PHYSICS ILLINOIS NEWS

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Quantum Computing without "Computing"

BY JAMES E. KLOEPPEL

By combining quantum computation and quantum interrogation, Bardeen Professor of Physics Paul Kwiat and his group have found an exotic way of determining an answer to an algorithm—without ever running the algorithm. Using an optical-based quantum computer, the researchers have presented the first demonstration of "counterfactual computation," inferring information about an answer, even though the computer did not run (O. Hosten, et al., *Nature* **439**, 949–952 [2006]).

Photo by L. Brian Stauffer

Paul Kwiat, right, John Bardeen Professor of Physics and Electrical and Computer Engineering, and graduate student Onur Hosten have shown that quantum computation can determine the answer to an algorithm—without ever running the algorithm.

Quantum computers have the potential for solving certain types of problems much faster than classical computers. Speed and efficiency are gained because quantum bits can be placed in superpositions of 1 and 0, as opposed to classical bits, which are either 1 or 0. Moreover, the logic behind the coherent nature of quantum information processing often deviates from intuitive reasoning, leading to some surprising effects.

"It seems absolutely bizarre that counterfactual computation—using information that is counter to what must have actually happened—could find an answer without running the entire quantum computer," said Kwiat. "But the nature of quantum interrogation makes this amazing feat possible."

Sometimes called interaction-free measurement, quantum interrogation is a technique that makes use of wave-particle duality (in this case, of photons) to search a region of space without actually entering that region of space. Utilizing two coupled optical interferometers, nested within a third, Kwiat's team succeeded in counterfactually searching a four-element database using Grover's quantum search algorithm.

"By placing our photon in a quantum superposition of running and not running the search algorithm, we obtained information about the answer even when the photon did not run the search algorithm," said graduate student Onur Hosten, lead author of the *Nature* paper. "We also showed theoretically how to obtain the answer without ever running the algorithm, by using a 'chained Zeno' effect."

The Kwiat research group at the Alma Mater

Through clever use of beam splitters and both constructive and destructive interference, the researchers can put each photon in a superposition of taking two paths. Although a photon can occupy multiple places simultaneously, it can make an actual appearance at only one location. Its presence defines its path, and that can, in a very strange way, negate the need for the search algorithm to run.

"In a sense, it is the possibility that the algorithm could run that prevents the algorithm from running," Kwiat said. "That is at the heart of quantum interrogation schemes, and to my mind, quantum mechanics doesn't get any more mysterious than this."

While the researchers' optical quantum computer cannot be scaled up, using these kinds of interrogation techniques may make it possible to reduce errors in quantum computing, Kwiat said. "Anything you can do to reduce the errors will make it more likely that eventually you'll get a large-scale quantum computer."

In addition to Kwiat and Hosten, co-authors of the *Nature* paper are graduate students Julio Barreiro, Nicholas Peters, and Matthew Rakher (BS '03, now at the University of California, Santa Barbara). ■

This work was funded by the Disruptive Technologies Office and the National Science Foundation. The conclusions presented are those of the authors and not necessarily of the funding agencies.

Of Bits and Bytes: Physics Pioneers Computing at Illinois

In 1949, the University received approval to build a copy of a computer being designed at the Institute for Advanced Study in Princeton, New Jersey. The Illinois computer group was organized as the Digital Computer Laboratory with Ralph Meagher, a physicist, named chief engineer for the computer project. Completed in 1951 and named ORDVAC, the computer was one of the fastest in existence—performing with an add time of 92 ms and a multiplication time of 700 ms. Measuring 10-ft long, 2-ft wide and 8.5-ft high, the 5-ton machine contained 2,800 vacuum tubes.

Its successor, dubbed ILLIAC, was completed in Fall 1952 and was one of the first electronic computers built and owned entirely by an educational institution. Operating initially only 8 hours a day, its schedule was gradually expanded to 24-hours-per-day, six-days-a-week operation. ILLIAC would provide the major portion of the computer services for the University for 10 years, finding use in the design of other research instruments such as high-energy particle accelerators and

Abraham Traub and Ralph Meagher with ILLIAC I

the University's radio telescope.

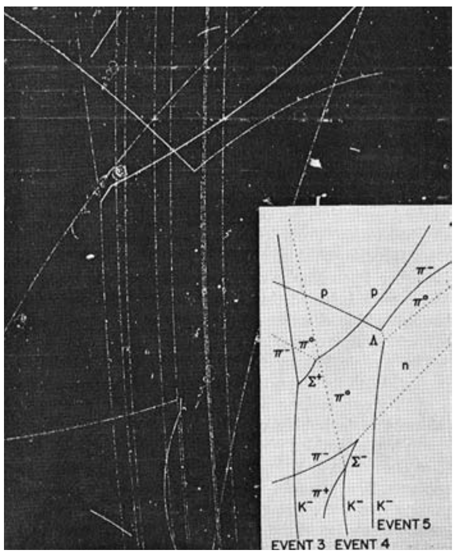
Using the ILLIAC for brain power, U of I faculty introduced PLATO, the nation's first computer-based program of instruction. Beginning in 1959, Physics faculty member and Control Systems Laboratory Director Daniel Alpert championed the idea of Chalmers Sherwin (also a Physics faculty member) that computers could be used for instruction, a concept that was to emerge as PLATO. About 25 years later, Lorella Jones would write the country's first computerized homework problems on PLATO for an elementary physics course at Illinois.

In 1964, the Digital Computer Laboratory—comprised mainly of Physics faculty—was renamed the Department of Computer Science, but the undergraduate degree program in computer science wasn't introduced until 1972.

In 1985, the National Science Foundation established the Center for Supercomputing Research and Development and the National Center for Supercomputing Applications, making Urbana-Champaign the nation's only university campus with two supercomputer centers. Larry Smarr, an astrophysicist, was named NCSA's first director.

The NCSA would drive the development of computer visualization software. Physics graduate student Brand Fortner (BS '77, MS '82, PhD '93), co-founder of Spyglass Inc., licensed the software from the University and developed the first graphical browser for the Internet, Mosaic®, in 1995.

The Department of Physics—its faculty and alumni—has had an enormous influence on the development of computing at the University of Illinois and beyond. This issue of *Physics Illinois News* features interviews with several of the central figures in computing history at the U of I, and we invite you to enjoy this glimpse of our important heritage. ■



Physics faculty developed a pattern recognition computer, which would become ILLIAC III, to solve the problem of interpreting millions of bubble-chamber photographs.

Message from the Head

This is the seventh issue of *Physics Illinois News* and my last as head of the department. I will be stepping down as head and retiring from the University this summer. At that time, I will have completed 39 years as a member of the faculty and 6 as head. As I look back, I am amazed how quickly 39 years has passed and how much the personnel, research, teaching styles, and the outreach programs of the Department of Physics have changed, and at the same time how the ethos of department—the collegial Urbana spirit—has endured. The latter is the most important news I have to report, and I am proud of that.

During my tenure as head, especially in the last four years, the long-standing implicit covenant between public universities and their state governments has changed irreversibly, even at land grant universities such as ours. In the current academic year, for example, only 20 percent of the total UIUC budget comes from state appropriations, a smaller fraction than comes from tuition. Nevertheless, we have been able to hire new faculty, the lifeblood of our department, during every year that I have been head.

Between January 2005, when Joe White took office as the new president of the University of Illinois system, and Summer 2006, when my successor takes over, there will have been a complete turnover of the administrative hierarchy: Head of Physics, Dean of Engineering, Provost, Chancellor, and President. Starting in Spring 2005, the ground work was laid for a strategic planning process at all levels of the University to redefine its mission and its relationship to the State and, at the same time, to expand its national and international reach. The planning process will come to completion in June 2006.

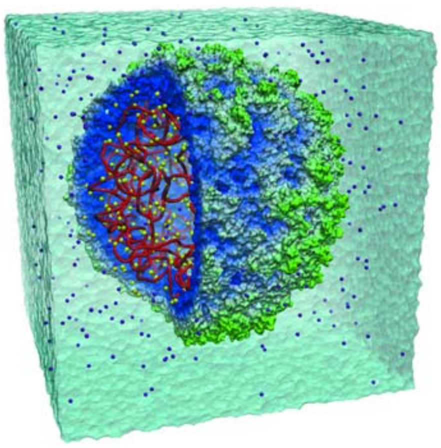
Executing the strategic plans at the departmental, college, campus, and university system levels will be a multi-year challenge. I am confident that the Department of Physics will come out stronger in the end, but it will need help from all of its friends. I am also confident that the Department will play a major role in assisting the College of Engineering and the University of Illinois at Urbana-Champaign to meet their challenges and goals as well. I also know that the new head of the Department of Physics will struggle with the same issues that Wheeler Loomis and every department head since have had to deal with—money and space!

It has been a great honor to have served as head of the Department of Physics, and I am deeply humbled to have been entrusted with that opportunity and responsibility. ▪

Jeremiah D. Sullivan

First Atom-by-Atom Simulation of a Life Form

The computing horsepower of one of the world's most powerful supercomputers has been harnessed by Swanlund Professor of Physics Klaus Schulten and his research group to visualize the behavior of a complete life form, the satellite tobacco mosaic virus. According to the researchers, their simulation, done at the National Center for Supercomputing Applications, University of Illinois at Urbana-Champaign, is the first to capture an entire biological organism in atom-by-atom detail. A better understanding of viral structures and mechanisms is an essential step in allowing scientists to develop improved methods of combatting viral infections in plants, animals, and eventually, humans.



Theoretical and Computational Biophysics Group

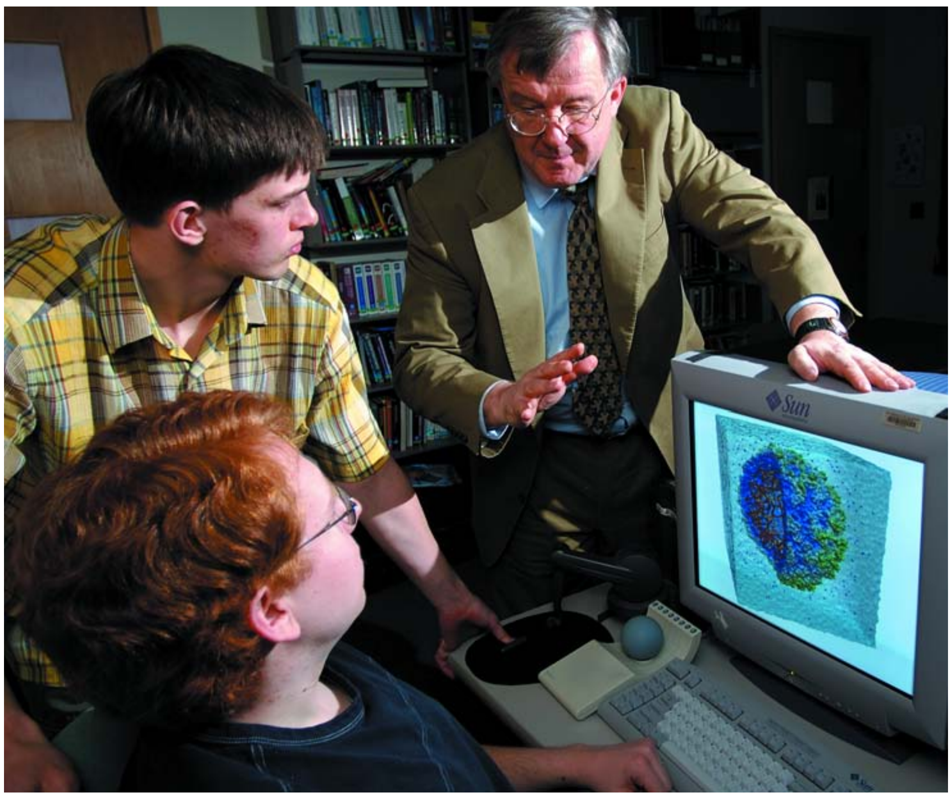
First all-atom simulation of the satellite tobacco mosaic virus

Schulten's group, which includes Peter Freddolino, a graduate student in biophysics and computational biology, and Anton Arkhipov, a graduate student in physics, collaborated with crystallographers at the University of California, Irvine—Alexander McPherson, a professor of molecular biology and biochemistry, and research specialist Steven Larson. The group's results were published in the March issue of *Structure* (P.L. Freddolino, et al., *Structure* **14**, 437–449 [2006]).

The researchers visualized the dynamic atomic structure of the virus in a saline solution by calculating, in femtosecond time steps, how each of its ~1 million atoms moved. The simulation utilized the latest version of NAMD®, a software program developed by Schulten and his colleagues over the last decade to model the molecular dynamics of biological molecules. The program allowed the supercomputer's 500 processors to work in parallel on the same problem. Even so, the simulation took about 50 days to generate 50 ns of virus activity. "Such a task would take a desktop computer around 35 years," according to Schulten. "This is just a first glimpse of a moving virus," he said, "but it looks gorgeous."

"The simulations followed the life of the satellite tobacco mosaic virus, but only for a very brief time," added Freddolino and Arkhipov. "Nevertheless, they allowed us to discover key physical properties of the viral particle, as well as providing crucial information on its assembly."

In the brief simulation, the virus looks spherical but expands and contracts asymmetrically, as if it were "breathing." The model also shows that the virus coat collapses without its genetic material, suggesting that when reproducing, the virus builds its coat around the genetic material, rather than inserting it into a pre-existing coat as was commonly assumed. "We saw something that is truly revolutionary," Schulten said.



Klaus Schulten, right, with students Peter Freddolino, bottom, and Anton Arkhipov, center

Ultimately, computational biophysicists will generate longer simulations of larger biological macromolecules, but that development will wait on the next generation of supercomputers, the so-called petascale high-performance computing systems.

"It may take still a long time to simulate a dog wagging its tail with a computer," said Schulten. "But a big first step has been taken to 'test fly' living organisms. Naturally, this step will assist modern medicine as we continue to learn more about how viruses live." ▪

This work was supported by the National Institutes of Health and by allotments of computing time from the National Center for Supercomputing Applications through its National Science Foundation funding. The conclusions presented are those of the authors and not necessarily those of the funding agencies.

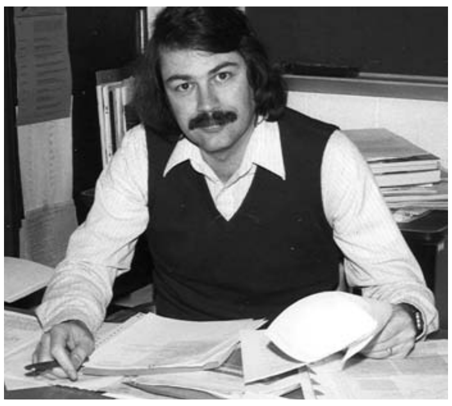
Physics and Computing at Illinois

1948 The Board of Trustees approves the purchase of a large digital computer for $150,000 from the Reeves Instrument Company. When it becomes clear that the company cannot deliver the machine, the University's Research Board, headed by physicist Louis Ridenour, proposes that it design a computer itself. (On January 13, 1949, the Trustees authorize the Research Board to proceed.)

1949 The Digital Computer Laboratory (DCL) is organized as a unit of the Graduate College and tasked with building the University's first computer system. Ralph Meagher (Physics) is named Chief Engineer. (Professors of Physics will be involved in the design and construction of ORDVAC and ILLIACs I, II, and III.)

1950 Arnold Nordsieck (Physics) finishes building his "differential analyzer"—an analog computer capable of solving complex equations and drawing curves—out of war surplus materials. Clones will subsequently become the first computers at the University of California Radiation Laboratory (which will become Lawrence Livermore National Laboratory) and at Purdue University.

Larry Smarr: NCSA's Architect Still Revolutionizing Information Infrastructure



Larry Smarr as a young assistant professor, when NCSA was only a dream.

BY CYNDI PACELEY

When he left the University of Illinois for the University of California six years ago, former Physics professor Larry Smarr knew that uncharted waters awaited him. But little did he realize that he would also gain the opportunity to captain a maiden ship and to learn about entirely new academic disciplines—including a key component of our earth's oceans.

New frontiers have always appealed to Smarr, who knew from the first grade that he was going to be a scientist. Early in his career, Smarr made his mark in relativistic astrophysics, founding the field of numerical general relativity and making major contributions to computational high energy astrophysics—supernovae, neutron stars, blackholes, relativistic magnetohydrodynamics, and galactic jet dynamics.

It was his work in computational science that led him to realize the need for an integrated system for computing, storage, visualization, and analysis to support scientific research.

Not surprisingly, Physics played a major role in the origins of such a system. With a joint appointment in Physics and Astronomy, Smarr and his colleagues began building an early version of a supercomputing center in 1979–80. With the fitting acronym of VIP (VAX and Image Processing Center), a consortium of faculty in physics, astronomy, atmospheric sciences, and theoretical and applied mechanics pursued interdisciplinary collaborations in computer simulations and visualizations of large data sets.

"It was a first step in gaining experience to address the very limited computing power available to university researchers at that time," Smarr recalled.

Creating VIP sparked discussions across the Urbana-Champaign campus about supercomputing's increasingly central role in basic research. At the same time, Smarr was exposed to supercomputing in action. As a Fellow at Germany's renowned Max Planck Institute for Physics and Astrophysics during the summer of 1982, he saw firsthand what a Cray supercomputer could do—and that its speed was several hundred times faster than anything achieved with the local VAX computer, which was as large as any US research group had at the time. These experiences led Smarr and his UI colleagues to compile 65 case studies from 16 departments, demonstrating the need for greater computing capabilities to carry out research projects.

Putting It In Writing

In 1983, while the National Science Foundation was still conducting blue-ribbon panel discussions on the need for supercomputing, Smarr wrote a proposal recommending development of a national supercomputer center.

"It still amazes me that I—an assistant professor at the time—had the nerve to author an unsolicited proposal for $55 million to the NSF," Smarr said.

He sought the guidance of Ralph Simmons, head of the physics department, on how to best deliver the document.

"Ralph suggested that we put it in an envelope marked 'Director, NSF,' hop on a plane, and deliver it to NSF's Math and Physical Sciences assistant director Marcel Bardon, whom Ralph knew well," Smarr explained. "That someone of Ralph's stature was willing to support a junior professor like me in such a substantial way speaks volumes about his leadership."

After a "frustrating" wait of a year and a half while the NSF leaders reviewed Smarr's proposal as part of a new national competition, the University of Illinois was tapped as one of the nation's five NSF supercomputer center locations, creating the National Center for Supercomputing Applications (NCSA) in 1985.

But the first step was finding a suitable location for the actual supercomputing units. Enter another Smarr mentor in the person of Ned Goldwasser, a former Physics professor who had become Fermilab's deputy director in 1967 and then returned to campus as vice chancellor for research and dean of the Graduate College.

"Because of his background in physics accelerators, Ned understood that we needed a world-class facility to house the supercomputers and their storage units. Fortunately, the Advanced Computation Lab's second floor had been built to house the University's ILLIAC IV computer in 1968," Smarr said. "I told Ned that with a little work, it could become our first supercomputer work room." That "little work" translated into several million dollars—a huge commitment for the campus at that time.

It was quickly apparent that the first two-processor Cray X-MP would soon have to be upgraded, since a lone theoretical and particle physicist—John Kogut—could easily use all of one of the processors while the other was reserved for the rest of the country.

"I then worked closely with Ted Brown, the vice chancellor for research, and George Badger, head of the Computing Services Office, in creating the structure of NCSA. By that time, I was so far into it, I had to become the first director," Smarr said. He assumed the reins in 1985 and was named in 1997 to head the National Computational Science Alliance before stepping down in March 2000.

"A Long, Proud Tradition"

Smarr saw NCSA as "a very natural step in a long, proud tradition of supercomputing technology for the U of I at Urbana-Champaign."

In answer to those who attempt to credit solely him for NCSA, he offers an interesting historical footnote to coincidence or fate—or both.

"A letter dated October 16, 1948—the day I was born—was sent from the U of I to J. Robert Oppenheimer, who had recently left the Los Alamos Manhattan Project to direct the Institute for Advanced Study in Princeton, New Jersey. The letter advocated plans for constructing two "supercomputers"—one in Princeton for John von Neumann and the other at the U of I. That computer became ILLIAC I.

"So I can say that fully all of my life, the U of I has been at the forefront of high performance computing," Smarr said.

"Completed 31 years before my initial NSF proposal, ILLIAC I was that key first step in making Illinois a computing powerhouse," he continued. "As a result of the ILLIAC I, II, III, IV, and CEDAR, the University for many years recruited faculty in different departments who did the type of work suited to supercomputing," he added. "That Illinois had the fertile intellectual ground already in place—and nationally recognized—was the reason we were able to organize around NCSA."

Heading West

Pursuit of emerging science has been one of the happy outcomes of Smarr's move to California in 2000, where he was recruited to the University of California, San Diego (UCSD) in the Department of Computer Science and Engineering. Although intending to return to basic research in distributed computing architectures, Smarr was again asked to play a trailblazer role—this time to answer the call to create a California Institute for Science and Innovation, an initiative championed by both the state's governor and then UC President Richard Atkinson. Smarr was asked to pull together a team between UCSD and UC, Irvine, develop a proposal, and win the competition.

Given his previous success in launching NCSA, it's no surprise that Smarr did just that. Bringing together more than 100 faculty at the frontiers of information technology, telecommunications, nanotechnology, and applications of all of these to biomedical research, intelligent transportation, the environment and civil infrastructure, and the new media arts "was a once-in-a-lifetime opportunity," he said.

The Institute's newest project, just unveiled in mid-January, unites Smarr's professional interest in computational structures with a personal love of marine reefs.

Researchers at UCSD will build a state-of-the-art computational resource and develop software tools to decipher the genetic code of communities of microbial life in the world's oceans. The new resource will help scientists understand how microbes function in their natural ecosystems and enable studies on the effect humans are having on the environment, as well as permit insight into the evolution of life on Earth.

The project gives Smarr "a wonderful opportunity" to learn entirely new disciplines, such as microbial ecology metagenomics "with mentors who are the worlds' leading scientific researchers."

"I get to combine that frontier scientific-discovery excitement with the ability to architect whole new classes of science servers connected by dedicated optical networks to the laboratories of end-users around the globe," he said. "It's hard to imagine a more exciting challenge." ■

Announcing the Moore Foundation grant for the CAMERA project. Left to right: Craig Venter, President, J. Craig Venter Institute; UCSD Chancellor Marye Anne Fox, Calit2 Director Larry Smarr; and Scripps Institution of Oceanography Deputy Director John Orcutt.

1951 Hoping to avoid the mass exodus of Urbana researchers that occurred during World War II, Louis Ridenour, now dean of the Graduate College, works with Wheeler Loomis to establish the Control Systems Laboratory (CSL). Funded by grants from all three branches of the Armed Services, the CSL focuses on radar and on possible uses of the new digital computers.

1957 The Digital Computer Laboratory, which has been offering classes to students since 1954, becomes a full department with Ralph Meagher (Physics) as its head. (A subsequent head, James N. Snyder, will also come from Physics.)

1959 Daniel Alpert (Physics) begins a project in CSL for computer-assisted instruction, which will come to be known as PLATO.

1960 A pattern recognition computer (ILLIAC III) is designed in Physics to analyze bubble chamber photographs of high-energy particle events.

1961 Using ILLIAC I as a computational engine, PLATO becomes the nation's first computer-assisted program of instruction. Conceived by Chalmers Sherwin (Physics) and developed under the direction of Don Bitzer (Electrical Engineering), PLATO is the world's first time-shared computer-based education system and the home of the world's first on-line community.

Dan Alpert Continues Shaping Technology and Education

BY CYNDI PACELEY

From solving college-level mathematics problems posed by a revered high school algebra teacher to developing a device for airborne radar to pioneering the field of ultra-high vacuum, it's no surprise that Dan Alpert's zest for learning created the path to computer-based education. Pursuit of new horizons in education and public policy could be the central theme of this 88-year-old scholar's life.

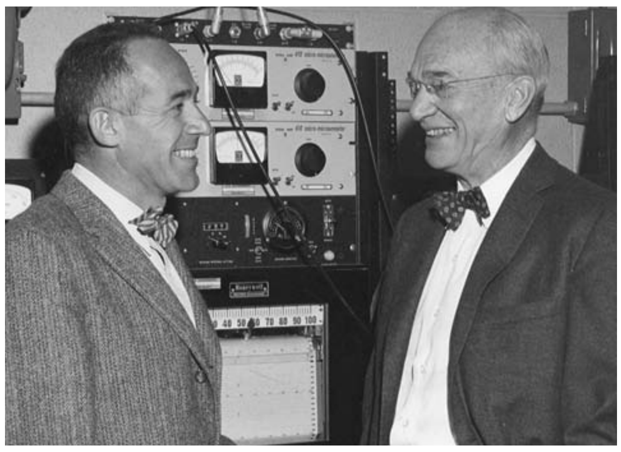
In addition to his role as Physics faculty member, Alpert also served the campus as technical director of the Control Systems Laboratory and director of its successor, the Coordinated Science Laboratory, dean of the Graduate College, director of the Center for Advanced Study, director of the Program in Science, Technology and Society, and senior policy adviser in the National Center for Supercomputing Applications (NCSA). He is drawing on these experiences to promote education reform and reconsideration of science and technology policy in his current role as a senior policy adviser at the University's Institute for Government and Public Affairs.

Alpert's papers, donated to the University Archives in 1999, reveal the scope of his interests and the impact of his leadership. Notes from his course on technology, values and the future share space with his original plan for the Science, Technology and Society Program. Early notes on supercomputing on the Urbana-Champaign campus join an initial proposal for the Beckman Institute for Advanced Science and Technology. Alpert co-authored the earliest peer-reviewed paper on the PLATO project, and as chairman of a national multidisciplinary committee appointed by the National Academy of Sciences, he was principal author of the influential report, "The Impact of Science and Technology on Regional Economic Development."

Early Years Set the Stage

Alpert joined the campus in 1957 as professor of physics and technical director of the Control Systems Laboratory, following a successful career as a research physicist and Physics Department manager at the Westinghouse Research Laboratories. While at Westinghouse, he became internationally known for his contributions to the field of ultra-high vacuum, including the co-invention of the Bayard–Alpert ionization gauge.

As technical director of CSL, which had been started as a classified research enterprise during the Korean War, Alpert responded to a key directive: to develop and implement a strategic plan for the Laboratory, an effort obviously requiring consultation with UI faculty, military sponsors, and CSL professional staff. The central features of the plan included ending classified research at the laboratory and opening its facilities to the campus; using CSL's traditional problem-solving capabilities to address public problems; and changing the name of the laboratory but retaining the initials CSL—by which it was known to the campus and to its Washington sponsors. This was the new mission setting in which the PLATO project was started—in the search for projects for which computers could be applied to civilian needs. With the completion of ILLIAC in Fall 1952, the campus had already gained acclaim for building one of the first electronic computers owned entirely by an educational institution. The computing era was fully underway.



University of Illinois Alumni Association

Daniel Alpert (left) and Wheeler Loomis in the Control Systems Laboratory, November 1958

PLATO Emerges

The possible application of computers to education was one of the first areas that Alpert explored. He assembled a group of engineers, educators, mathematicians, and psychologists to consider how computers might aid in students' learning. The group was positive about the prospects, but quite negative about setting up a new project in CSL given the absence of leadership personnel in the required areas of expertise. Despite the committee's negative recommendation, Alpert proceeded on a quite different tack. Based upon his experience with interdisciplinary projects, he sought a single imaginative researcher who was technologically gifted and was qualified to teach at least one course in what was later to be called computer science. He found those characteristics in an electrical engineering graduate student, Don Bitzer, who was soon recognized as the technical genius of the overall design, and the project was born.

Within a few months, individuals in various roles were added to the project, and after a year or more, the PLATO name was adopted. "My role was that of champion, source of financial support, and bridge to the academic and Washington scenes," Alpert recalled. "I was in the unique position to help bring all of the right personnel and pieces together, while others provided the technological inspiration for the authoring system."

Providing access for student learning at all levels, each PLATO terminal could also be used to "author" lessons, modules, and courses and could be used in various educational institutions, in community colleges, and in military training centers. By the early 1980s, a single PLATO system had a network of more than 2000 terminals, located between Boston and Hawaii. Over time, hundreds or thousands of authors and thousands of students were served by a single PLATO network. It contained features such as email, listservs, and messaging, similar to such features now available on the Internet, though at much higher costs for the communication services.

And PLATO continues today. A public company headquartered in Bloomington, Minnesota, with offices throughout North America and the United Kingdom, as well as international distributors worldwide, PLATO Learning, Inc. is a leading provider of computer-based and e-learning instruction for kindergarteners through adult learners.

The latest [i.e., 1975, *ed.*] *in Physics discussion sections. Thirty PLATO terminals in Room 220 Physics Building are busy nearly 40 hours per week during the school year. The computer-assisted instruction provided by PLATO supplements the work in numerous courses, and, for about 200 students in a developmental group in elementary mechanics, PLATO provides a substantial portion of their instruction. (from the Summary of Engineering Research,* College of Engineering, University of Illinois, Urbana, Illinois, 1976)

New Horizons

Though his involvement with PLATO ended 30 years ago, Alpert is still a proponent of broadening the horizons for using innovative technology in teaching and learning at all levels. He serves on the board of advisers for the Office of Mathematics, Science and Technology Education (MSTE) within the U of I College of Education. MSTE is accessible to students and teachers throughout the Internet world, offers low-cost or no-cost modules on otherwise difficult topics, and supports a growing MSTE network of teachers and students.

Dan Alpert at an early PLATO terminal

The MSTE and his policy-centered work for the Institute of Government and Public Affairs are the focus of Alpert's current energies. In a paper recently co-authored with IGPA director Robert Rich, Alpert addresses the information revolution's implications for higher education policy. And as a participant in a project involving NCSA and IGPA, he is exploring how advanced technologies can assist ongoing efforts in the public sector to improve the effectiveness and efficiency of government agencies.

"The relationship between academic research and the real world has been a longstanding concern of mine," he said.

It would appear that Alpert is managing his own academics-life relationship quite well in his semi-retirement. From his home in Colorado, he continues to advance computer-based education and policy analysis while pursuing hiking, biking, and downhill skiing with equal zeal. ▪

1966 The High Energy Physics Group (HEPG), the largest single user of University mainframe computers, begins negotiations with CSL to provide computer services.

1967 The CSL completes the CSX-1 computer for the HEPG and moves it to the Physics Building. Designed by CSL Professor Richard Brown, who will later join Physics along with his computer, the CSX-1 is the first computer to be partially designed by another computer, in this case the ILLIAC II.

1984 Larry Smarr (Physics) submits proposal #8404556 to the National Science Foundation to establish a supercomputer center at the University of Illinois.

1986 The National Center for Supercomputing Applications opens in Urbana, one of the five original NSF supercomputer centers, with Larry Smarr as its director.

1989 Wolfram Research, founded by Stephen Wolfram (Physics) in 1987, releases *Mathematica*®.

The Innovation of PLATO Homework

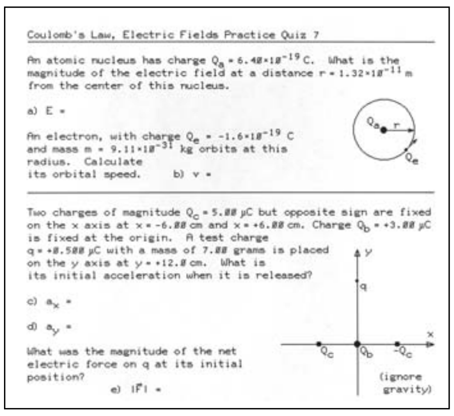
BY CYNDI PACELEY

How does a major research university maximize its resources while providing optimal teaching when a required course can pull in as many as 1,200 students a semester?

At the University of Illinois a little more than 30 years ago, computer-based instruction delivered via the PLATO system emerged as a new and intriguing way "to do a better job of teaching large-enrollment courses," recalled Denny Kane, senior specialist for automated education and teaching associate in Physics.

Since his arrival on the Urbana-Champaign campus in 1972, Kane has served as the continuing thread in the department's computer-based instruction. He first worked with Bruce Sherwood in converting physics lessons from PLATO III (a primarily development system) to PLATO IV (the first production-level system in the series developed by the Computer-Based Education Research Laboratory at Urbana-Champaign).

"We placed the roughly 1,200 students enrolled in the introductory mechanics course into two groups: PLATO and non-PLATO sections," Kane said. "We thought that some type of automation would benefit the student experience by making teaching assistants more available to the students for one-on-one instruction."



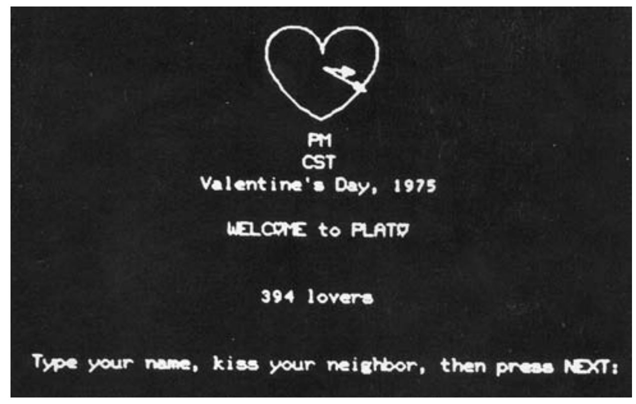
A Physics 107 PLATO quiz. What was the magnitude of the net electric force on q *at its initial position? (ignore gravity)*

The idea was to do a more uniform and efficient job of teaching the material—particularly with continuing high enrollments in these courses, along with fewer graduate students available to teach.

After repeatedly comparing outcomes from PLATO and non-PLATO classes, it was clear that these large courses could be taught successfully in the new, more efficient way. The new method was shown not to adversely affect student learning and actually to improve overall student attitudes about the courses.

"We know that in the physics courses for engineers, the best way to learn is for the students to work story problems—and lots of them," Kane said. "That means taking the information provided, modeling the story in algebra, and calculating an answer to the numerical question that had been posed.

"A computerized approach seemed ideal for presenting and grading dozens of problems over the course of a semester for the hundreds of students we typically have enrolled in our introductory courses," he continued.



The PLATO log-in screen at 3:20 p.m. CST, February 14, 1975

This pioneering effort with PLATO eventually led to the development of the Tycho system used today—a Web interface that delivers various kinds of for-credit homework and quiz exercises to all students in the department's large-enrollment courses. As with PLATO's individualized approach, Tycho exercises usually include a help button that provides an optional sequence of simpler questions to assist the student in mastering more basic material or in offering additional help that guides the student to solving the initial problem.

Kane recalled that when the late Professor Lorella Jones became involved with PLATO—known then and now as NovaNet—in the early 1980s, she was interested in motivating students. She guided the development of an on-line quiz system in the introductory electricity and magnetism course. Preparation for these quizzes became the weekly homework activity. At their assigned quiz time, students had 20 minutes at a terminal to work a variant of one of the multi-part problems in the set they had studied for that week.

In a memorial prepared for the 1995 Physics Newsletter, Robert Delbourgo (University of Tasmania, Australia) and Laura H. Greene (University of Illinois at Urbana-Champaign) recalled this aspect of Jones' work:

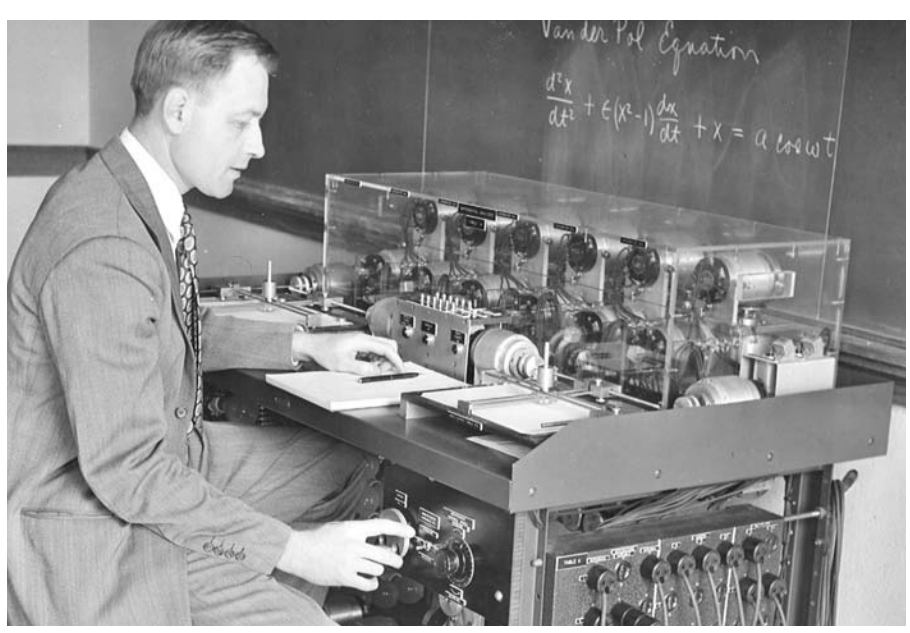
"Professor Jones was a dedicated and innovative teacher who was particularly interested in the application of computers to physics education. In 1985, she pioneered the use of computerized quizzes for a large elementary physics course at Illinois, one of the earliest developments of its kind, nationwide. Recently, she collaborated in the development of computer lessons, incorporating digitized video of lecture demonstrations. She also initiated a project to develop materials and curricula to introduce physics in the local elementary schools."

Although Jones was a superb scientist, perhaps one of her most enduring legacies will be the way in which thousands of U of I physics and engineering alumni remember her—as a faculty member who helped them learn to learn through innovative physics computerized homework. ■

History of the PLATO Project

1960 June	PLATO I (one terminal)
1961 January	PLATO II (two terminals)
1961 March	First remote terminal (30 miles)
1961 Spring	First teaching attempt using PLATO
1962 Spring	First college credit for students taking a course using PLATO
1963 Fall	First stage of PLATO III completed
1964 December	First on-line editing possible
1966 March	PLATO III (20 terminals)
1967 Summer	TUTOR author language in use
1968 March	PLATO IV system design started
1968 June	First time-shared authoring and student use
1968 Winter	Four remote demonstration centers in operation (12 to 14 terminals in each)
1969 Summer	150 hours of instructional material developed by this date
1970 Summer	720 hours of instructional material developed; 100,000 student contact hours of use
1971 May	Delivery of first Digivue display from Owens-Illinois
1971 June	Delivery of first PLATO IV terminal from Magnavox
1972 Summer	1,600 hours of PLATO III instructional material in about 70 courses with 154,000 student contact hours to date
1972 Summer	40 PLATO IV terminals in operation; intensive PLATO IV lesson development; remote on-line demonstrations in Canada, Europe, and USA
1972 Winter	250 PLATO IV terminals in operation at approximately 40 locations (15 on the UI campus and about 25 off campus)
1973 June	PLATO III phased out
1973 Fall	Remote on-line demonstrations in Sweden and the Soviet Union; 1,500 hours of available PLATO IV lesson material in 50 teaching areas; 25,000 student contact hours between September and December 31, 1973
1974	400 terminals in operation at approximately 70 locations (20 on the UI campus and about 50 off campus)

from PLATO (Computer-based Education Research Laboratory, University of Illinois at Urbana-Champaign, 5/74)



The News-Gazette

This photo of Arnold T. Nordsieck and his "differential analyzer," an early analog computer, was published in the April 2, 1950, edition of the Champaign News-Gazette. *Under the screaming headline, "Illini Scientist builds 'brain' with $700," the editors breathlessly announced that the machine "all but talks." Their caption: "Doctor Arnold T. Nordsieck, professor of physics at the UI, sits before the 'Differential Analyzer,' which he built out of war surplus materials. The machine calculates complex mathematical problems and draws curves."*

1992 Physics graduate student Brand Fortner (BS '77, MS '82, PhD '93), who had been working on visualization software at NCSA, founds Spyglass, Inc. with Timothy Krauskopf (MS '87, Computer Science) to develop scientific software.

1994 Spyglass, Inc. releases *Mosaic*®, the first commercial Internet browser.

2000 Richard Martin (Physics), with Duane Johnson (MatSE and Physics), secures funding from the National Science Foundation and IBM Corporation to establish the multidisciplinary Materials Computational Center in the MRL.

2006 Paul Kwiat (Physics) and his research group, using an optical-based quantum computer, demonstrate "counterfactual computation," inferring information about the results of a computation even though the computer did not run.

2006 Klaus Schulten (Physics and Chemistry) and his research group create the first atom-by-atom simulation of a life form, the satellite tobacco mosaic virus, a tiny spherical package of RNA. The simulation modeled how each of the ~1 million atoms in the virus interacted with one another and with the atoms in a surrounding saline solution every femtosecond.

Faculty News

Budakian Shares World Technology Award

On November 15, at a gala ceremony at the San Francisco City Hall, Raffi Budakian, an assistant professor of physics, was recognized with the 2005 World Technology Award in the "materials" category. Budakian shared the award with his former IBM colleagues Daniel Rugar, John Mamin, and Benjamin Chui. The World Technology Network (WTN) combines a global meeting ground, a virtual think tank, and an elite club whose members are involved with the business or science of important emerging technologies of all types (from biotech to new materials, from IT to new energy sources). The WTN's membership is comprised of nearly 1000 individuals and organizations from more than 60 countries that have been nominated and judged by their peers to be the most innovative in the technology world.

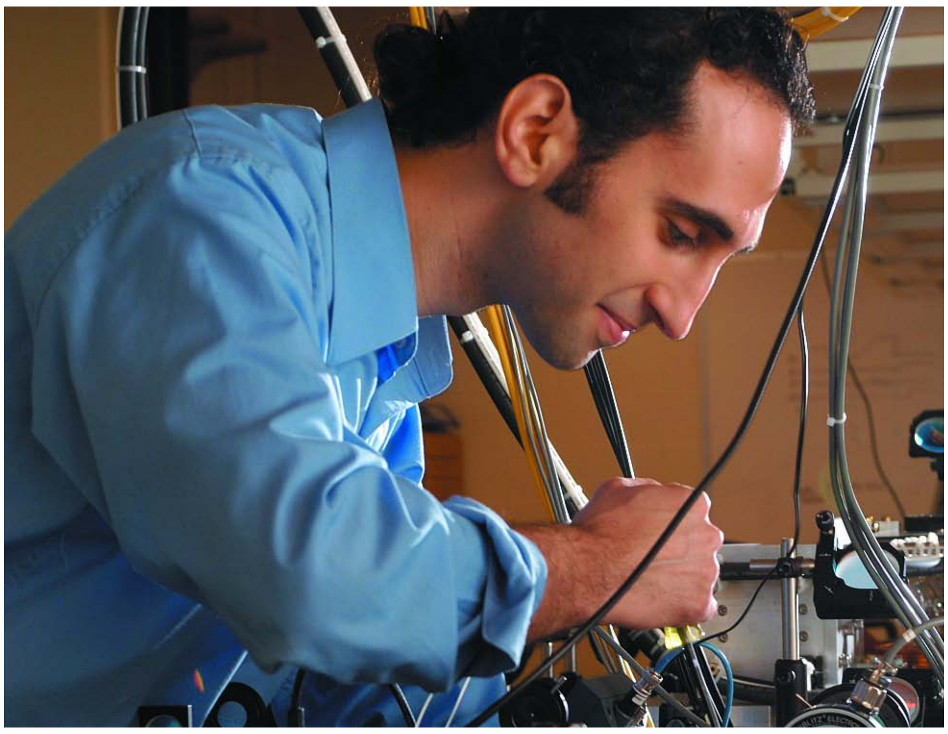
"The award recognizes our work on single spin detection using a technique known as magnetic resonance force microscopy (MRFM)," explained Budakian, who joined the Physics faculty in August 2005. "The ultimate goal of MRFM is for three-dimensional imaging of matter on the atomic scale. If successful, it will help shed light on such problems as determination of protein structure, which remains an unsolved problem with profound implications to our understanding of protein function. Our work on single spin detection is a crucial milestone along the way to three-dimensional imaging of single molecules."

Budakian earned his bachelor's, master's, and PhD degrees in physics from the University of California, Los Angeles. From 2002 to 2005, he was a visiting scientist at the IBM Almaden Research Center in San Jose, California, where he was part of a team that first imaged the spin of a single defect in glass.

At Illinois, Budakian is developing ultra-sensitive spin detection techniques for single spin imaging and quantum readout. Current areas of research include designing and fabricating micro-machined silicon cantilevers for sub-attonewton force detection, devising spin detection/manipulation protocols that enable force detection at the thermal limit, imaging single dopants and defects in semiconductors, using active feedback to achieve spin control, and combining MRFM with electron nuclear double resonance (ENDOR) for high-sensitivity nuclear spin detection. ■

Raffi Budakian

DeMarco Receives Sloan Fellowship



Brian DeMarco

Assistant Professor of Physics Brian DeMarco was one of 20 young physicists in the United States and Canada to receive a 2006 Alfred P. Sloan Research Fellowship. DeMarco is an AMO experimentalist who is interested in quantum information science and atomic Bose–Einstein condensates and Fermi gases. His current research is focused on achieving a workable "quantum simulator," which uses a quantum system over which precise and microscopic manipulation is possible to simulate efficiently many-body quantum mechanics—the initial motivation behind the quantum computer that was proposed by Feynman, Benioff, and others in the 1980s.

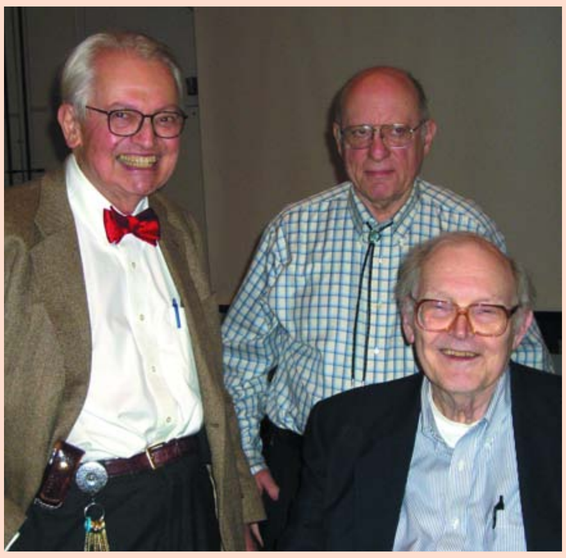
DeMarco plans to utilize ultra-cold neutral atoms trapped in an optical lattice to achieve quantum simulation. In optical lattice experiments, atoms are confined by the optical dipole force in the potential wells formed from the spatial interference pattern of intersecting laser beams. According to DeMarco, "Ultra-cold atoms trapped in optical lattices have fantastic promise for quantum information processing, because millions of atoms having long internal-state coherence times can be precisely manipulated in parallel."

The first step in the quest to build a quantum simulator was reached by DeMarco's group in August 2005, when they successfully created a Bose–Einstein condensate of ^{87}Rb atoms. They are now working on developing the optics and laser systems required to create an optical lattice.

The Sloan Research Fellowships were established in 1955. They are intended to enhance the careers of the very best young faculty members in specified fields of science. Currently about 100 grants are awarded annually in seven fields: chemistry, physics, mathematics, computer science, economics, neuroscience, and computational and evolutionary molecular biology. ■

Second Annual Slichter Colloquium

Nigel D. Goldenfeld



On March 30, the second Slichter Colloquium was held in Physics. Michael Tinkham, Rumford Professor of Physics and Gordon McKay Professor of Applied Physics at Harvard University, spoke on "50 Years of Superconductivity." Shown here with Tinkham (right) are Charles Slichter and Donald M. Ginsberg, who was Tinkham's thesis student.

The Science of Stability: Research Reveals Insight into Stability of Thin Films

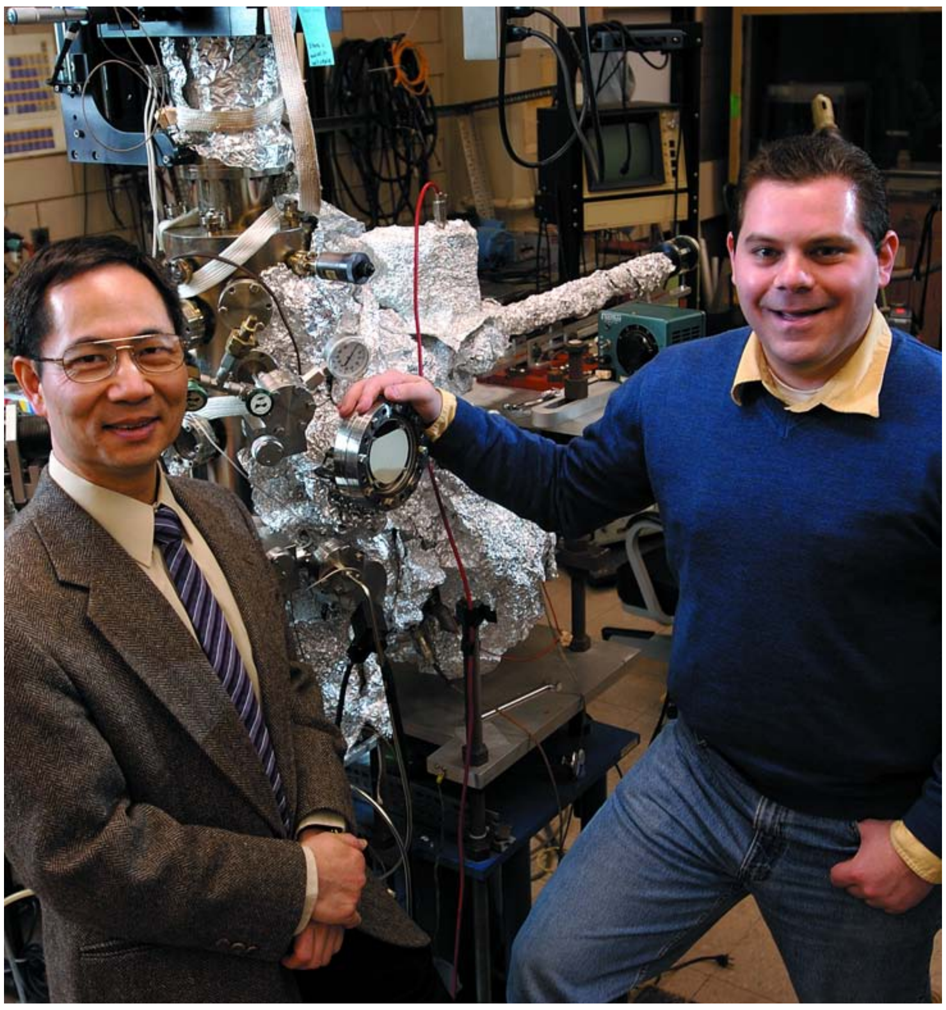
BY JOHN MORGAN, SCIENCE WRITER—THE SYNCHROTRON RADIATION CENTER, UNIVERSITY OF WISCONSIN

Just as every snowflake is different from any other, an individual snowball exhibits exceptionally different properties from the thousands of snowflakes that make it up. A group led by Dr. Tai-Chang Chiang studies how thin films of materials—such as lead films deposited on silicon—exhibit different traits from those of their more massive cousins. Most recently, the researchers have found that it is possible to turn unstable films into stable ones.

"Our results demonstrate that unstable film thicknesses can be turned into stable ones. This capability is important for developing strategies for device applications," wrote Chiang and his colleagues (D.A. Ricci, T. Miller, and T.-C. Chiang, *Phys. Rev. Letters* **95**, 266101 [2005]). The work was also summarized recently as a research highlight in the journal *Nature* (12 January 2006).

"In the present work, we compare the stability properties of Pb films deposited on Pb-, In-, and Au-terminated Si surfaces," explains Chiang. The research reveals that while odd-numbered layers of thin films are normally less stable than even-numbered ones, when an intervening layer of indium atoms is put between lead and silicon, the odd-numbered films become more stable.

"In our research at the Synchrotron Radiation Center (SRC) at the University of Wisconsin, where the research was conducted, we measure the electronic structure of films. Essentially all physical properties of materials are determined by their electronic structure. Due to quantum confinement and boundary effects, thin film electronic structure can be very different from the bulk counterpart, and likewise the properties can be substantially different and possibly useful," Chiang explains.



Tai-Chang Chiang and Dominic Ricci (PhD '06)

Indeed, it's this ability to reduce materials down to a few atoms of thickness—along with making the films as smooth as possible—that is the group's goal. "In some ways what we're trying to get is the simplest possible sample," explains Dr. Tom Miller, a member of the research team and a resident scientist at SRC. "So in a way we're trying to get the most boring sample possible!"

Yet for several years the group's progress has been anything but boring. In fact, Chiang and his colleagues have been exceptionally successful; while the work is deeply rooted in the fundamental exploration of physical properties, there are many exciting practical benefits to this research.

"Our work on atomically uniform films provides a fundamental understanding of the relationship between structure and properties based on quantum physics. Ultrathin films are important components for devices, now and in the future," says Chiang. "Our work on quantum well states began in the 1980s (at the SRC). The first report of quantum well states as observed by angle-resolved photoemission appeared in 1986. My group discovered in 1998 that atomically uniform films of Ag can be prepared on Fe. In 2004, we reported that atomically uniform films of Pb and Ag can be prepared on Si and Ge, the most important electronic substrate materials. The work has potential for great impact on future electronic devices." ■

New APS Fellows

The American Physical Society announced in December 2005 that Physics faculty James N. Eckstein and Taekjip Ha, along with two distinguished alumni, had been selected as 2006 APS Fellows in recognition of their pioneering contributions to physics.

James N. Eckstein, professor of physics, *for development of layer-by-layer growth of oxide films for fundamental studies and for planar tunneling junctions made from oxide superconductors and oxide magnets* (Materials Physics)

Taekjip Ha, associate professor of physics and Howard Hughes Medical Institute Investigator, *for innovative work in the determination of nucleic acids' structure and dynamics using single molecule fluorescence resonance energy transfer* (Biological Physics)

Alan David Bross (MS '74, PhD '77), staff scientist, Fermilab, *for his pioneering efforts in developing the D0 fiber tracking detector* (Particles & Fields)

Eric Lawrence Shirley (MS '88, PhD '91), staff physicist, Physics Laboratory, NIST, *for important contributions to the computation of the optical properties of solids from the infrared to the x-ray spectral regions* (Condensed Matter Physics)

CONGRATULATIONS!

James N. Eckstein

Taekjip Ha

Department News

Vijay R. Pandharipande, 1940–2006

Vijay R. Pandharipande, Donald B. and Elizabeth M. Willett Professor in Physics, died on January 3, 2006, in Boston, Massachusetts, after a long battle with cancer. A memorial service was held at the Beckman Institute in Urbana on January 15.

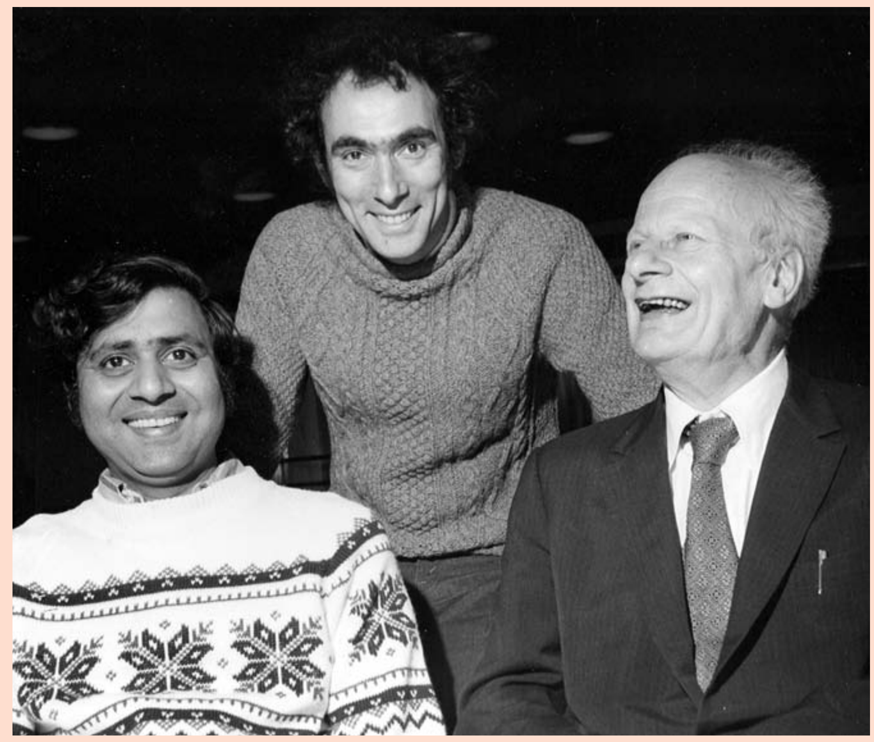
Professor Pandharipande was born on August 7, 1940, in Nagpur, India, the son of Raghunath and Kamal Pandharipande (née Brahma). He married Rajeshwari Sinha in 1966; she survives. Also surviving are his son Rahul Pandharipande of Princeton, New Jersey, daughter Pari Pandharipande of Boston, Massachusetts, grandson Dhruva Schlondorff of Boston, Massachusetts, and his sister Kalpana White of Waltham, Massachusetts. He was preceded in death by his parents and his brother.

Professor Pandharipande studied at the College of Science, Nagpur, India, and received a bachelor of science degree in physics, mathematics, and applied mathematics, and a master of science degree in physics from Nagpur University, Nagpur, India, in 1959 and 1961 respectively. Upon graduation, he joined the Tata Institute of Fundamental Research, Bombay, India, where he simultaneously began work towards a doctorate in physics, which was awarded by the University of Bombay in 1969. After postdoctoral fellowships at the Niels Bohr Institute, Copenhagen, and Cornell University, he came to the Department of Physics at the University of Illinois as a research associate in 1972 and was appointed to the faculty as an assistant professor in 1973. He was promoted to associate professor in 1974 and to full professor in 1977.

A member of the board of directors of the European Center for Theoretical Nuclear Physics, Professor Pandharipande also held a visiting faculty appointment at Argonne National Laboratory from 1983 until his death.

An internationally recognized nuclear theorist, Professor Pandharipande played a leading role in the development of the nuclear many-body problem. His contributions led to a state-of-the-art comprehensive, quantitative, and reliable theory of nuclei, neutron matter, and neutron stars, and were extended more generally to quantum liquids. His theoretical contributions set the agenda for experimental work, significantly advancing the use of electron scattering as a probe of nuclear structure. Working with his graduate students and collaborators, he initiated and carried out over several decades a successful research program to describe all nuclear systems in terms of the elementary two- and three-body interactions of the constituent nucleons. His pioneering variational Monte Carlo calculations have become the standard methods for the field.

In addition to his nuclear studies, Professor Pandharipande applied his expertise to condensed matter physics, where his research included Bose and Fermi helium liquids and drops, including structure, response, and elementary excitations. Most notably, he predicted structures subsequently observed in the dynamic response of Bose superfluid helium and demonstrated the important effects of the enhancement of the effective mass at the Fermi surface of Fermi liquid helium.

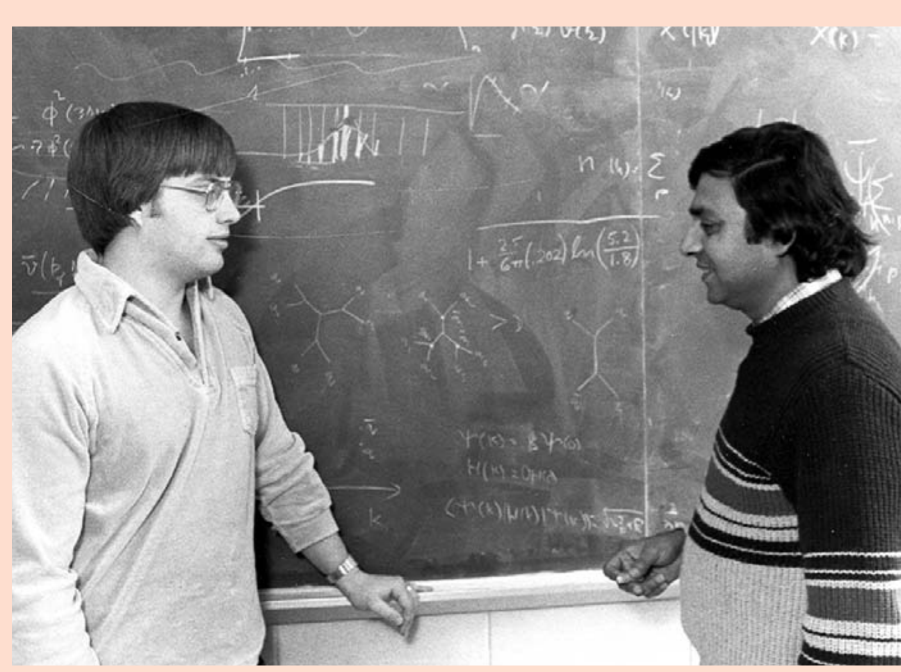


Vijay Pandharipande with his lifelong friends and collaborators, Gordon Baym and Hans Bethe (April 28, 1977, in Urbana)

Professor Pandharipande was a life member of the Indian Physical Society, a Fellow of the American Physical Society, and a permanent member of the University of Illinois' Center for Advanced Study. He served as a member of the editorial board of *Physical Review C,* American Physical Society, 1991–1994, and a member of the editorial board of the *Journal of Physics G: Nuclear and Particle Physics,* Institute of Physics (UK). He also served as an editor for *Nuclear Physics and Computer Physics Communications,* North Holland.

In recognition of his fundamental contributions to determining the structure of light nuclei by solving the Schrödinger problem with more than three nucleons using realistic nucleon-nucleon interactions supplemented by three-body forces, Professor Pandharipande was awarded the prestigious Tom W. Bonner prize of the American Physical Society in 1999.

Among those who knew him well, Professor Pandharipande will be remembered most for two things, his devotion to his family and his dedication to his students. His daughter Pari wrote of him, "His style of gardening, a favorite hobby of his, best exemplifies his manner—he planted and nurtured flowers with striking attention to their growth, but without fences or boundaries. From early spring to late fall, he loved to watch each variety thrive in its moment." ■



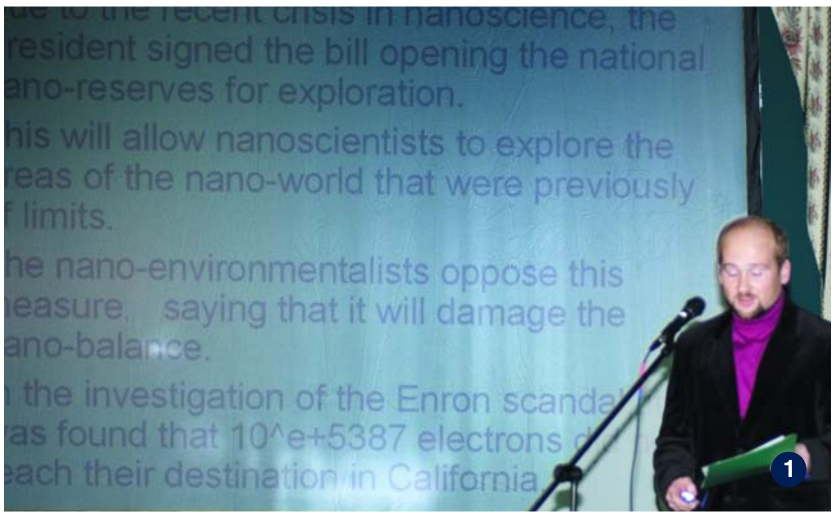
Vijay doing what he loved—talking physics with one of his students (Joe Carlson, MS '79, PhD '83)

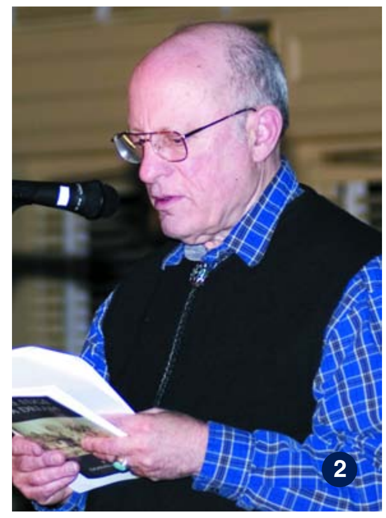
Special Symposium

A special symposium will be held in Urbana on **September 29–30, 2006,** to honor the life and celebrate the scientific achievements of Vijay R. Pandharipande.

For further information, email cmelliot@uiuc.edu.

Physical Revue 2005: *Refuse of Modern Physics*





1. *PR veteran Igor Roshchin*
2. *Donald Ginsberg, the poet laureate of Physics*
3. *Good advice from "So Now You're a TA" instructional movie*
4. *Mike Stone "gets his groove on" in "Hollywood Freaks"*
5. *The WLLP "sports" wrap-up*

The worst snowstorm of the season did not deter the standing-room-only crowd for the 2005 Physical Revue, *Refuse of Modern Physics.* Graduate student Paras Naik was the laid-back, gold-chain-bedecked, hip-hoppin' emcee for the show, which featured a WLLP news broadcast, some stuff played on guitar (Soren Flexner), and poetry by Donald "Everyone takes my vital signs/But still I have some left" Ginsberg.

The world-renowned PR veteran, Igor Roshchin, who "speaks Russian with a strong English accent," returned from balmy San Diego to deliver "Son of the Revenge of the Return of Igor." The presentation featured news of the world, including the President's controversial decision to address the crisis in nanoscience by allowing exploration in the national nanoscience reserves, much to the dismay of the nano-environmentalists.

Eugene "The TA" Torigoe offered insights from his 11 semesters of teaching, including how physics students could avoid dirty looks from the MRL denizens when gate-crashing their coffee hour. The Dan Vandervelde Experience (Dan Vandervelde and Rob Dinsmore) expanded on the theme with a vintage movie, modeled after 1950s instructional films, "So Now You're a TA." Unlike the Hollywood blockbusters it emulated, the entire movie was brainstormed on Sunday, written and filmed Monday through Wednesday, and touched up and rendered Thursday afternoon, before its premiere Thursday night. A low-resolution version of the movie is online at *https://netfiles.uiuc.edu/rdinsmor/shared/sonowyoureata.wmv* for those who missed it the first time.

Quite fittingly, this year's PR was physical as well as cerebral. James Reed, 1st Dahn, introduced the audience to *Kuk Sool Won,* a traditional Korean martial art that involves highly acrobatic jumps and flips while brandishing an enormous sword. *Los Loomiseros* entertained the crowd with lively and polished salsa dancing.

In a break with recent tradition, only one band performed. The Perturbations (graduate students Paco Jain, Paras Naik, John Gergley, and Andrew Missel) brought down the house with "Doctorate," "Superfluid," and "Stuck in Urbana." In keeping with tradition, "Hollywood Freaks," an animated feature by Eric White, poked fun at the faculty.

A new feature this year was Phantasy Physics—sets of trading cards featuring the all-time greats in physics. The audience was encouraged to trade cards, and prizes were awarded to the person assembling the collection of the rarest cards (Albert Einstein, Richard Feynman, John Bardeen, and Soren Flexner), the most complete set, and the most cards of the same physicist. Mike Weissman won the grand prize, a new toy Yoda (not a new Toyota, much to his chagrin).

The only disappointment of the rollicking evening was the non-appearance of any faculty acts (with the exception of Professor Ginsberg's traditional poetry reading). It is uncertain whether the faculty has simply given up, after having been upstaged by the graduate students year after year, or if they are merely working up to something spectacular for 2006. This critic hopes it's the latter. ▪

"Intersections" Conference Tradition Continues

The ninth Conference on the Intersections of Particle and Nuclear Physics (CIPANP 2006) again offered the opportunity for discussion and collaboration in areas where the two subfields intersect. In addition, this year's meeting of the triennial event featured workshop activities for young scientists. Rio Grande, Puerto Rico, was the setting for the conference from May 30 to June 3.

The conference program of 20 plenary talks provided comprehensive and pedagogical overviews, plus 10 parallel strands explored topics in depth – all spanning the range from hot dense nuclei to cold dark matter; from deep-inelastic scattering to hadron spectroscopy; from tests of the standard model to consequences of the solar model. Abstracts are on the conference web site at *http://cipanp.physics.uiuc.edu*

"Because nuclear and particle physics are closely related, both fields benefit from discussion and collaboration on joint projects, similar techniques, different perspectives on the same physics, and other manners of overlap," said Conference Chair David W. Hertzog, one of six University of Illinois physics department faculty who organized the conference.

Thanks to financial support from Brookhaven National Laboratory, Fermilab, Jefferson Lab, Berkeley Lab, Los Alamos National Laboratory, the National Science Foundation, the U of I Physics Department, and University Research Associates, students and postdocs were able to participate in the conference for a reduced registration fee. In addition, a unique short course on physics communications skills offered young scientists expert counsel on the preparation of talks, papers, figures, and proposals, and a technical editor was available to offer writing critiques and practical, one-on-one advice to the participants throughout the conference.

Hertzog was joined in conference planning efforts by professors Douglas Beck and Jen-Chieh Peng of the nuclear physics group and Tony Liss, Mats Selen, and Scott Willenbrock of the high-energy physics group. Significant contributions were also made by Physics staff and students. ▪

Detailed information about the conference, including the list of plenary speakers and abstracts, is available at http://cipanp.physics.uiuc.edu.

Student News

Walsh Helps Electrify Village in India

Walsh drilling support beams for the solar dryer. On the right is one of the group's volunteer translators from the Jagannath Institute for Technology and Management.

Illinois' Engineers Without Borders *with villagers and members of the local partner organization* Gana Chetana.

Walsh with the completed generator; his right arm is resting on the vegetable oil tank. Note the two fuel tanks—the engine starts on conventional diesel fuel to warm up the cylinder for one minute, and then a valve switches over to the vegetable oil fuel.

Physics undergraduate T. Patrick Walsh, a junior from Riverside, Illinois, and a member of the UI student chapter of Engineers without Borders (EWB-UIUC), spent the summer of 2005 bringing electricity and hope to rural India. Here is the story of how bright, energetic, dedicated UI students changed the life of a village.

Last May, six EWB members—Walsh, Ben Barnes and Brian Haman, mechanical engineering; Sean Poust and Maren Somers, civil engineering; and Stephanie Bogle, materials science and engineering—journeyed to Badakamandra, Orissa, India, to build a biofuel electrification system. Unlike "biodiesel," which refers to chemically refined oils, the students' project involved "biofuel." They inexpensively modified a commercial diesel engine, not the fuel (which would have required complex and expensive chemical refining), so that it could be run on cheap, abundant local vegetable oil.

The project was an ambitious one that addressed a variety of the villagers' needs: enable the use of new fuels (vegetable oil and oil cake), produce electricity, provide additional income for villagers by introducing mechanical spice-grinding equipment, and stimulate internal village governance. Completely on their own, the students managed to find their way to a village in the middle of nowhere and undertook a project for which there was no instruction book, no precedence, and no higher authority.

After arriving in India, the students purchased an off-the-shelf 7.5-kW diesel generator and modified it to cleanly burn filtered vegetable oil. Several varieties of oil-seed-bearing trees grow plentifully in India's tropical climate, within easy reach of tens of thousands of unelectrified rural villages. By demonstrating the use of this vegetable oil, the students gave predominantly unemployed villagers the chance to produce a substitute for diesel fuel, a liter of which costs the daily wage of many laborers.

The EWB students brought basic tools and parts needed for the engine modification from the US, purchasing the rest of the equipment in Orissa. The modification involved the addition of a filtering system and an inline fuel heater to reduce the vegetable oil's viscosity.

The group had to work through continual frustrations—no building to house the generator, low-lying land subject to flooding, few or no translators, gender-related difficulties with the village organizing committee, and scorching hot temperatures. Two members of the group, Walsh and Somers, who extended their stay by four weeks to complete the project, spent their last days in India in the hospital, felled by food poisoning and a parasite, hooked up to IVs for fluid replacement.

During the course of the project, the students converted the diesel generator to run on vegetable oil, built a building to house it, constructed a solar dryer for the oil seeds, and installed a 5-hp oil expeller, a 3-hp mechanical spice grinder, and a 2-hp rice huller. They worked side-by-side with the villagers as they struggled with organizational issues and decision-making.

When Somers and Walsh finally left on July 2, the modified generator was running on vegetable oil and powering electric lighting for the project building. The students received help with the electrical system from an Australian electrician working with AID.

"By the time we left, the infrastructure for the project was completed to the point that the system could be finished by the villagers, with assistance from the associated NGOs: AID-Orissa and Gana Chetana," Somers reported. The two organizations have formed a coalition to act as stewards of the project for the future.

About the Orissa Project

The UI chapter of Engineers Without Borders (EWB-UIUC) began the biofuel electrification project in January 2004, with the objective of aiding agricultural villages cut off from India's power grid. The group, with a committee of about 20 graduate and undergraduate students, applied to work on the project, which was originally presented to Engineers Without Borders–USA in an application submitted by the Association for India's Development (AID-Orissa). The project was intended to serve as a model for practical, scalable energy sources for similar areas in central Asia.

In May 2004, a small team of five UI students undertook a 10-day site survey of the target villages and met with other engineers at the Kalinga Institute of Industrial Technology. The fall semester of 2004 was spent corresponding with their Indian collaborators, fundraising, and researching and designing their project, taking into account the economic constraints and needs of the community. With research and prototyping in the US included, the cost of the project was approximately $16,000 (not including the students' travel expenses).

The students received $6,000 from the College of Engineering Design Council to get the project off the ground. The International Programs in Engineering office, which is funded primarily through alumni donations, also provided fellowships to the students to pay for 80 percent of their airfare. Without the College of Engineering's initial financial support, the entire project would have been hopelessly delayed.

At the end of May 2005, Malia Appleford and Maren Somers represented EWB-UIUC at a special conference where they received, on behalf of their fellow volunteers, the DaimlerChrysler/UNESCO "Mondialogo Engineering Award." A copy of their presentation about the project is available at www.physics.uiuc.edu/alumni/Biofuel.pdf.

EWB-UIUC Today

The Illinois EWB continues its involvement with the village in Orissa and is looking into water-related needs in the village, as well as an expansion of the biofuel concept to surrounding areas. The organization has also been working on two other research projects: improved woodstove technology to conserve wood and improve indoor air quality and the design of power electronics needed to efficiently generate electricity by wind- and bicycle-power in Maharashtra, India.

In addition to the India projects, EWB-UIUC has recently taken on a project in Enugu State, Nigeria. Currently, the 10,000 inhabitants of Andu Achi Town in Enugu State must walk 3 km to their only water source, a stagnant, dirty stream. Illinois students are investigating a variety of alternative solutions, including a bore well, rainwater collection, and stream-water treatment. ■

About Patrick Walsh

T. Patrick Walsh (third from right) in Badakamandra

Patrick Walsh is a junior, working on a double major in engineering physics and economics. He originally decided to study physics out of philosophical curiosity. "I always figured that searching for enlightenment through physics was more of a symbolic gesture than a practical one, but I like physics. Lately I've been looking towards less theoretical and more human-oriented applications, so it's nice to have the 'engineering' already in my degree.

"I'm interested in the production of energy because its scarcity seems to be the root cause of a lot of the world's strife and suffering. That's how I got interested in the biofuel project, and the understanding of basic physics I got here at school helped me to grasp the overall challenges in ways that the more specialized engineers at our level weren't as able to, so it was a great fit."

His experience in India taught Walsh that the problem of energy production and distribution in the developing world must be addressed in a much bigger way. "I'm now interested, first, in long-term development of technologies that will increase global energy production by orders of magnitude, and second, in short-term development of technologies that will directly benefit the world's poor."

Walsh has gotten involved this semester in a fusion energy research project in the Department of Nuclear, Radiological, and Plasma Engineering, and he'll be working on a plasma gun experiment for his senior thesis in Physics.

He is also trying to organize a project to raise some investment capital to mass produce solar-charged, battery-operated LED lanterns to replace some of the >1 billion inefficient kerosene lamps used now in the developing world. He just wrote a proposal to the US Environmental Protection Agency for seed-funding for the project.

Walsh says he's "up in the air" on future plans. "I know I'll have to pick something to concentrate on soon, and make a decision about grad school and such. I don't know if I want to do research or work on policy issues or some combination of the two; I'm looking for advice!"

If you have career advice to offer, contact the editor at cmelliot@uiuc.edu. ■

Ramsey at AAS

Physics undergraduate Caitlin Ramsey was the center of attention on January 9, when NASA Administrator Michael Griffin stopped by to chat about her poster, "An Optical Study of Stellar and Interstellar Environments of Seven Luminous and Ultraluminous X-ray Sources," at the American Astronomical Society annual meeting in Washington DC.

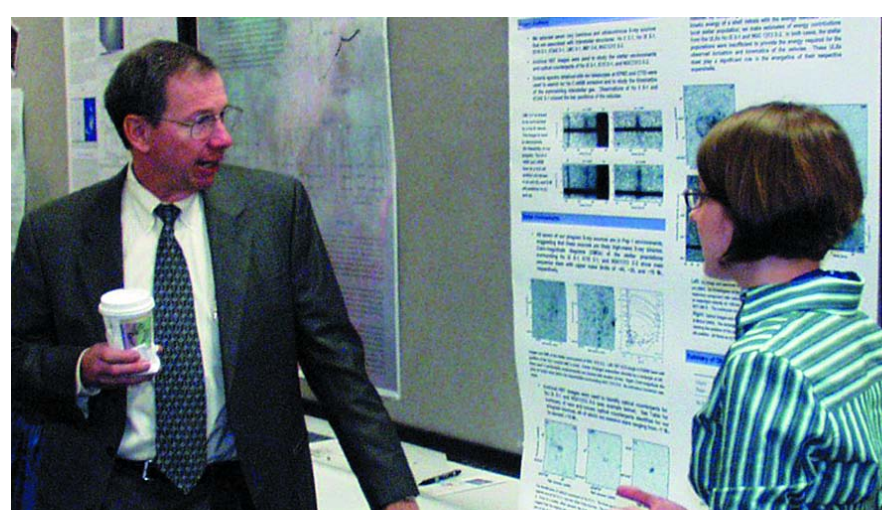
Ramsey, a junior from Rochester, Illinois, attended the meeting with You-Hua Chu, professor of astronomy at Illinois, who supervised her undergraduate research project. Caitlin used archival Hubble Space Telescope images to identify the optical counterparts of the ultraluminous x-ray sources (ULXs) Ho IX X-1 and NGC 1313 X-2 and made photometric measurements of the local stellar populations of these and the luminous source IC 10 X-1 (C.J. Ramsey, et al., "An Optical Study of Stellar and Interstellar Environments of Seven Luminous and Ultraluminous X-Ray Sources," *Astrophys. J.* **641**, 241-251 [2006]).

A highlight of the conference for Ramsey was a talk given by Vera Rubin about the early years of her career in astronomy in the 1950s, and her instrumental role in the discovery of dark matter. Ramsey herself was raised on Carl Sagan's *Cosmos* series and became more seriously interested in physics and astronomy when, at age 11, she audited an undergraduate course at Sangamon State University (now University of Illinois, Springfield) with Professor of Astronomy and Physics Charles Schweighauser.

Ramsey is preparing for a senior thesis project this summer with S. Lance Cooper, a condensed matter experimentalist. Her future plans are to pursue a PhD in biophysics and biomedical engineering.

About her trip to AAS, Ramsey noted, "A number of professors and students from other universities, as well as independent astronomers, were interested in my poster, and I am glad that I was able to answer a lot of questions that morning. This was a good opportunity to learn about the work that others were doing in x-ray astronomy and with ULXs." ■

[Eds. note: Funding for Caitlin's attendance at the AAS meeting was provided by the Department of Physics' Excellence in Physics endowment. If you would like to contribute to the fund, so that we can continue to support worthy student activities, please see www.physics.uiuc.edu/support/excellence.html.]



AAS photo by Kelley Knight, © 2006 American Astronomical Society

NASA Administrator Michael Griffin talks with Caitlin Ramsey at the AAS meeting in January

Physics Website Gets New Look

The department has recently undertaken a complete overhaul of its 18-GB, >16,000-page website, giving it a fresh new look.

"People have been asking me, 'Why change?'" said Celia Elliott, department webmaster. "While the old site was content rich and straightforward to navigate, the look was very dated and did not, I believe, reflect the stature of the department. The site was also getting harder and harder to maintain as it grew—each page was hard-coded HTML. If we wanted to change something in the footer, we had to make the change 16,000 times, one page at a time. The old pages also relied on tables for layout, which are not accessible to anyone having a visual impairment who relies on a screen reader.

"Thus, we had three major design goals: get a more up-to-date look, meet or exceed federal accessibility guidelines, and switch to cascading style sheets (css) for easier maintenance. Unfortunately, doing any of these things was far beyond my abilities," Elliott added, "but we got wonderful help from the University's Office of Creative Services and their web designer, Valerie Lohmann. Val was able to take my vision and translate it into a beautiful design and idiot-proof css templates that I was able to use."

The project has not been without its setbacks. "Oh, it's like any other do-it-yourself project I've ever undertaken," Elliott laughed. "It took ten times longer than I expected, cost twice as much, and pushed me *waaaaay* beyond the limits of what I could do competently. Fortunately, I got great support from Val and people here in the department, particularly Gabe Gibson, Becky McDuffee, Mark Tomory, and Johnetta Wilde. We'd still be looking at the old pages if it hadn't been for them."

Plans for the future? "Before we do this again, I'm going to be the *former* webmaster," said Elliott. Check out the new look at *www.physics.uiuc.edu.* ■

Alumni News

Yildiz Wins International Prize

colleaphoto.com

Alan I. Leshner, chief executive officer of AAAS and executive publisher of Science *(left) and new AAAS President Gilbert S. Omenn (right) congratulate alumnus Ahmet Yildez (PhD '04).*

For his discovery of how proteins move within cells, Ahmet Yildiz (PhD '04), won the 2006 Young Scientist Award, supported by GE Healthcare and the journal *Science*. He received the $25,000 award in February during the 2006 Annual Meeting of the American Association for the Advancement of Science (AAAS), the world's largest general scientific society, which publishes *Science*. His wife, Hatice Yildiz, Paul Selvin, his thesis adviser, and Physics Head Jeremiah Sullivan attended the ceremony.

Selvin explained the significance of Yildiz's work. "First, Ahmet has improved single molecule fluorescence by developing a technique that can locate the position of a single dye to within 1.5 nm, which is 20 times better than has previously been achieved and 200 times better than the classical diffraction limit of light," said Selvin. "Ahmet then applied this technique to measure how myosin V, a biomolecular motor involved in intracellular transport, moves."

While working in the Selvin group, Yildiz developed the technique of fluorescence imaging with one-nanometer accuracy (FIONA). This work was recognized with a Foresight Institute Distinguished Student Award in 2003. He went on to use FIONA to study the molecular walking mechanism of the motor proteins myosin V, myosin VI, and kinesin. Yildiz's 2004 thesis was awarded the Gregorio Weber International Prize in Biological Fluorescence.

In 2005, Yildiz moved to the University of California, San Francisco, where he is a postdoctoral fellow in the research laboratory of Ronald Vale. He is currently studying the structural mechanism of cytoplasmic dynein.

A native of Sakarya, Turkey, Yildiz received a bachelor's degree in physics from Bogazici University, Istanbul in 2001, and later that year started his graduate studies in biophysics at the University of Illinois.

Yildiz's winning essay is posted at www.sciencemag.org. ▪

Alumna Cynthia Chiang (BS '02), a graduate student in the Observational Cosmology Group at Caltech, spent December 2005–February 2006 at the geographical South Pole installing the Background Imaging of Cosmic Extragalactic Polarization (BICEP), her thesis experiment. BICEP is designed to measure the polarization of the cosmic microwave background to unprecedented precision, and in turn to answer crucial questions about the beginnings of the Universe. It will operate at 100 GHz and 150 GHz at angular resolutions of 1.0° and 0.7°, respectively, with an array of 96 polarization-sensitive detectors, mapping a large region of the sky around the South Celestial Pole.

Magnetism Coexists with Superconducting Electron Partners

At absolute zero, unconventional superconductivity, formed by electron pairs dancing at the surface of an electron sea, hides a background of antiferromagnetism. Lifting the veil by applying a magnetic field reveals magnetism coexisting with superconducting electron partners. (Illustration by Shirley Veenis)

When water crystallizes into ice, H_2O molecules are either in a liquid state or in a solid crystalline state—or a mixture of the two—depending on temperature and pressure. Researchers at Illinois and at Los Alamos National Laboratory, in studies of the heavy fermion superconductor $CeRhIn_5$, have demonstrated that its magnetic state can coexist with another state—superconductivity—in a certain range of temperature and pressure.

In a letter published in the March 2 edition of *Nature* (T. Park et al., *Nature* **440,** 65–68 [2006]), the researchers describe their discovery—that the magnetism is merely hidden by unconventional superconductivity but can be made to reappear in the presence of an applied magnetic field.

"Hidden broken symmetries and quantum-phase transitions underlie theoretical models of how Nature is organized, ranging from the fabric of the cosmos to the most fundamental components of elementary particles," said Physics alumnus Tuson Park (PhD '03), the letter's lead author. "$CeRhIn_5$ has provided a bench-top example in which the presence of a hidden broken symmetry is revealed, as well as its relationship to phase transitions controlled by quantum fluctuations. These discoveries, though specific to condensed matter, underpin broadly applicable concepts common to diverse classes of quantum problems."

The point at which magnetism becomes hidden actually lies on a line of quantum critical points separating a purely unconventional superconducting phase from a phase of coexisting magnetism and unconventional superconductivity. Such behavior can be explained quantitatively by a theory developed explicitly in the context of the high-T_C cuprates, but which has been impossible to test so definitively in the cuprates. These discoveries provide an entirely new framework that unifies the relationship among magnetism, unconventional superconductivity, and quantum criticality in cuprate and heavy-fermion systems.

This work is one in a series of ongoing collaborations between Myron Salamon's group at Illinois and the Condensed Matter and Thermal Physics Group at Los Alamos. Park, for whom Salamon was thesis adviser, is now an Oppenheimer Postdoctoral Fellow at Los Alamos. ▪

This work was supported by the National Science Foundation, the Institute for Complex Adaptive Matter, and the Office of Basic Energy Sciences in the U.S. Department of Energy Office of Science.

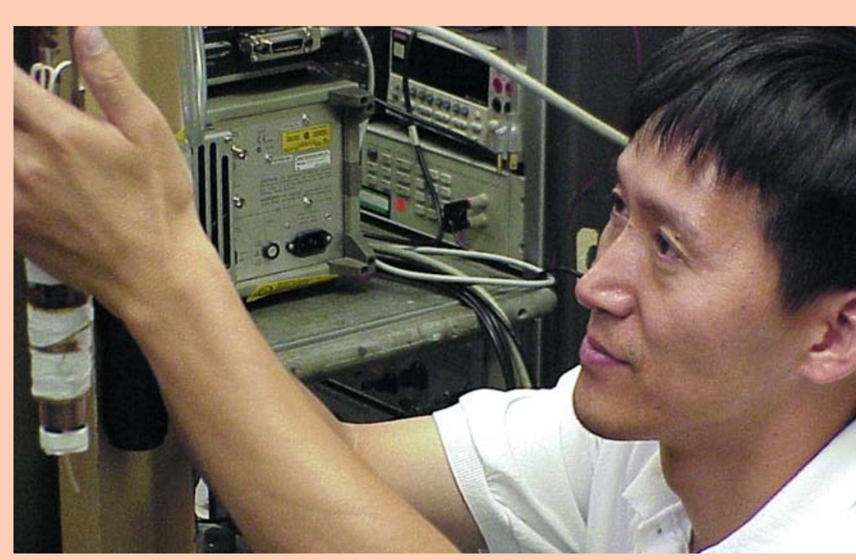


Photo courtesy Vladimir Sidorov

Tuson Park (PhD '03), J.R. Oppenheimer Postdoctoral Fellow at LANL, is preparing a high-pressure study on strongly correlated electron systems.

Redfield Wins 2006 APS Biological Physics Prize

Alfred G. Redfield (MS ’52 PhD ’53), professor emeritus of biochemistry and physics at Brandeis University, received the 2006 APS Biological Physics Prize “for his seminal contributions to the theory and technical development of nuclear magnetic resonance spectroscopy, and for pioneering applications of this technique to the study of biological molecules.”

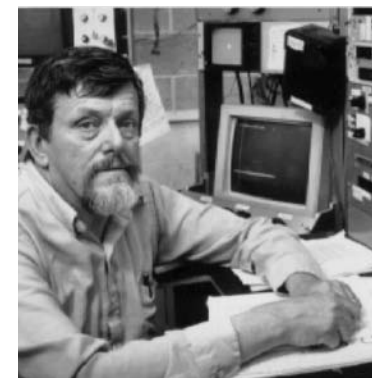
Redfield received a BA from Harvard in 1950, and a PhD from the University of Illinois in 1953; his thesis adviser was Robert J. Maurer. He was a postdoctoral researcher with Nicolaas Bloembergen at Harvard, where he published his first NMR papers on spin thermodynamics in the rotating frame and on perturbation theory of relaxation. He joined the IBM Watson Laboratory at Columbia University in 1955, where he used field-cycling NMR, including extension of the seminal NMR relaxation result of Hebel and Slichter to low temperatures, to study normal and superconducting metals and the structure of the type-II fluxoid lattice. In 1969, he shifted to work on biological NMR with Raj Gupta, starting with the first NMR observation of intra-protein electron transfer in cytochrome C. He joined the Brandeis Departments of Physics and of Biochemistry in 1972, where his early work included demonstration and utilization of pulsed FT NMR using soft and composite pulses in, especially, transfer RNA. Later his group worked on NMR studies of the Ras protein.

Most recently, during semi-retirement, Redfield has developed another field-cycling device to move a sample from its usual position at the center of the magnet in a commercial 11.7-T NMR instrument out to a lower-field position above the magnet, and back, with a minimum round-trip time of 200–300 ms and a field as low as 50 G. The device allows investigators to insert a low-field interval into any pulse sequence, which can be used to study relaxation or cross-polarization rates at the lower field. With Professor Mary Roberts of Boston College, Redfield has published articles demonstrating the utility of this device for studying dynamics of a DNA fragment and the geometry and dynamics of polar head groups in phospholipid membranes. Many further applications of this device for the study of, for example, protein dynamics and structure can be expected.

Redfield is a member of the National Academy of Sciences and a fellow of the American Academy of Arts and Sciences. He received the 1995 ISMAR Prize from the International Society of Magnetic Resonance, and he was a Miller visiting professor at the Illinois Physics Department in 1963. ■

Redfield remembers…

By A.G. Redfield



Alfred Redfield with his apparatus at Harvard, during the second year of his postdoc with Bloembergen. The slanted chassis is the rf spectrometer that he built. The Varian magnet in the background was brand new, but his original work used a permanent magnet that was probably built by Purcell’s group.

I was recruited to go to Illinois for my graduate work by Charlie Slichter, with whom I had worked in Woods Hole during school vacations, in a wartime lab there doing electronics. In 1949, he was leaving with his Harvard PhD for Urbana, and I was a junior at Harvard. He made sure to tell me about the arrival of Fred Seitz, and the other interesting things at Illinois, and I decided that it would be good for me to get out of the northeast coast of the country and see the world.

While I was working at Illinois for Bob Maurer, I got the idea for observing the Hall effect in photoconducting insulators, and got it to work in diamond and alkali halides. I shared a lab with Dave Dutton (MS ’49, PhD ’53) and Ken Teegarden (MS ’51, PhD ’54), which was right next to John Bardeen’s office; every day we would be inspired by the sight of him reading the newspaper. I finally got up the courage to show him my results on diamond, which approximated the $T^{-3/2}$ dependence as predicted. His first question was, “electrons or holes?” Blast it, I had no idea and retreated in embarrassment to look at my lab notes.

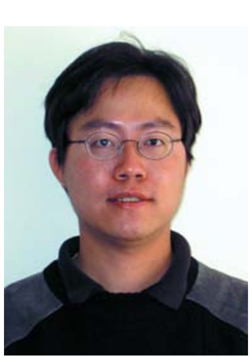
To do the Hall effect, I needed a high magnetic field but not a good one, and I negotiated a space in Slichter’s lab in the lower edge of a magnet built by Dick Norberg (AM ’47, PhD ’51) and previously used by Don Holcomb (MS ’50, PhD ’54). So I spent a lot of time near people doing NMR and was in the same lab as Tom Carver (PhD ’54) during his historic observation of the Overhauser effect. For this and other reasons I learned that you don’t need a big magnet to do NMR.

When I started my postdoc at Harvard, I was somewhat surprised to find that Harvard was no better than Illinois in most ways. For some strange reason I had decided to do a theory postdoc, but fortunately my intended theory mentor was too busy and I was politely invited to join the group of a new professor at Harvard, Nico Bloembergen. Finally, I landed accidentally in a lab working in a field where I soon did the best work of my life, after passing up the possibility to do the same thing in Illinois.

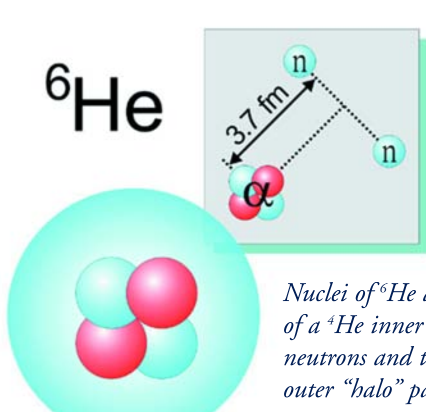
I had not realized how interesting magnetic resonance was, nor how outstanding both Slichter and Bloembergen were. The work I did in my postdoc is probably a major reason why I got the recent Biological Physics prize and is a tribute to my fine education at Illinois. The biological part came much later; there was an excellent biophysics group in the Illinois Physics Department, but I had little to do with them except socially.

Fifteen months after I graduated, I passed through Urbana to rendezvous for a car trip to ski in Colorado. I indiscreetly headed for Slichter’s lab in his absence, where I chatted with his students. I mentioned a plan I had to study NMR relaxation in a superconductor. His students immediately informed me that Chuck Hebel (MS ’54, PhD ’57) was attempting the same thing. Later Charlie graciously encouraged me to continue in my plans independently. I eventually lost this race but I had a lot of fun trying, and I happily continued in this area for many years. The experiment involved cycling the magnetic field to below the critical field for a very short time, and I am still working on an experiment like this in retirement, but applying it to study proteins. ■

Wang Receives 2006 DNP Dissertation Prize



Li-Bang Wang



Nuclei of ⁶He are thought to consist of a ⁴He inner part (denoted by two neutrons and two protons) and an outer “halo” part consisting of two more neutrons. (Courtesy of American Institute of Physics)

Li-Bang Wang (PhD ’05) was awarded the American Physical Society’s 2006 Dissertation in Nuclear Physics Award “for his outstanding and innovative experimental work to precisely measure the charge radius of the exotic and short-lived isotope ^{6}He by laser spectroscopic studies of single atoms stored in a magneto-optical trap.” His work, a *tour de force* in experimental nuclear physics, measured the charge radius for ^{6}He for the first time. His result contributes to our understanding of the nature of weakly bound nuclei and serves as a key benchmark for nuclear models. His thesis adviser was Roy J. Holt, now at Argonne National Laboratory.

The ^{6}He nucleus comprises a ^{4}He nucleus (two protons plus two neutrons) surrounded by a halo of two more neutrons; the isotope is produced at a special beamline at Argonne National Laboratory by smashing a beam of lithium ions into a target. The stray ^{6}He nuclei produced during this process were confined and cooled in a magneto-optical trap, and laser spectroscopy was used to measure the isotope shift between ^{6}He and ^{4}He (Wang et al., *Phys. Rev. Lett.* **93**, 142501 [2004]).

Wang received a BS in physics from National Taiwan University in 1996, where he was awarded the Dr. Paul C.W. Chu Fellowship for Materials Science. After two years’ mandatory service in the Taiwanese army, he became a full-time teaching assistant in laboratory physics at National Taiwan University for one year. In 1999, he enrolled in the U of I’s graduate program in physics.

At Illinois, Wang first worked with Roy Holt and Douglas Beck on a parity violation experiment to test the standard model in simple atomic systems. In Fall 2001, he joined Roy Holt and Zheng-Tian Lu’s group at Argonne National Laboratory, where he used an atom trapping technique for nuclear physics studies. He received his PhD in May 2005 and is now a postdoctoral fellow at Los Alamos National Laboratory. His current research involves ion trapping and precision laser spectroscopy to test the constancy of fundamental interactions. ■

So Who Was Loomis Anyway?

Francis Wheeler Loomis, ca. 1929, when he came to Illinois as head of Physics.

In 1929, F. Wheeler Loomis was appointed head of the Department of Physics; he would turn it from a pre-quantum mechanics physics backwater to the world-class center of physics research and teaching that it is today. Initially dismayed by the quality of the faculty and suffering from an Easterner's disdain of the rural Midwest, Loomis nevertheless saw the potential of Illinois. According to Loomis, "I came here knowing … that the department was obsolete and the only way to get it over being obsolete was to get some new people."

This nontraditional photograph of Wheeler Loomis, showing him as a young faculty member, was selected deliberately. Throughout his long and distinguished career at Illinois, he retained the vigor, imagination, and unpretentiousness of a young man. A noted scientist and administrator of science, he headed the department until 1957, building it into one of the leading physics departments in the world. He was president of the American Physical Society and elected to membership in the National Academy of Sciences, both in 1949. Much of this article is taken from a memorial written by Professor Charles P. Slichter for the dedication of the Loomis Laboratory of Physics.

Wheeler Loomis made important contributions to national defense as associate head of the MIT Radiation Laboratory during World War II, as head (1951–52) of Project Charles, which led to formation of the MIT Lincoln Laboratory, and as director (1952–59) of the Control Systems Laboratory at the University of Illinois. He was awarded the degree of Honorary Doctor of Science in 1969 by the University of Illinois, and the Board of Trustees honored Loomis posthumously by rededicating the Physics Building as the Loomis Laboratory of Physics.

Loomis was born August 4, 1889, in Parkersburg, West Virginia. He attended schools in Ohio, Wisconsin, and Massachusetts. Both his undergraduate and graduate work were done at Harvard University, where he received his PhD in 1917. During World War I, as a captain in the Army Ordnance Department, he was in charge of antiaircraft range firing and preparation of ballistic tables at the Aberdeen Proving Ground. For two years, he worked as a research physicist at the Westinghouse Lamp Company and then joined the physics department at New York University. While abroad in 1928–29 as a Guggenheim Fellow studying at Zürich and Göttingen, he was invited to become head of the physics department at the University of Illinois, a job he retained until just before his retirement, except for the leaves of absence for work at MIT on national defense.

Loomis began research in physics with his PhD thesis on thermodynamics, but following World War I, he changed to the new field of molecular spectroscopy, a field in which he was active up to World War II. In 1920, he discovered the isotope effect in molecular spectra, thereby opening the way to identification of several molecular species and to discovery of important new isotopes, including several of carbon and oxygen. He also did important work in diatomic molecules of iodine and the alkali metals.

A believer in the importance of attracting beginning students to science, for years he gave the lectures in elementary physics himself. He exemplified his own ideal of a faculty totally involved in physics, every member active in research and teaching at both the elementary and advanced levels. He demonstrated keen judgment of young scholars—identifying many who later became famous and creating a climate conducive to their best work. Among his graduate students was Polykarp Kusch, who, as professor of physics at Columbia University in 1955, won the Nobel Prize in Physics.

Loomis built the Department of Physics twice, the first time in his quest to get rid of the "obsolete," despite the Great Depression, and the second time after the disruptions of World War II. As the economy gradually improved in the late 1930s, Wheeler Loomis began to build his department. His strategy—upon realizing that Illinois lacked the ambience, money, and prestige to attract senior scientists—was to hire promising youngsters and nurture them assiduously, thus beginning the tradition of "Loomis tenure." Between 1937 and 1941, Loomis hired twelve new physicists, including the noted theorists Sidney M. Dancoff and Robert H. Serber, Donald W. Kerst, who invented the betatron while at Illinois, Leland J. Haworth, later director of the National Science Foundation, the noted experimentalists Norman Ramsey and Maurice Goldhaber, and R.H. Bolt, an expert in acoustics. Others included Gerald M. Almy, Ernest M. Lyman, and P. Gerald Kruger, who brought Illinois to the forefront in nuclear physics, and the theorist J.H. Bartlett. Loomis's enthusiastic spending inspired the following verse, written by a colleague for the 1941 Physics newsletter: "There was a young fellow named Wheeler/Who for more men put out a feeler/Many men did he hire/And none did he fire/But spent cash like a drunken New Dealer."

Distinguished visitors marking the dedication of Loomis Laboratory of Physics on September 21, 1977. From left, I.I. Rabi, Edith Loomis, Fred Seitz, and Ned Goldwasser.

The outbreak of World War II led to a general exodus of faculty and staff to the MIT Radiation Laboratory and to a super-secret government installation near Los Alamos, New Mexico, to contribute to the war effort. Loomis began the annual Physics newsletter in 1940 as a way of keeping in touch with absent faculty members.

After the war ended, Loomis was faced with the task of rebuilding the department once again, as many faculty moved on to other institutions instead of returning to Illinois. In an era when few physicists deigned to study "dirt physics," Loomis, with his usual vision, introduced research efforts in solid state and low-temperature physics to the department in 1949, bringing the noted theorist Frederick Seitz to head the group, with Robert J. Maurer and four instructors to begin experimental work—David Lazarus, Dillon E. Mapother, Charles P. Slichter, and John C. Wheatley. Later additions included Professor John Bardeen, who in 1956 shared the Nobel Prize with William Shockley and Walter Brattain for the discovery of the transistor, and who in 1972 again shared the Nobel Prize, this time with J. Robert Schrieffer (MS '54, PhD '57) and Leon Cooper for their joint work at Illinois that gave an explanation of superconductivity.

Other notable scientists whom he brought to Illinois included the well-known particle theorists Geoffrey Chew, Francis Low, and K. Nishajima. Loomis also brought Chalmers Sherwin and James Allen, who did important work on establishing the existence and properties of the neutrino.

Loomis's ability as a keen judge of science talent, and his ability to generate a strong enthusiasm and sense of purpose among his colleagues, led to his being asked by Lee DuBridge, the director, to assume the #2 position in the MIT Radiation Laboratory, a post Loomis held from 1941 to 1946. The Laboratory was the principal developer of radar in the United States. In 1951, possession of the atom bomb by the Soviet Union led to concern over the air defense of the United States. As a result of his reputation among America's top scientists as a perceptive and strong leader of a research team, Loomis was called upon to head a study, Project Charles, to investigate methods to protect the United States from Soviet airborne attack. President Killian of MIT wrote of Loomis, "There is serious question as to whether any other person could be found who could hold together the team required for the work." For a period of eighteen months in 1951–52, Loomis directed Project Charles and the formation of the Lincoln Laboratory, which was operated under the auspices of MIT.

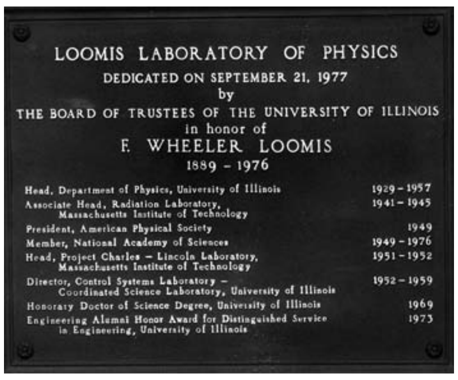
In 1952, after the Korean War broke out, Loomis founded and directed the Control Systems Laboratory at the University of Illinois to contribute to further development of radar—including airborne Doppler radar having a moving target lock-on, portable "sentry" radar, and synthetic aperture radar (SAR) imaging—and the application of digital computing to national defense. Later the name of the laboratory was changed to the Coordinated Science Laboratory and it pursued unclassified research.

Loomis was active in affairs of science at the national level. In his 1950 address as the retiring president of the American Physical Society, *Can Physics Serve Two Masters?,* he gave a discussion of the relation and role of basic and applied physics that stands as one of the most perceptive, balanced, yet eloquent analyses ever given of the importance of basic research, of the potential dangers of government control, and of the policies needed for wise support of basic science. He stated:

> The misconception that physics is primarily a utilitarian subject pervades even the university campuses, where it is studied largely as a tool by engineers and premedics and studiously avoided by our colleagues who plan the curriculum in liberal education; or at least so diluted as to be unrecognizable. Unless one defines a humanity as a subject of which everyone thinks he understands something, or as one suitable for dinner-table conversation, physics deserves as high a rank among the humanities as any discipline whatever, and its omission will leave just as wide a gap as would the omission of philosophy or history in the appreciation of the major intellectual achievements of our civilization and the forces which affect it.

His style was direct and to the point, often spiced with dry humor. Describing himself, he once wrote, "I am married and have three small daughters. My avocations are yachting (15 foot nondescript) and mountaineering, or at least hilling." In response to a graduate student doing research on the history of quantum physics in the United States between 1920 and 1935 he wrote, "You ask whom I was particularly associated with in Göttingen in 1928–29. It was James Franck. In Zürich I was 'under' Pauli, but I spent most of my fellowship term there on a trip back to the States to study and consider an offer from the University of Illinois, which I accepted."

Loomis's abilities as a leader of scientists led to repeated invitations to head major government agencies, university departments, or otherwise take up new careers. But though he took leaves to serve his country, he always returned to his position as head of the physics department he had built at the University of Illinois. He most wished to be close to working physicists, to try to build an active center of the finest physics. He knew he could best achieve this goal as department head, where he could judge what was happening first-hand, take part as a colleague in discussions of the results of research, and help to promote that spirit of excitement and of the importance of doing physics by his presence. Scientists worked hard for him because he conveyed to them his own sense of the importance of the work in which they were engaged.



The plaque installed in Loomis Laboratory, commemorating the milestones and achievements of its namesake.

In many ways, Wheeler Loomis imprinted his indelible stamp on this department and defined its character. His legacy is a physics department unsurpassed in its dedication to teaching, its pursuit of excellence, and its hallmark of cohesion and collegiality. As Jerry Almy noted at a dinner on May 24, 1957, honoring Loomis on his upcoming retirement, "I am inclined to take at face value his [Loomis's] satisfaction and pride in the department and its accomplishments… And I believe that this widespread feeling of pride in the department and in being a part of it is a chief ingredient of its strength through the ups and downs of its fortunes. We are very grateful to Wheeler for his important part in creating this atmosphere." ■

Wheeler Loomis at the tiller of "15-foot nondescript"

University of Illinois Alumni Association

Backward Glance

Important scientific news is indicated by this picture, taken in the U of I Physics Laboratory. Seated, from left: Nathan Levine, Giovanni De Pasquali, and Prof. Hans Frauenfelder. Standing: Eberhard von Goeler, Angelo Rossi, Norman Peacock, and H. R. Lewis. On the team but not in the picture is Renato Bobone. In January [1957, *ed.*], *physicists were astonished to learn that, in experiments at Columbia University, a 20-year-old law of physics, known as "the conservation of parity," had been upset. Professor Frauenfelder set out, at top speed, to test an independent consequence of the upset. He called in the group in this picture, all his associates or students, from a variety of research projects. Working day and night for 30 days, these men built the apparatus shown here and demonstrated conclusively the predicted consequences of the law's failure. Working as a unit, the scientists proved that an electron emitted from radioactive nuclei as a beta ray has its axis spin aligned parallel to its direction of motion. (*The Alumni News, *Vol. XXXVI, No. 3, April 1957.)*

PHYSICS ILLINOIS NEWS

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The mission of the Department of Physics of the University of Illinois at Urbana-Champaign is to serve the people of the State of Illinois, the nation, and the world through leadership in physics education and research, public outreach, and professional service.

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not a place, a habit of mind...

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