hundred trees throughout the site.

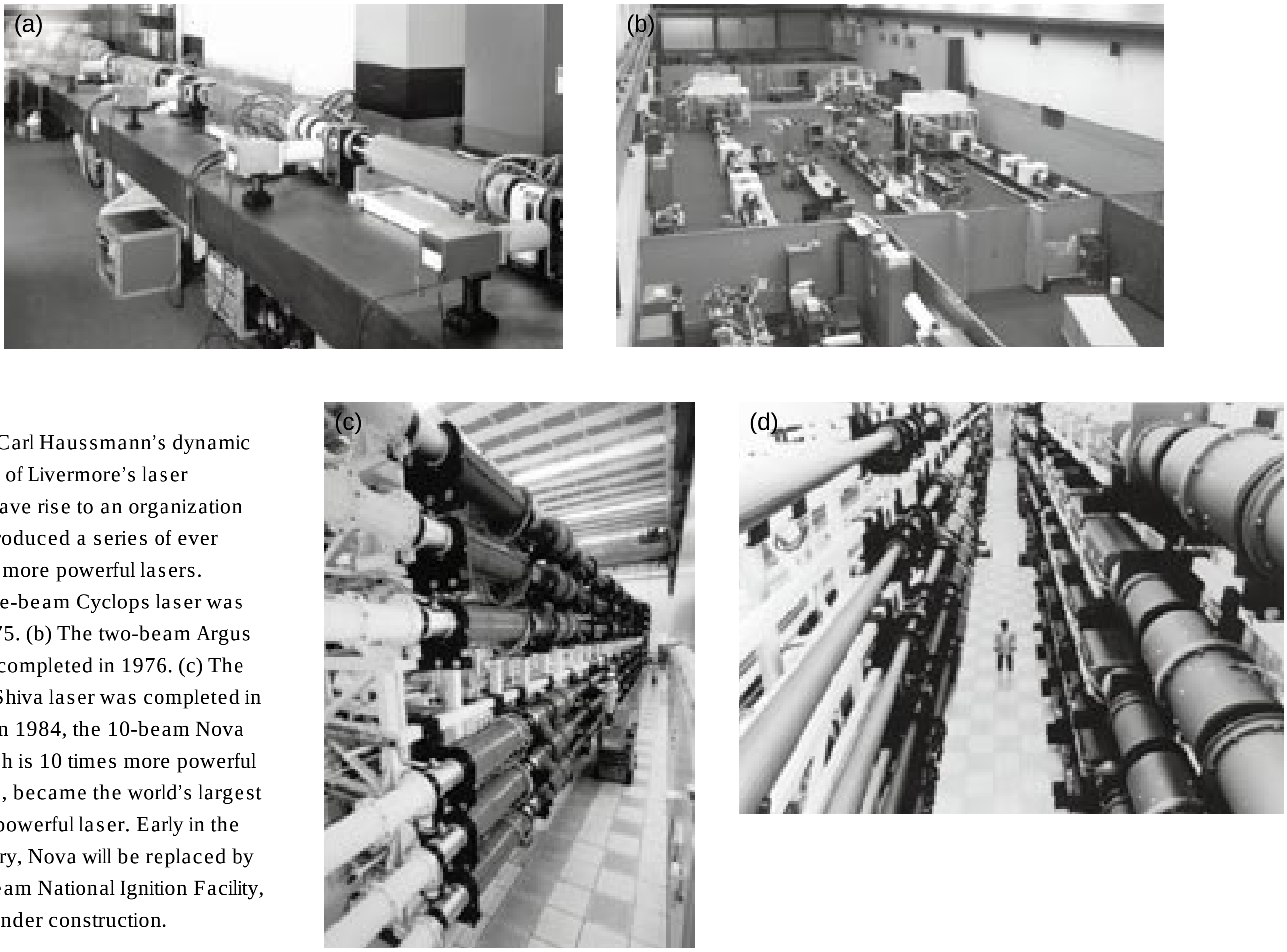

Figure 6. Carl Haussmann's dynamic leadership of Livermore's laser program gave rise to an organization that has produced a series of ever larger and more powerful lasers. (a) The one-beam Cyclops laser was built in 1975. (b) The two-beam Argus laser was completed in 1976. (c) The 20-beam Shiva laser was completed in 1977. (d) In 1984, the 10-beam Nova laser, which is 10 times more powerful than Shiva, became the world's largest and most powerful laser. Early in the next century, Nova will be replaced by the 192-beam National Ignition Facility, currently under construction.

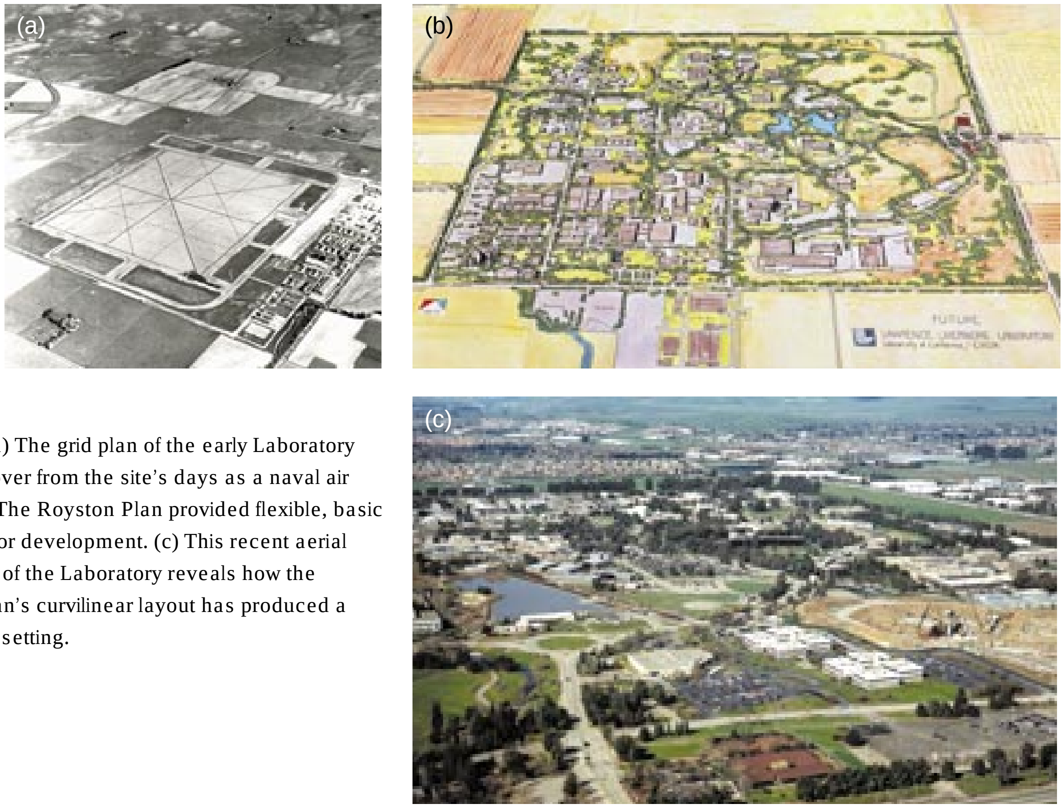

Figure 7. (a) The grid plan of the early Laboratory was a holdover from the site's days as a naval air station. (b) The Royston Plan provided flexible, basic guidelines for development. (c) This recent aerial photograph of the Laboratory reveals how the Royston Plan's curvilinear layout has produced a campuslike setting.

Former colleagues recall how Haussmann urged resource managers to "fence off" landscaping money within project budgets, because he knew that once project managers started running low on funds, the first thing they would defer would be trees. "Take that money away before they get their hands on it," he'd tell them. Today, thanks to Haussmann and the Royston Plan, employees enjoy a tree-studded, campuslike environment throughout most of the Laboratory (Figure 8).

Using Land, Buying More

The construction of the Shiva–Nova laser complex in the north-central portion of the site was consistent with the Royston Plan's recommendation of siting new facilities away from the crowded southwest corner of the Laboratory. Perhaps that move spurred other improvements as well. The new complex had carpeting on its office floors, a first for the Laboratory. Even more radical was the space planning notion successfully advocated by Haussmann and other associate directors. They wanted space designed in a way that would cause people to bump into each other; the impromptu encounters would promote communication and idea-sharing.

As the Laboratory grew, Haussmann recognized that the town around it was growing as well. In response to projections made by Livermore city planners, he realized that Laboratory capabilities and security could be compromised by new housing developments, so he urged the purchase of buffer land. He was instrumental in working with the Department of Energy and Congress to secure funds to purchase the hundreds of acres needed for a buffer zone adjoining both Lawrence Livermore and the neighboring Sandia National Laboratories. He also persuaded Laboratory management to fund landscaping of the buffer zone on the Laboratory's west side to match that of the housing development across the street.

Fostering Talent and Programs

One of Haussmann's final accomplishments was mentoring the young scientists in the Laboratory's fabled O Program, a group dedicated to advanced defense research and development. In time, this "merry band," as he referred to them, built a program funded with tens of millions of dollars a year. Haussmann's presence was felt throughout O Program, yet it was never dominating.

Edward English, who was a part of this program in the late 1970s,

Figure 8. Haussmann’s love of trees led to a site shaded by approximately ten thousand trees of over 50 species.

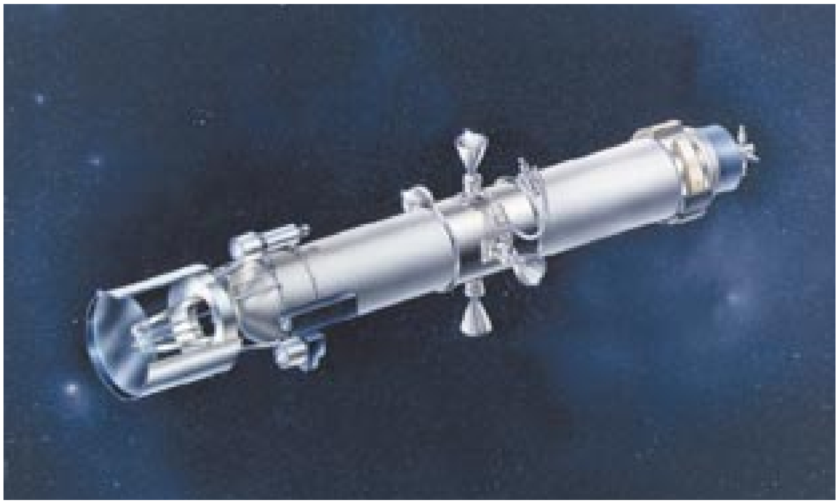

Figure 9. The “brain” of a Brilliant Pebble spacecraft was to be a high-performance computer system, its “eyes” a collection of target-tracking video cameras, and its “legs” an agile propulsion system for intercepting a ballistic missile or other target.

remembers how Haussmann saw to it that everyone was well prepared for making presentations. English says, “You were schooled in ‘Viewgraph 101,’ and then he would open the doors and let you walk through to make all your points to the senior military officers.”

Haussmann worked with O Program researchers to develop technologies for the Defense Advanced Research Projects Agency. The results were advanced computer chips, the S-1 supercomputer for the Navy, and the beginning of projects for the fledgling Strategic Defense Initiative (SDI) organization. Haussmann also communicated with senior military officers and members of Congress to provide information needed to help build the consensus for the Brilliant Pebbles program of nonnuclear defense spacecraft (Figure 9). English remembers how Haussmann would release his nervous energy during many long meetings by tearing Styrofoam coffee cups into creative designs, even as he was helping to focus attention on important points.

After Haussmann’s retirement in 1988, the spacecraft aspect of Brilliant Pebbles continued, changing course to become a major new research program. The work generated considerable national recognition for the Clementine spacecraft and continues today, with the creation of microsatellites for space exploration and defense. English says that the microsatellites are “just like Carl—compact, energetic, functional, and bound to capture the imagination.”

It is easy to forget today the early role and large part Carl Haussmann played in so many Livermore programs. His contributions can still be seen, however, in the Laboratory’s continuing technical successes and its commitment to the expression, encouragement, and development of new ideas in science and technology to serve the national interest.

—Arnie Heller, with Katie Walter and Gloria Wilt

Key Words: Argus laser, atomic vapor laser isotope separation (AVLIS), copper vapor lasers, Cyclops laser, diode-pumped solid-state laser, inertial confinement fusion (ICF), Janus laser, loop road system, Materials Testing Accelerator (MTA), Military Research Associates, Nd:glass (neodymium-doped glass) laser, Nevada Test Site, Nova laser, O Program, Operation Hardtack, Operation Matterhorn, Polaris, Royston Plan, S-1 supercomputer, SCALD (Structured Computer-Aided Logic Design), Shiva laser, site planning, solid-state lasers, Strategic Defense Initiative (SDI), Woods Hole, Univac.

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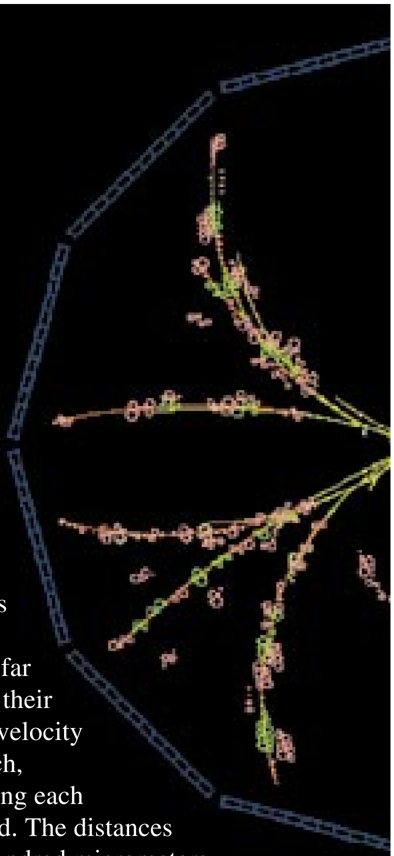
Imaging the Elephant

The BaBar Detector and the Mystery of Matter



LATER this spring, electrons and positrons will collide in the heart of the new BaBar Detector at the Department of Energy's Stanford Linear Accelerator Center (SLAC), creating an alphabet soup of subatomic particles. These particles will shoot out, interacting with BaBar's layered subsystems and leaving clues about their identities. Once these data are gathered and processed, physicists from both ends of the physics continuum will examine the results, looking for evidence that will illuminate worlds both infinite and infinitesimal.

For cosmologists, the experiments may point the way to a clearer picture of the earliest moments in our universe. For particle physicists, the experiments will yield insights into unexplored regions of the fundamental interactions of matter.

The BaBar Detector,* the work of 500 physicists from over 70 organizations worldwide, is part of DOE's B Factory shown in Figure 1. (For more information about the B Factory project, see *S&TR*, January/February 1997, pp. 4–13.) When it's up and running, SLAC's B Factory will produce B and anti-B mesons, particle–antiparticle pairs that scientists believe will open a new window on our understanding of nature and matter.

B Mesons and the Big Bang

Prevailing theory holds that at the time of the creation of the universe—by the so-called Big Bang—matter and antimatter existed in equal quantities. Fifteen billion years later, we look around and see a universe primarily of matter. The question is: "What happened to all the antimatter?"

Current theoretical models of elementary particles predict that an effect called charge parity violation favors the decay of antimatter over matter on the subatomic scale. Although a small charge-parity-violation effect was first observed in the 1960s, the theoretical explanation remains unresolved.

To detect charge parity violation in the laboratory, physicists measure the difference in the decay rates of particles and their antiparticles. Prime candidates for studying this effect are the B meson and its antiparticle, the anti-B meson. The electrically neutral B and anti-B mesons are short-lived, existing about 1.5 trillionths of a second before decaying. To determine the rates of decay for each B and anti-B meson, physicists measure how far the particles have traveled from their creation point. By knowing the velocity and the distance traveled for each, physicists can determine how long each particle existed before it decayed. The distances are exceedingly small—a few hundred micrometers. Subtle variations in the distribution of the distance traveled for the B and anti-B mesons will be the evidence for charge parity violation.

A thorough investigation of charge parity violation requires a "factory" that can produce 30 million pairs of B and anti-B mesons each year. The B Factory—a virtual time machine back to the earliest moments of the Big Bang—will do just that by colliding electrons with their antiparticles, positrons. The electrons are accelerated to a higher energy than the positrons—9 billion electron volts for the electron versus 3 billion electron volts for the positron. The particles created from the collision will then move together in the same direction. Only a few of the electron–positron collisions, about one in a billion, will result in B meson–anti-B meson pairs.

The B and anti-B mesons have a "rich" decay chain; that is, they decay into a variety of subatomic particles—leptons, neutrinos, and lighter hadrons—some of which decay in turn. This decay process repeats, creating hundreds of different decay pathways. About one in a thousand B–anti-B meson pairs is expected to take a certain decay pathway that can be used to search for the violation of charge parity.

The B Factory's BaBar Detector will gather information about the decay products and pathways. Physicists will then use sophisticated computer programs to reconstruct the millions of recorded events, looking for the few that will shed light on the matter–antimatter paradox.

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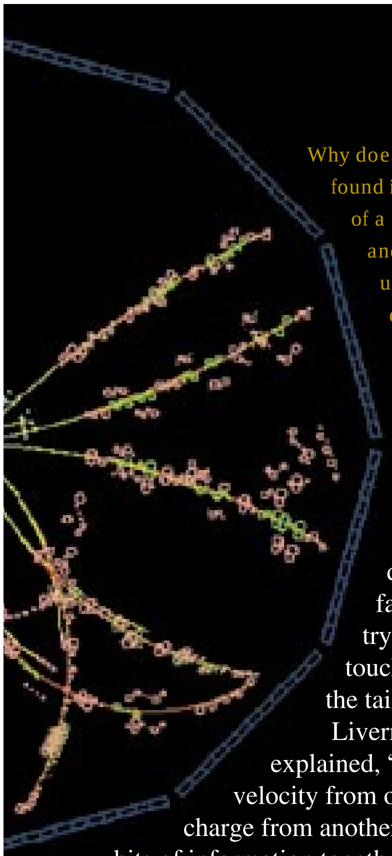
* The BaBar Detector is named after the elephant in Jean de Brunhoff's children's stories and is a playful pun on the physics notation for B and anti-B mesons—B, $\overline{B}$—which is pronounced "B, B bar." The name "BaBar" is used with permission of Laurent de Brunhoff, who holds the copyright.



Why does our universe consist of mostly matter, not antimatter? Could the answer be found in the minute difference in how particles and antiparticles decayed fractions of a second following the Big Bang? Accelerator systems such as the B Factory and its BaBar Detector at the Stanford Linear Accelerator Center are being used to answer these questions. Shown at left is a simulation of some of the decay products that will be produced by the B Factory.

Touching the Elephant

The BaBar Detector has seven subsystems, each of which has a different purpose in the effort to identify all the decay products. It's a bit like the fable of the blindfolded wise men trying to identify an elephant by touching different parts—the trunk, the tail, the leg.

Livermore physicist Doug Wright explained, "We identify a particle's velocity from one subsystem, its position and charge from another, and so on. We then pull those bits of information together and say: 'Aha! These are the characteristics of such-and-such a particle.' Some of those particles will lead us back to the B–anti-B meson pairs we're looking for."

The subsystems, shown in Figure 2, are the silicon vertex detector, the drift chamber, the DIRC (for detection of internally reflected Cerenkov light), the calorimeter, the cylindrical resistive plate chamber (RPC), the superconducting solenoid magnet, and the instrumented flux return (IFR). Working with research groups and manufacturers in the U.S., Italy, Britain, Japan, China, and Russia, Lawrence Livermore played a major role in the design, development, and delivery of the last four systems. Those leading these efforts included physicists Doug Wright, Richard Bionta, Marshall Mugge, and Craig Wuest and engineer Thomas O'Connor.

The first three subsystems look for clues about particles that carry a negative or positive charge. The silicon vertex detector subsystem detects the direction a charged particle travels, providing the position of a particle's decay to within 80 micrometers. The drift chamber and the DIRC measure, respectively, the momentum and velocity of charged particles. With this information, the B Factory investigators determine a charged particle's mass and sign (negative or positive).

The calorimeter, codesigned by Wuest and engineer Alan Brooks, primarily detects electrons, positrons, and photons. When these particles enter one of the calorimeter's 6,800 cesium iodide crystals, the crystal emits a flash of light. From this flash, physicists can then estimate a particle's position and energy.

The cylindrical RPC subsystem, developed by Wright, Bionta, and Mugge, detects charged particles that escape the calorimeter. The RPC is a gas-filled chamber between two conductive plates. When a charged particle goes through the detector and hits a gas atom, it knocks electrons off and causes a spark. From this spark, investigators ascertain the position of the particle.

The BaBar Detector's superconducting solenoid and 800-ton steel flux return, designed with O'Connor's assistance, are key to providing additional clues in this identification game. The solenoid's strong magnetic fields bend the path of charged particles—negatively charged particles in one direction, positively charged particles in another. The steel flux return

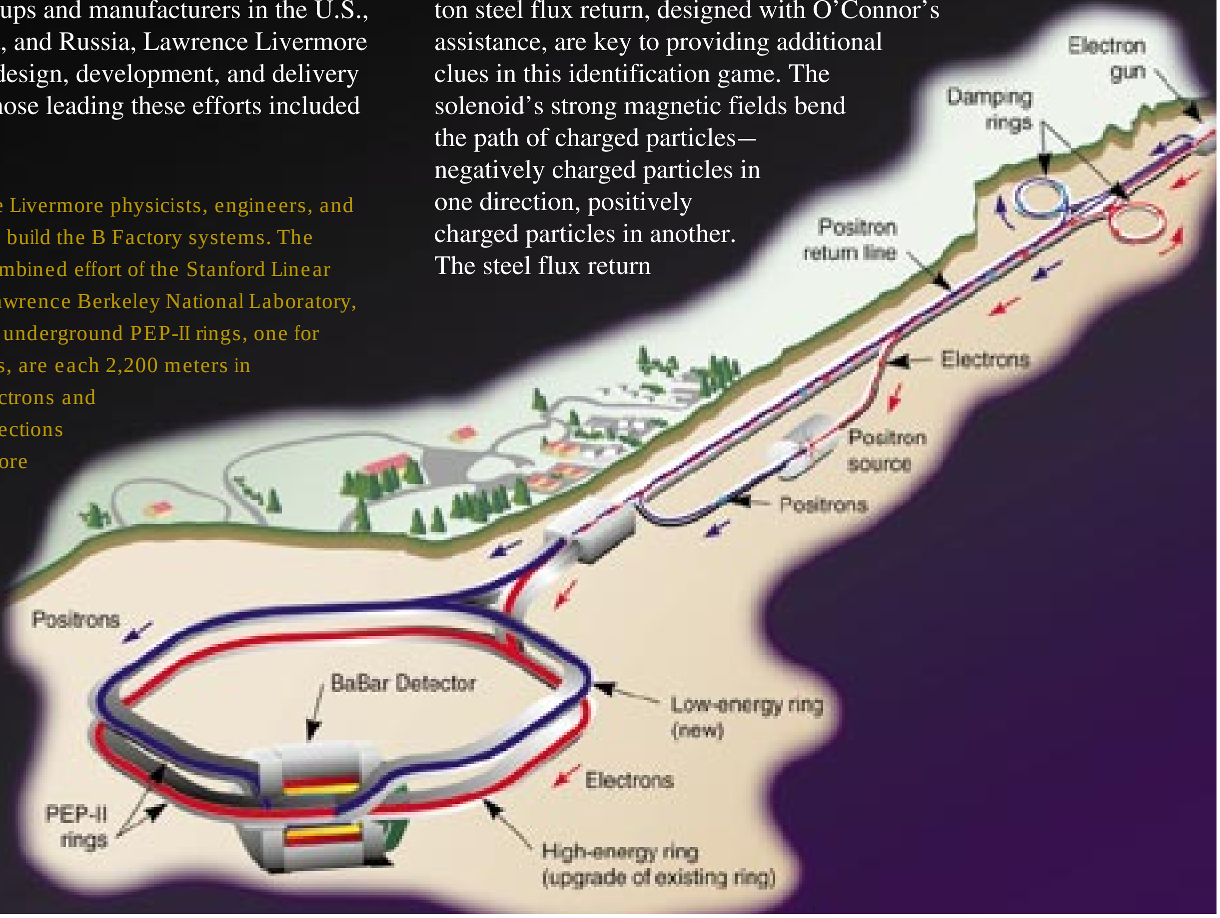


Figure 1. About 200 Lawrence Livermore physicists, engineers, and technicians helped design and build the B Factory systems. The accelerator portion was the combined effort of the Stanford Linear Accelerator Center (SLAC), Lawrence Berkeley National Laboratory, and Lawrence Livermore. The underground PEP-II rings, one for electrons and one for positrons, are each 2,200 meters in circumference. Streams of electrons and positrons travel in opposite directions at nearly the speed of light before converging in an interaction region surrounded by the BaBar Detector.

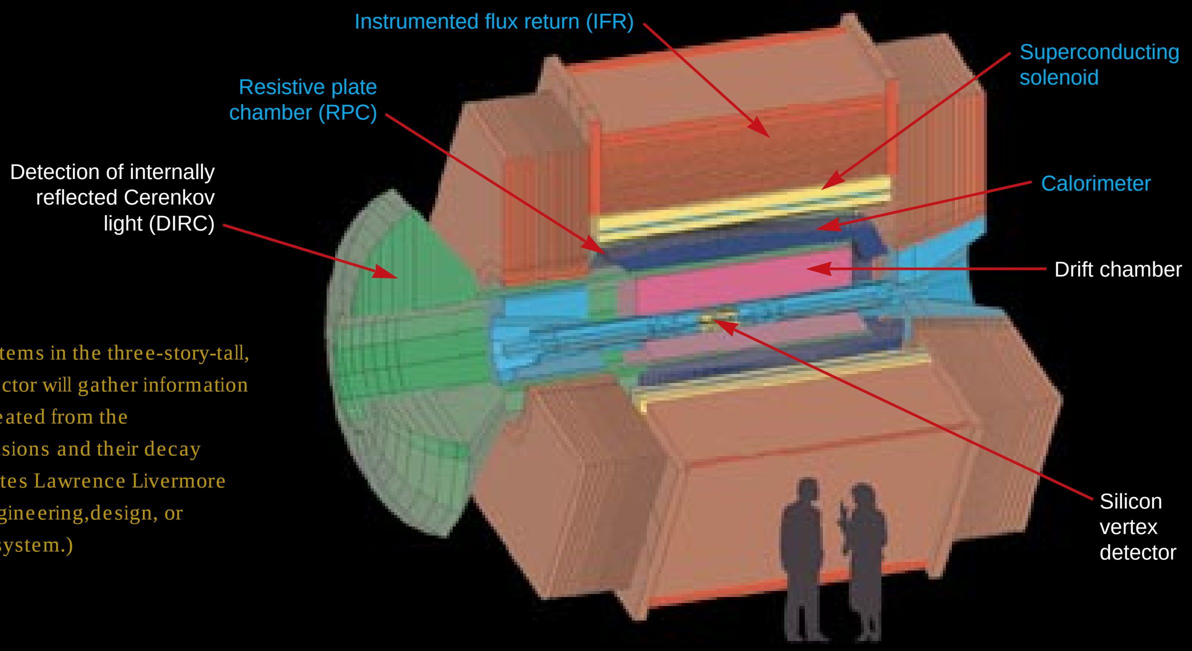


Figure 2. The subsystems in the three-story-tall, 1,000-ton BaBar Detector will gather information about the particles created from the electron–positron collisions and their decay products. (Blue indicates Lawrence Livermore involvement in the engineering,design, or fabrication of the subsystem.)

is the main support structure for the detector and has been designed to withstand up to a 7.9 earthquake with minimal damage. Located just 2 miles from the San Andreas fault, the entire BaBar Detector is sitting on seismic isolators that protect the delicate physics equipment inside the detector.

The final BaBar subsystem is the IFR, which detects charged particles and provides a target for long-lived neutral particles. The IFR, codeveloped by Bionta and Wright, has 2,000 square meters of resistive plate chambers, each one layered between steel plates. These chambers detect muons (a heavier cousin of the electrons) and other charged, high-energy particles. As Bionta noted, “These particles are all very penetrating; they go right through the other subsystems.” The IFR has another important function: its 800 tons of steel plates trap the enormous magnetic field produced by the superconducting magnet, confining the field effects to BaBar. “Otherwise,” said Bionta, “the magnetic field would simply extend outward in all directions, affecting the electron and positron beams in the accelerator beam tubes as well as other B Factory equipment.”

Once all the data are gathered from the BaBar subsystems, it’s time to put the puzzle pieces together. This is where computer simulation and reconstruction programs come in, taking the data and completing a coherent picture of all the particles and their decay pathways.

Simulating the Physics of Particles

About 50 BaBar physicists, with contributions from Laboratory physicists including Xiaorong Shi, Torre Wenaus, and Doug Wright, developed computer programs that translate the predictions of particle theory into quantities that can be directly compared with the signals coming out of the BaBar Detector. The programs also simulate in detail how the subatomic particles interact with all the materials in each subsystem and provide the electronic responses of those interactions. In the end, B Factory physicists will have computer-generated results—simulated from theory—that can be compared with actual experimental results once BaBar is up and running. Checking previous known physics results with simulations validates the simulation programs and builds confidence in their predictive power.

Last year, using the Livermore Computing Center’s computers, Shi simulated 7 million of the 10 million events needed for a mock data challenge that tested the BaBar simulation and reconstruction programs. The results from the data challenge set the guidelines for all the physics analysis.

The Answer to the $64,000 Question Is . . .

So, is charge parity violation “the” reason that we live in a universe of matter, instead of antimatter? When the data from BaBar begin to arrive, B Factory collaborators may find the long-sought clues. The information provided promises to open a new window on the subatomic world. Ultimately, the B Factory and BaBar will provide scientists with a more complete and accurate picture of the fundamental nature of matter and energy.

—Ann Parker

Key Words: BaBar Detector, B Factory, Big Bang, B mesons and anti-B mesons, charge parity violation, particle physics, Stanford Linear Accelerator Center (SLAC).

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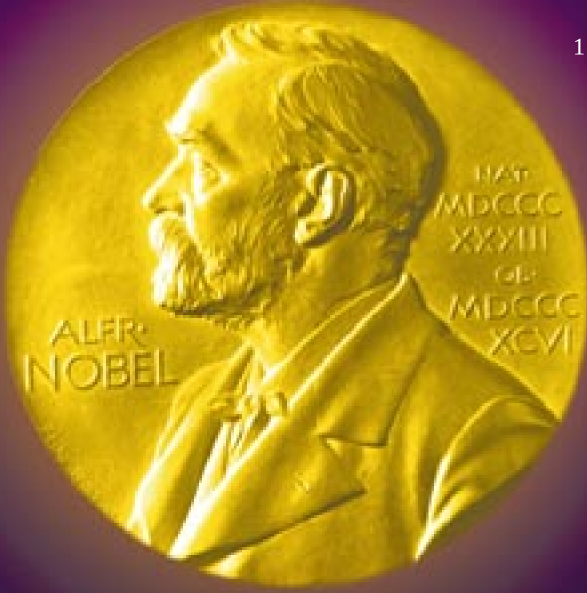
More information about the BaBar Detector is
available on the Internet at
http://www.slac.stanford.edu/BF/doc/www/bfHome.html.

1998 Nobel Prize Winner Laughlin Credits Livermore Colleagues



WHILE Lawrence Livermore's environment of multidisciplinary teamwork has long earned high marks in the research community for nurturing technological advancements, it is now being cited as a basis for a Nobel Prize—by none other than its recipient. Last December, Robert B. Laughlin, a longtime Laboratory employee and a professor of physics at Stanford University, received the 1998 Nobel Prize for physics. Laughlin shared the prize with Horst Stormer of Columbia University and Daniel Tsui of Princeton University.

In 1983 when Laughlin was a member of the Laboratory's condensed matter division, he provided a groundbreaking—and to some, startling—explanation for Stormer and Tsui's discovery of the fractional quantum Hall effect. Laughlin's cogent argument showed that electrons physically confined to two dimensions at very low temperatures and in a powerful magnetic field can condense into a new quantum state with elementary excitations—its "particles"—carrying a fraction of an electron's electrical charge. The explanation, now firmly entrenched as part of quantum physics theory, was considered revolutionary in this context.

Laughlin received the prize in Stockholm from the Swedish Academy of Sciences on December 10. While he is the seventy-first Nobel Prize winner who worked at or conducted research at a Department of Energy institution or whose work was funded by DOE and is the eleventh University of California employee to receive a Nobel Prize in physics, he is the first National Laboratory employee ever to win the prize.

Robert Laughlin (left) receiving the Nobel Prize for physics from Swedish King Carl XVI Gustaf at the ceremonies in Stockholm, Sweden, on December 10, 1998. (AP Photo/Jonas Ekstromer)

“My presence at Livermore was crucial to my work,” says Laughlin. In particular, he gives credit to his Livermore colleagues for aiding him in his intellectual struggle to explain a most peculiar aspect of physics. “My colleagues helped me significantly,” he says. “I owe the Laboratory a great deal.”

Story Begins in 1879

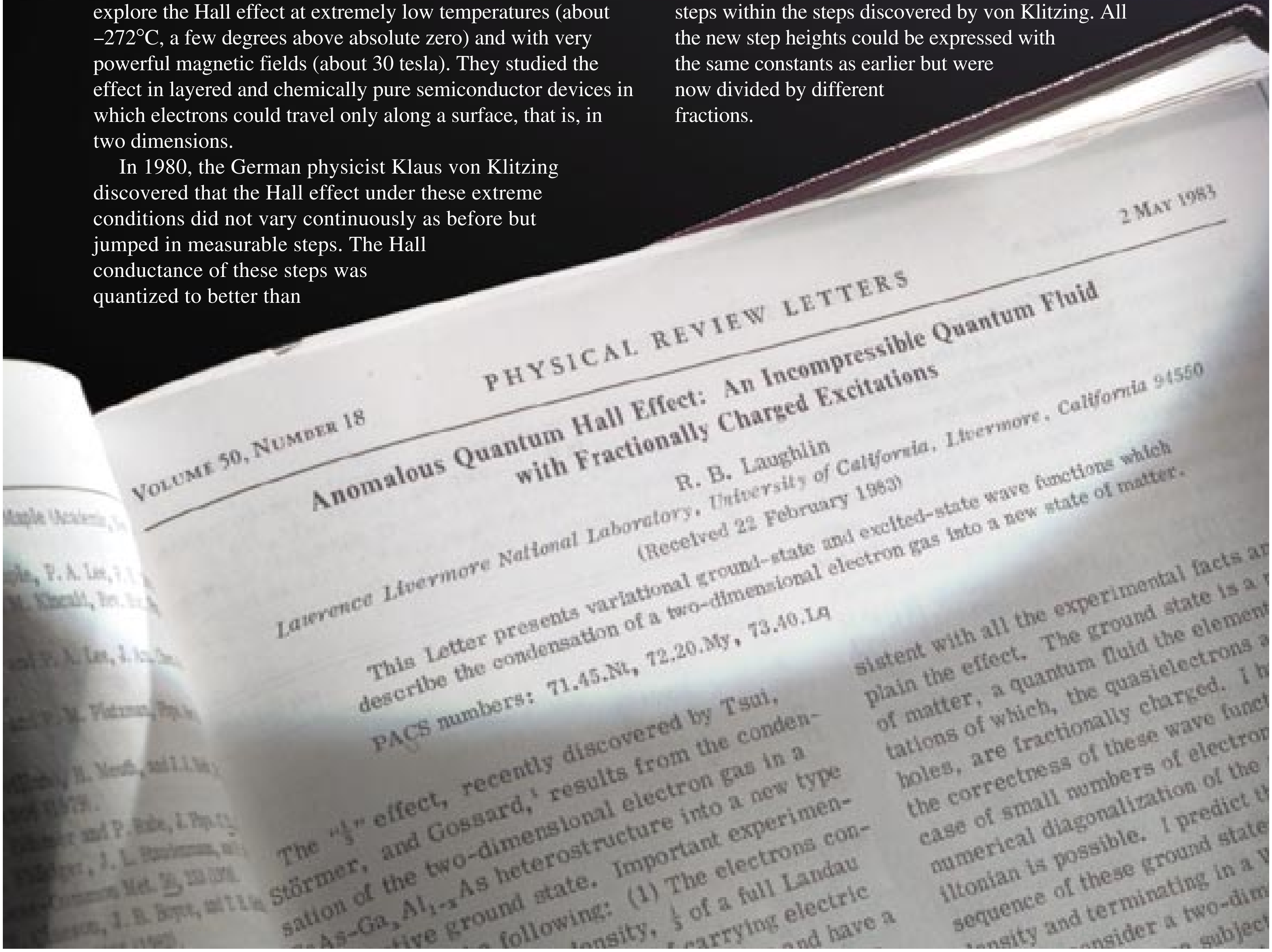
The story of the 1998 Nobel Prize for physics really begins in 1879, when British physicist Edwin Hall discovered an unexpected phenomenon. He found that if a thin gold plate is placed in a magnetic field at right angles to its surface, electrons will drift sideways compared with the direction of the current’s flow. As charge accumulates on one side of the plate, a voltage is created, known as the Hall voltage or Hall effect. As the magnetic field is increased, the Hall voltage increases proportionately as well.

Hall’s experiments were conducted at room temperature and with moderate magnetic fields (less than 1 tesla, a basic unit of magnetic strength). In the late 1970s, researchers began to explore the Hall effect at extremely low temperatures (about –272°C, a few degrees above absolute zero) and with very powerful magnetic fields (about 30 tesla). They studied the effect in layered and chemically pure semiconductor devices in which electrons could travel only along a surface, that is, in two dimensions.

In 1980, the German physicist Klaus von Klitzing discovered that the Hall effect under these extreme conditions did not vary continuously as before but jumped in measurable steps. The Hall conductance of these steps was quantized to better than one part in a million to a combination of fundamental constants. Von Klitzing won the Nobel Prize in 1985 for this discovery.

While working at Bell Laboratories in New Jersey in the field of solid-state physics, Laughlin was intrigued by von Klitzing’s data. In a notable paper published in 1981, shortly before he arrived at Livermore, Laughlin argued that the experiment was accurate because the quantum Hall effect really measures the charges on electrons (*Physical Review Letters B*, **23**, 5632 [1981]). “Von Klitzing always observed the same proportionality,” says Laughlin. “There had to be a simple reason why he got such accurate results. I eventually figured out that the experiment fundamentally measures the charge on the electron, which is, of course, accurately quantized.”

The Tsui–Stormer experiments built on von Klitzing’s work. In 1982, the researchers used even lower temperatures and more powerful magnetic fields in the study of electron motion in the two-dimensional space at the interface of two semiconductor crystals. The researchers found, to their surprise, additional steps within the steps discovered by von Klitzing. All the new step heights could be expressed with the same constants as earlier but were now divided by different fractions.



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Anomalous Quantum Hall Effect: An Incompressible Quantum Fluid with Fractionally Charged Excitations

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(Received 22 February 1983)

This Letter presents variational ground-state and excited-state wave functions which describe the condensation of a two-dimensional electron gas into a new state of matter.

PACS numbers: 71.45.Nt, 72.20.My, 73.40.Lq

The “$\frac{1}{3}$” effect, recently discovered by Tsui, Störmer, and Gossard,[1] results from the condensation of the two-dimensional electron gas in a GaAs-Ga$_x$Al$_{1-x}$As heterostructure into a new type ...tive ground state. Important experimen... following: (1) The electrons con... density, $\frac{1}{3}$ of a full Landau ... carrying electric ... and have a

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Explaining Quarklike Excitations

The new phenomenon was thus named the fractional quantum Hall effect. However, physicists were at a loss to explain the phenomenon. "There were a lot of implausible explanations offered," recalls Livermore theoretical physicist and Laughlin colleague Stephen Libby. "And then Bob came out on his own with a brilliant explanation."

Laughlin had known Tsui and Stormer while at Bell Laboratories, and he was familiar with the unexpected findings coming out of their laboratory. As a new member of the Laboratory's H Division (which focuses on condensed matter physics), he was assigned to modeling extremely hot plasmas. While his security clearance was being processed, colleagues from H Division taught him the mathematics of hot plasmas and how to simulate their interactions on computer.

"I was around researchers who understood fluids," says Laughlin, "and I realized that the fractional quantum Hall ground state had to be a new kind of fluid. There was no other easy way to explain why the experimental findings were so accurate. You had one-third charge 'things' in there. It's a great case of truth being stranger than fiction." Laughlin says he received a lot of valuable physics advice from Livermore physicists such as Forrest Rogers, Marv Ross, and Hugh Dewitt. He also benefited from the generosity of his group leader at the time, Hal Graboske (now associate director for Chemistry and Materials Science at Livermore). Graboske was "very liberal" in allowing Laughlin to research the quantum Hall effect on the side, in addition to his actual job of modeling plasmas.

In 1983, Laughlin offered his groundbreaking theoretical explanation for Tsui and Stormer's findings in a paper published in *Physical Review Letters* (**50**, 1395 [1983]). He persuasively showed that electrons in a powerful magnetic field and at extremely low temperature can condense to form a new kind of fluid, the disturbance of which by outside forces causes particlelike motion of the fluid—quasi-particles—to materialize. These carry the precise fractional charges of an electron. These quasi-particles, said the Nobel committee, "are not particles in the normal sense but a result of the common dance of electrons in the quantum fluid."

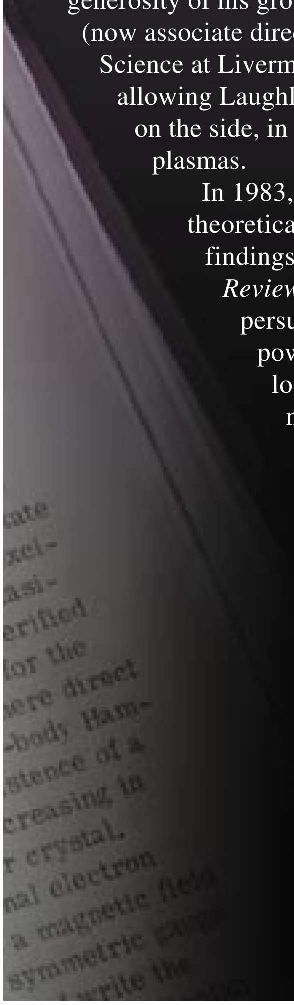
"The paper was a lightning bolt of clarity. The abstract was one sentence," says Libby, who attended the awards ceremony in Stockholm with his family as the Laughlins' guests. "Bob developed a new kind of wave function, Laughlin's wave function. It's elegant because it's a compact formula that captures all the physics involved." Libby adds, "It's amazing that ordinary, boring electrons in a special situation behave as if they have a fractional charge. Of course, you can't put your hand in and take out a quasi-particle with a fractional charge."

Theory Disturbed Some

While most of the physics community quickly embraced Laughlin's paper, the theory seemed outlandish and even disturbing to a few. "Some people found it easier to dismiss the experiment as being wrong and go on with their lives rather than accept the idea that there was a new kind of liquid exhibiting fractional charges," Laughlin says. Subsequent experiments over the past 15 years have demonstrated more and more fractionally charged steps in the Hall effect, and Laughlin's wave function has explained all of them.

While some experts contend that Laughlin's work will someday lead to revolutionary advances in computers or power-generating devices, Laughlin sees the main value as revealing fundamental insights into nature. "The significance of the discovery is what it tells you about the quantum world. It's cutting-edge knowledge that is completely unexpected. It enlightens us; it's not something you're going to buy, at least not for awhile."

According to Libby, "Bob's work is so important because it's going to affect how we look at many things that may seem disconnected from semiconductors. It pushes the envelope of the possible in quantum mechanics, and thus it will inevitably affect our views of many parts of physics. It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The theory of the fractional quantum Hall effect, for which Laughlin eventually won the 1998 Nobel Prize in physics, first appeared in an article in *Physical Review Letters* in 1983. The clarity of Laughlin's thinking is revealed in his ability to summarize the immensely complex theory in just one sentence.

enlarges our knowledge of what can exist in the world and that has never failed to have practical effects."

A year after publication of the *Physical Review Letters* paper, Laughlin won an E. O. Lawrence Award. In 1986, he won the Oliver Buckley Condensed Matter Physics Prize, the nation's most prestigious award in solid-state physics. For many years, he split his time between Stanford and Livermore; he currently spends most of his time at Stanford. His research focus today is high-temperature superconductivity theory, and he has produced a controversial theory on the subject that borrows from his quantum Hall effect research.

Laughlin notes that sometimes scientists have to fight for ideas that they believe in. "All new ideas experience resistance and for good reason. I've had a lot of good ideas that weren't right," he laughs. He expresses concern, however, for younger people who may not want to fight for new ideas because of the possible risk to their careers in times of constrained budgets. In that respect, he is an outspoken advocate for federal support for basic and theoretical research. He decries those who would abandon support for the kind of basic research that makes possible most Nobel Prizes.

"I believe that fundamental research should be one of the main goals of government research because the private sector takes care of other types of research extremely efficiently." In particular, Laughlin urges a rethinking of the role of the national laboratories.

"National laboratories like Livermore are capable of world-class basic research when given the opportunity," he says. "My history proves it."

—Arnie Heller

Key Words: fractional quantum Hall effect, Laughlin's wave function, Nobel Prize, quarks.

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Each month in this space we report on the patents issued to and/or the 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

Patent issued to	Patent title, number, and date of issue	Summary of disclosure
Jeffrey E. Mast	**Automatic Position Calculating Imaging Radar with Low-Cost Synthetic Aperture Sensor for Imaging Layered Media** U.S. Patent 5,796,363 August 18, 1998	An imaging system for analyzing structures comprising a radar transmitter and receiver connected to a timing mechanism to allow a radar echo sample to be taken at a variety of delay times for each radar pulse transmission. The radar transmitter and receiver are coupled to a position-determining system that provides the x,y position on a surface for each group of samples measured for a volume from the surface. The radar transmitter and receiver are moved about the surface to collect groups of measurements from a variety of x,y positions. Return signal amplitudes represent the relative reflectivity of objects within the volume. The delay in receiving each signal echo represents the depth of the object in the volume and the propagation speeds of the intervening material layers. Successively deeper z planes are backward propagated from one layer to the next, with an adjustment for variations in the expected propagation velocities of the material layers that lie between adjacent z planes.
Fred Mitlitsky Blake Myers Frank Magnotta	**Lightweight Bladder Lined Pressure Vessels** U.S. Patent 5,798,156 August 25, 1998	A lightweight, low-permeability liner for graphite-epoxy-composite, compressed-gas storage vessels. The liner is composed of polymers that may or may not be coated with a thin layer of a low-permeability material—such as silver, gold, or aluminum—deposited on a thin polymeric layer or substrate formed into a closed bladder using torispherical or near torispherical end caps, with or without bosses therein, about which a shell made of a high strength-to-weight material, such as graphite-epoxy composite, is formed to withstand the storage pressure forces. The polymeric substrate may be laminated on one or both sides with additional layers of polymeric film. The liner may be formed to a desired configuration using a dissolvable mandrel or by inflation techniques. The liner can be used in most any type of gas storage system and is particularly applicable for hydrogen, gas mixtures, and oxygen used for vehicles, fuel cells, or regenerative fuel-cell applications.
Thomas E. McEwan Gregory E. Dallum	**Soliton Quenching NLTL Impulse Circuit with a Pulse Forming Network at the Output** U.S. Patent 5,804,921 September 8, 1998	An impulse-forming circuit that produces a clean impulse from a nonlinear transmission line compressed-step function without customary soliton ringing the circuit formed by means of a localized pulse-shaping and differentiating network, which shunts the nonlinear transmission line output to ground.
Thomas E. McEwan	**Impulse Radar with Swept Range Gate** U.S. Patent 5,805,110 September 8, 1998	A radar range finder and hidden-object locator based on ultrawideband radar with a high-resolution swept-range gate. The device generates an equivalent time amplitude scan, with a typical range of 4 inches to 20 feet and an analog-range resolution on the order of 0.01 inch. A differential sampling receiver is employed to effectively eliminate ringing and other aberrations induced in the receiver by the proximity of the transmit antenna, so a background subtraction is not needed. Circuitry is thus simplified and performance improved. Several techniques are used to reduce clutter, and the antennas can be arranged in a parallel configuration or in a coplanar opposed configuration to significantly reduce main bang coupling.

Patent issued to	Patent title, number, and date of issue	Summary of disclosure
John F. Cooper	**Electro-osmotic Transport in Wet Processing of Textiles** U.S. Patent 5,810,996 September 22, 1998	Electro-osmotic (or electrokinetic) transport is used to efficiently force a solution (or water) through the interior of the fibers and yarns of textile materials for wet processing of textiles. The textile material is passed between electrodes that apply an electric field across the fabric. Used alone or in parallel with conventional hydraulic washing (forced convection), electro-osmotic transport greatly reduces the amount of water used in wet processing. The amount of water required to achieve a fixed level of rinsing of tint can be reduced, for example, from an industry benchmark of 20 pounds of water per pound of fabric to 1 to 5 pounds of water per pound of fabric.
Kar-Keung David Young	**High Precision Redundant Robotic Manipulator** U.S. Patent 5,811,951 September 22, 1998	A high-precision, redundant robotic manipulator for overcoming contents imposed by obstacles or by a highly congested work space. One embodiment of the manipulator has four degrees of freedom and another embodiment has seven degrees of freedom. Each of these is configured with one selective compliant assembly robot arm (SCARA) to provide high stiffness in the vertical plane and a second SCARA to provide high stiffness in the horizontal plane. The seven-degrees-of-freedom embodiment also uses kinematic redundance to provide the capability of avoiding obstacles that lie between the base of the manipulator and the end effector (or link) of the manipulator. The additional three degrees of freedom are added at the wrist link of the manipulator to provide pitch, yaw, and roll. The seven-degrees-of-freedom embodiment uses one revolute joint per degree of freedom. For each of the revolute joints, a harmonic gear coupled to the electric motor is introduced, and together with properly designed based-servo-controllers, they provide an end point repeatability of less than 10 micrometers.

Awards

Laboratory Director **Bruce Tarter** was honored in November with the U.S. Navy League's **Roosevelts Gold Medal Award for Science**. In presenting the award, Victor Gainor, president of the League's New York Council, described Tarter's leadership as "challenging and inspirational" and added that the League is "proud to salute Dr. Tarter and the Livermore Lab for the important role they play in making our nation and the world a safer place to live."

Three Laboratory scientists have been elected **Fellows of the American Physical Society**. APS Fellowships recognize those who have made advances in knowledge through original research and have made significant and innovative contributions in the application of physics to science and technology.

Gail Glendinning was honored for "clear and illuminating experimental investigations for ablation-front Rayleigh–Taylor stability, laser imprinting, and nonlinear hydrodynamic instabilities relevant to inertial confinement fusion . . . , high-energy-density physics, and astrophysics."

Luiz Da Silva was chosen for his "pioneering use of X-ray lasers and laser generated shock waves to study high density plasmas." His work extended the study of high-density plasmas to conditions relevant to planetary science, astrophysics, and inertial confinement fusion.

Guy Dimonte was recognized for his "outstanding contributions to understanding turbulence and mixing in high-energy-density fluids by novel experimental techniques and facilities." He developed new target configurations for the Nova laser and a linear electric motor that can accelerate projectiles up to 1,000 g's to investigate fluid turbulence and mixing. His experimental results can be applied to study areas as diverse as volcanic islands, underground salt domes, astrophysics, and inertial confinement fusion.

Abstract

Leading the Best and the Brightest

Carl Haussmann came to Livermore as a military research associate and stayed on for an illustrious 45-year career. As a major force during the Laboratory's early weapons program, Haussmann helped lead the breakthrough Livermore designs for the Polaris warhead for the first submarine-launched ballistic missile. In the early 1970s, Haussmann brought strong leadership and long-range vision to Livermore's disparate laser projects, founding a laser program that today is unmatched in the world. Inertial confinement fusion and atomic vapor separation of isotopes were the major projects during his tenure, and they remain the primary focus today. Haussmann also helped create a physical environment conducive to the finest scientific research and technical development.

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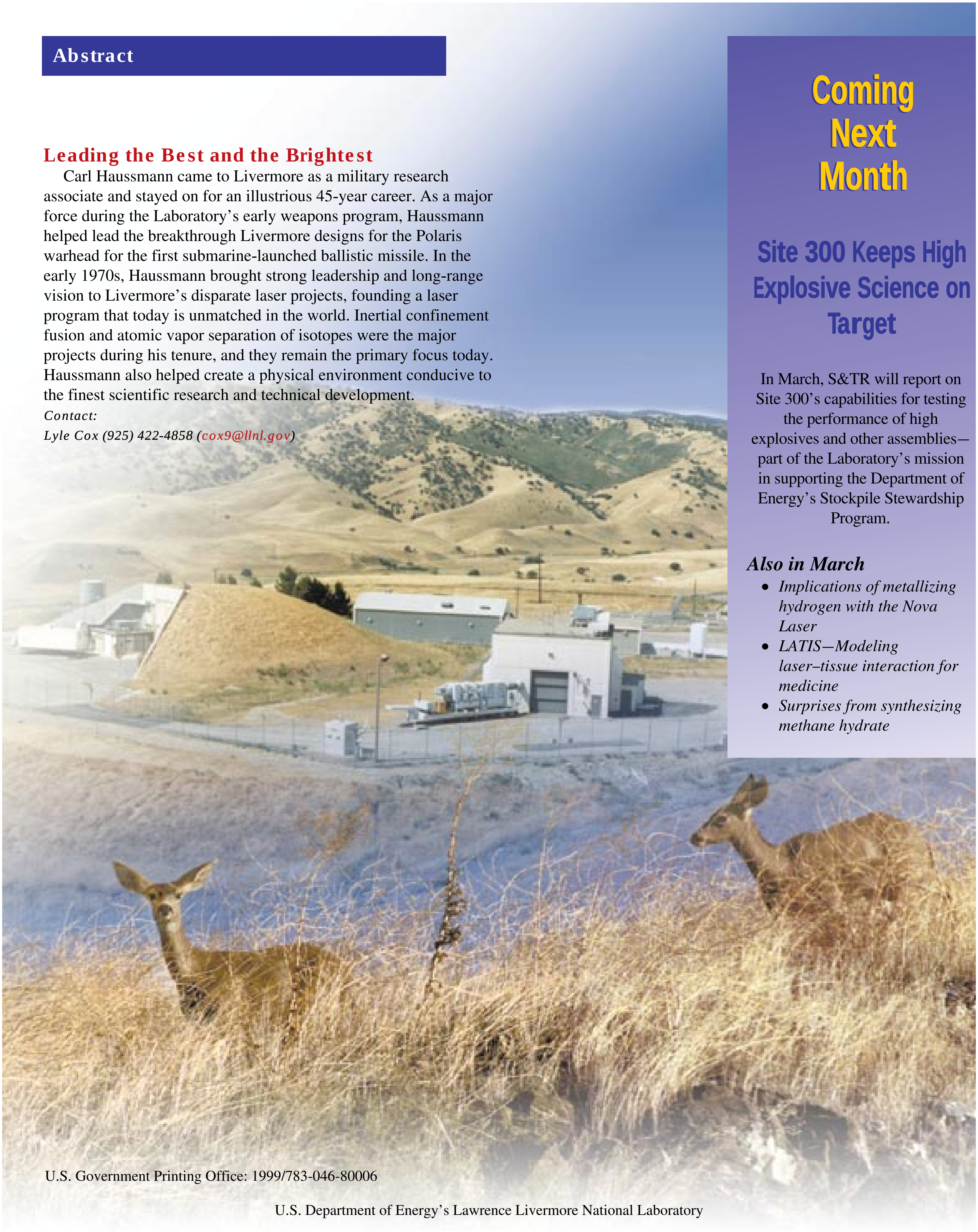

Coming Next Month

Site 300 Keeps High Explosive Science on Target

In March, S&TR will report on Site 300's capabilities for testing the performance of high explosives and other assemblies—part of the Laboratory's mission in supporting the Department of Energy's Stockpile Stewardship Program.

Also in March

- *Implications of metallizing hydrogen with the Nova Laser*
- *LATIS—Modeling laser–tissue interaction for medicine*
- *Surprises from synthesizing methane hydrate*

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