Physics Illinois News

THE DEPARTMENT OF PHYSICS AT THE UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN • 2004 NUMBER 1

Metallic Phase for Bosons Implies New State of Matter

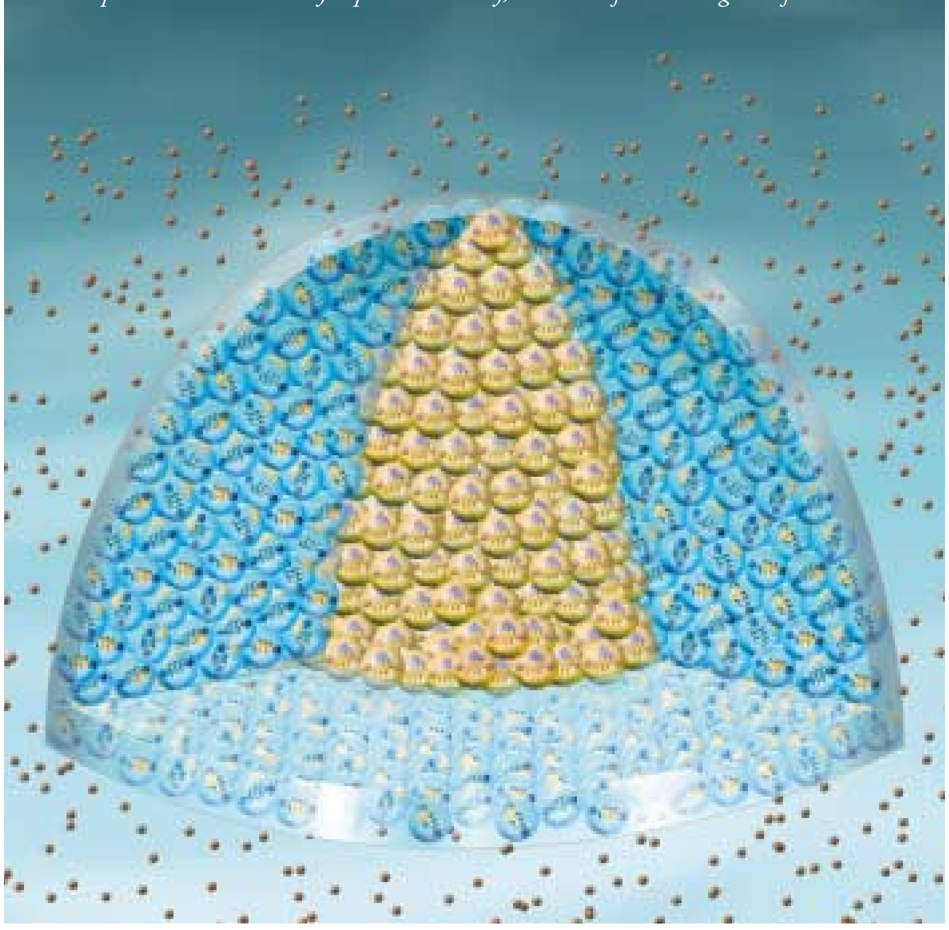
The Heisenberg uncertainty principle places severe constraints on the subatomic world. To illustrate, for bosons, the principle dictates that they must either condense to form a superconductor or remain localized in an insulator. However, experiments conducted during the last 15 years on thin films have revealed a third possibility—bosons can exist as a metal. Scientists have been struggling to interpret this surprising result.

"The conventional theory of metals is in crisis," according to Professor Philip Phillips. "The observation of a metallic phase for bosons directly contradicts conventional wisdom. A satisfactory explanation requires a new state of matter."

Writing in the October 10, 2003, issue of the journal *Science,* Phillips and Denis Dalidovich (PhD, '01, now at Florida State University) analyze the thin-film experiments and offer a new explanation in which the charge-carrying bosons condense into a glass-like, metallic state.

Normally, the charge carriers in metals are electrons—fermions that are subject to the Pauli exclusion principle, which limits the number of carriers that can occupy the same quantum state. In a superconductor, however, the charge carriers are pairs of electrons—bosons—that need not obey the Pauli exclusion principle. As a result, macroscopic occupation of a single quantum state is allowed.

Phase diagram showing the destruction of superconductivity:
1) The yellow region represents the ordered phase in which all the electron pairs share the same phase (all arrows pointing up), 2) The elusive Bose metal is in blue in which all the phases are disordered but form a glass, and 3) Beyond the electron pairs fall apart and form an insulator. The vertical axis represents temperature and the in-plane axes any of the tuning parameters that destroy superconductivity, such as defects or magnetic field.



"Like musicians in a marching band, bosons in a superconductor all march in step with one another, that is, they have the same phase," Phillips said. "When they march out of step, the result is an insulator."

In the experiments (performed at Stanford and the University of Minnesota) that Phillips and Dalidovich analyzed, a thin-film superconductor was transformed into an insulator either by decreasing the film thickness or by applying a perpendicular magnetic field. The signature of a superconductor is zero resistance, while the signature of an insulator is infinite resistance.

"But in these experiments, there was a wide range where the resistance was neither zero nor infinite—it was a finite value that seemed to persist all the way down to zero temperature," Phillips said. "And if you have a finite resistivity at zero temperature, that is called a metal."

According to the conventional theory of metals, "that metallicity shouldn't be there," Phillips explained. "So these experiments that destroy superconductivity, but don't

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Time Flies When You Are Having Fun!

BY RICK KUBETZ

For some people, retirement is a time to sit back and recount the blessings and achievements of a lifetime and a career. In the case of Charlie Slichter, that luxury will fall to others.

In 2004, Charles P. Slichter, Research Professor of Physics and Center for Advanced Study Emeritus Professor of Physics and Chemistry, will mark both his 80th birthday and his 55th year of doing physics in Urbana. A celebration is being planned for October, but not much else has changed. "Charlie" will still be in the lab tomorrow.

"I still find physics enormously interesting. I just love physics." It is a phrase that Slichter would repeat several times over the course of an interview about his career.

When Slichter initially "retired" in 1996, he chose the title of "research professor of physics" over "professor emeritus." It also meant that his salary came from the retirement system rather than the Department of Physics. He liked the idea that new talent could be recruited as a result.

"Now I'm retired in the practical sense," Slichter said. "My last (graduate) student just finished at the end of December. I still have a postdoc and we have some interesting experiments going."

These days, "retirement" means not having to watch the clock. "I try to walk on the treadmill in the morning, so I usually get to the office by about 9 a.m., and I stay until 4:30 or 5 p.m.," he said. "It's great to be free of the schedule."

As an internationally recognized leader in condensed matter physics, Slichter is one of the world's top research scientists in the area of magnetic resonance and has been a leading innovator in applications of resonance techniques to understanding the structure of matter. A deep physical insight and elegant experimental mastery have enabled him to make seminal contributions to an extraordinarily broad range of problems of both great theoretical interest and technological importance in physics and chemistry.

Explaining his research, Slichter stated, "We probe magnetic and electric fields at the atomic level by NMR to study many-body effects, phase transitions, magnetism, solids possessing unusual properties, and electronic and structural aspects of surface atoms and absorbed molecules (including catalysis).

"NMR has proved to be an important tool to study superconductivity," he added. "We are investigating the normal and superconducting states of high-temperature superconductors, such as $YBa_2Cu_3O_7$ or $La_{2-x}Sr_xCuO_4$, to learn how to describe the normal state, what mechanism leads to superconductivity, and why the transition temperatures are so high." The resonances of $^{63,65}Cu$, ^{17}O, ^{89}Y, $^{135,137}Ba$ permit NMR to probe specific atomic sites (e.g., Cu nuclei in the CuO_2 planes).

In 1969, the American Physical Society (APS) presented Slichter with the Langmuir Prize in Chemical Physics for his "innovation in the applications of magnetic resonance techniques to the understanding of the structural and dynamic properties of matter." In 1996, he received the Oliver E. Buckley Prize from APS for

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Letter from the Head

We have received many favorable responses to our redesigned newsletter, *Physics Illinois News.* I believe you will find this issue, which is filled with information about the faculty, staff, students, alumni, and activities of the department, interesting as well.

We have been particularly touched by the outpouring of interest and support for our library. I'm delighted to report that all three books on the "wishlist"—and several other valuable additions to our collection—were purchased by generous alumni within a few weeks of the publication of the last newsletter. One wrote, "That library was essential and integral to my graduate study…surely graduate students still work late nights, weekends, and all kinds of odd hours. Being trusted with a key to the Physics and MRL buildings and to the physics library was 'enabling,' as we would say today, allowing me to make adequate research progress. I am most concerned if today's graduate students have less than that opportunity." With the help of our friends, we'll see that we continue to provide an intellectually rich and supportive atmosphere for all.

Each spring there are numerous award ceremonies across the campus and at the national level. We are proud of the achievements of our students, faculty, staff, and alumni—their success is a tangible measure of our own. In this issue we tell you about our new APS Fellows, National Academy of Engineering members, and others who represent in many ways the department's excellence in physics.

The outreach activities of the department to elementary and high schools, and to the public more generally, are continuing to be well received. Many sessions of last fall's Saturday Physics Honors Program filled 141 Loomis, our largest lecture hall.

In keeping with Physics tradition, our undergraduate students built some remarkable exhibits for this year's Engineering Open House (see article and photos on Page 7).

This spring the Center for Theoretical Astrophysics, launched a Saturday Astrophysics Honors Program, which will expand our outreach portfolio. In addition, we are adding an entirely new thrust to our outreach in a new course, Physics 123: *Physics Made Easy.* The course was created by and is being taught by Mats Selen specifically for future elementary education teachers who are here at Illinois in the midst of their undergraduate studies. It is already clear that the course is a success. We believe it will have great leverage in the long run and will serve as a national model for giving elementary school teachers the training and support they need to be confident in talking about basic physics as illustrated by everyday phenomena.

Two major events will be taking place on campus next fall. The first will be the dedication of a new quadrangle on campus. The entire space between Engineering Hall on the south and the Grainger Engineering Library to the north and bounded on the west by Talbot Laboratory and the east by the recently remodeled Mechanical Engineering Laboratory will be dedicated as the Bardeen Quadrangle. This ceremony will take place during the 2004 Annual Meeting of the University of Illinois Foundation on October 14–16. Given the close connections physics has had to engineering from the early days of this university, it will be a special honor to have the space at the very core of the College of Engineering named after a former faculty member of the Department of Physics whose scientific discoveries are ubiquitous in the technology that surrounds us.

The second major event will be the *Symposium in Honor of Charles P. Slichter and the Early Days of Condensed Matter Physics at Illinois,* which will take place in Loomis on October 22–23, 2004. The symposium will honor Charlie's contributions to science and society and will also serve as an opportunity to launch a major effort to gather and preserve materials related to the first decades of solid state physics at Illinois. The schedule for the symposium and the plans for the history project are in the early stages. I encourage interested readers of this newsletter who have knowledge or documents related to this history to contact me.

In spite of continuing budget reductions for the 2004/05 academic year, the department is in the midst of three faculty searches and is completing a fourth. In the next issue of this newsletter, I will report on the results of these searches as well as what appears to be a successful graduate student recruitment effort for Fall 2004. I will also report on undergraduate recruiting, which is now in the capable hands of the newest member of the staff, Toni Pitts (see Page 3). The nationwide trend of growing numbers of undergraduate physics majors is very good news. ■

Jeremiah D. Sullivan

Metallic Phase for Bosons Implies New State of Matter

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immediately produce an insulator, pose a serious theoretical question."

Over the years, new states of matter have been proposed that had exotic magnetic or topological textures associated with the bosons. But these states lacked a key property of a metal—finite conductivity at zero temperature. A better explanation for the intervening metallic phase is that bosons are condensing into a glass-like state.

Glasses are inherently dynamical objects, Phillips said. "They look solid, but there is no crystalline structure and therefore no true ground state. Bosons moving in such a glassy environment fail to localize because no unique ground state exists."

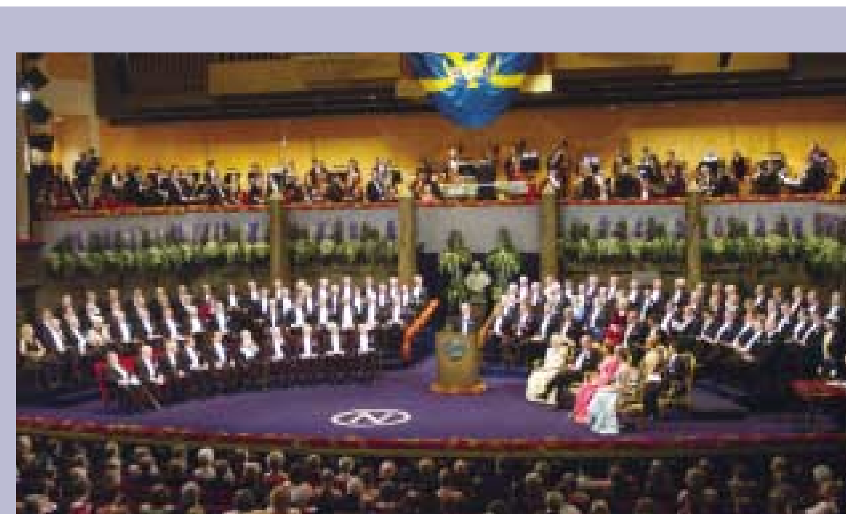
To illuminate what such a state looks like, consider again the marching band proceeding up a very long hill, Phillips explained. The musicians will tire at different rates and fall out of step. But the new marching patterns will propagate through the band. While the band as a whole is out of step, there will be local regions of order where groups of musicians still march in step at the same rate.

"In a similar fashion, when you disrupt the phases in a superconductor, you don't end up immediately with an insulator," Phillips added. "Instead, you have a dynamic system in which the phases have local order while overall there is disorder." Such an intermediate phase in which there is local order but global disorder lies outside the conventional rubric.

The researchers' findings are relevant to topological glasses in general, including the much-studied vortex glass state that has been argued to have zero resistance, and to explain the ground state of high-temperature copper oxide superconductors in a perpendicular magnetic field.

According to Phillips, "Recent experiments by researchers at Maryland and Caltech show that the resistivity does not vanish in the vortex glass state. The resistivity remains finite, so it now appears that the vortex glass is metallic and not a superconductor, consistent with the glassy Bose metal proposed." This agreement lends further credence to the glassy model proposed to explain the strange Bose metal state of matter. ■

Funding for this work was provided by the American Chemical Society and the National Science Foundation. Conclusions are those of the authors and not necessarily of the funding agencies.



Photos by the Champaign-Urbana News-Gazette

Physics Quiz

Question:

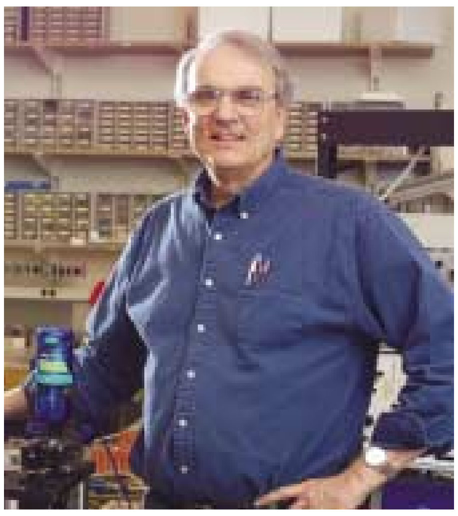
The number of Nobel Laureates in Physics who held faculty appointments in this department is:

A. Two
B. Three
C. Five
D. Seven

See answer on page 9

(above) Nobel Prize Award Ceremony at the Stockholm Concert Hall, December 10, 2003. (right) Tony Leggett receives his Nobel medal and diploma from His Majesty King Carl XVI Gustaf.

Agilent Technologies' Gift Outfits a New State-of-the-Art Teaching Lab



Professor Robert Clegg

Thanks to the generosity and vision of Agilent Technologies, the Department of Physics will soon have an advanced optical spectroscopy teaching laboratory to address unmet student needs for hands-on training with state-of-the-art instrumentation for life sciences research. With their gift of four uv-visible spectroscopy systems, fluorescence detectors, cuvettes, and control modules—nearly $100k of the latest equipment—Agilent will allow us to expand and institutionalize a novel new interdisciplinary laboratory course in advanced spectroscopy techniques. The course was successfully introduced by Professor Robert Clegg in 2003 using his own research equipment and drawing students from bioengineering, physics, biophysics, and molecular biology at the University of Illinois at Urbana-Champaign.

In a letter of support, Erica Messinger, the Agilent University of Illinois campus manager, wrote, "This advanced spectroscopy laboratory, unique in its caliber, will serve as a prime opportunity to continue support for one of our top engineering colleges in the U.S. as well as encourage more interdisciplinary work and link us more closely with the life sciences at one of Agilent's valued universities. The combination of instrumentation, electronics, nanoengineering, chemistry and computation to be reflected in this laboratory not only highlights many of the University of Illinois' key areas of strength, but also mirrors many key business areas for Agilent."

In announcing the gift, Clegg stated, "Progress in the biological disciplines has happened so rapidly that many educational institutions—Illinois included—have not been able to keep up with the necessary facilities for up-to-date training in the biophysical sciences. The advanced spectroscopy student laboratory will place the University of Illinois at the forefront of this area of education. It will also provide a valuable resource for many diverse research groups on campus, because their students can gain proficiency with these advanced spectroscopic techniques, which they could eventually incorporate into their research projects. The grant from Agilent will make these aspirations a reality."

The donation of equipment was made possible by the Agilent University Relations *Equipment Program for the University Teaching Laboratory* and reflects the company's long-time support of excellence in teaching to benefit the educational experience of students working towards their bachelor's degrees. ■

Please Welcome Toni Pitts

In early January, Toni Pitts joined the Department of Physics as the coordinator of recruiting, advising, and special programs. She replaced Nicole Drummer, who recently moved with her husband to Colorado.

"I love my job," Pitts stated enthusiastically. "I'm excited to be here. I'm looking forward to learning more about the Department of Physics and the science in general."

Toni grew up in Bloomington, Indiana. She earned an undergraduate degree in telecommunications and a graduate degree in instructional systems technology (training and development) from Indiana University. Her husband, Kevin Pitts, is an assistant professor in the Department of Physics. In their spare time together, they enjoy the antics of their 14-month-old daughter, Shelby.

Prior to joining the department, Toni worked in Engineering Administration and most recently served as interim director for Worldwide Youth in Science and Engineering (outreach program for high school students).

For information about student recruiting or undergraduate programs, contact Toni at tpitts@uiuc.edu. ■

Image #5

Image #10

Image #12

Image #20

Name that Physicist!

Heartfelt thanks to all who have taken the time to help us identify the members of the Bardeen "Superconductor" collage (see *Physics Illinois News* 2003, No. 2, and www.physics.uiuc.edu/Alumni/ Bardeen_photo.htm. Click on each person's head on the collage to see the magnified image).

Unfortunately, we still have the following UPSs (unidentified physics students). If you recognize any of them, please let us know.

Celia Elliott
cmelliot@uiuc.edu
(217) 244-7725

Library Update—Changes to Preserve Resources

After serving as Physics-Astronomy Librarian for more than eight years, Greg Youngen has moved across campus to become the head librarian at the College of Veterinary Medicine Library. As a result of budget constraints within the University Library, the Physics-Astronomy Library will remain a separate library although it will be functionally combined with the Grainger Engineering Library.

"At least for the next year, we are going to administer the Physics-Astronomy Library (PAL) from the Grainger Library," said Bill Mischo, head of the Grainger Engineering Library. Mischo will manage overall operations, with Linda Ackerson responsible for the collections and Mary Schlembach responsible for reference and public service. Mary Kay Newman and Sandra Holloway remain as staff members, handling day-to-day activities, and a new half-time library operations assistant will also be hired for the PAL.

According to Mischo, the Library has undergone a number of positive changes, offering additional resources to faculty and students. "The INSPEC database has been moved from the OVID platform to EI Village," he said. "This provides users simultaneous search capabilities over both the INSPEC and Engineering Index databases and also provides convenient one-click links to the full text of specific articles."

The Library has also developed systems that provide easy access to the full text of specific articles in journals. "In addition," Mischo notes, "we are also implementing a service that will allow users in the Physics-Astronomy Library to receive direct online reference assistance from a Grainger librarian."

Because of a renegotiated contract with Reed-Elsevier, the Library has freed up sufficient funds to purchase the back files of Elsevier's high-energy physics journals. Mischo explained that the library pays significant annual fees for license agreements and full-text access, allowing faculty and students to find and use the full text of every article ever published from several major publishers at their desktops.

"We now have electronic access to the full text of physics society journals dating back to the late 1800s," Mischo added. "This includes dozens of journals published by the American Physical Society, the American Institute of Physics, and the Institute of Physics (UK), which represent some of the most important works in the field." ■

Dear Friends,

I studied NMR in metals as a post-doc under Professor Charlie Slichter during the period 1962-64. It was a wonderful period for me and for my wife. We arrived in October 1962 and were married just one month earlier on 1st September 1962. Unfortunately, on our way over by ship, the Cuban missile crisis broke and the tension was high. During our first week in the states, air raid warnings sounded and shelter drills rehearsed. Fortunately matters quieted down fairly rapidly and we were able to settle into our new life.

My introduction to Charlie was arranged through my PhD supervisor, Professor J.G. Powles, during the last three months or so of my studies at Queen Mary College, University of London. I felt exceptionally privileged to be invited to Charlie's group. The scientific experiences and happy memories remain with my wife and I to this very day.

The training I received in Urbana, namely, to thoroughly understand the theory then apply this rigorously to the problem in hand, is the basis that all students were encouraged to work from. This approach has played a significant role in my research work ever since, and especially during the last 30 years when we were developing the fundamental theory and application of NMR to magnetic resonance imaging (MRI).

Sir Peter Mansfield
Emeritus Professor in Residence
University of Nottingham

Reserve The Date

Symposium in Honor of Charles P. Slichter and the Early Years of Condensed Matter Physics at Illinois

October 22–23, 2004

For further information, e-mail mgamel@uiuc.edu.

Time Flies When You Are Having Fun!

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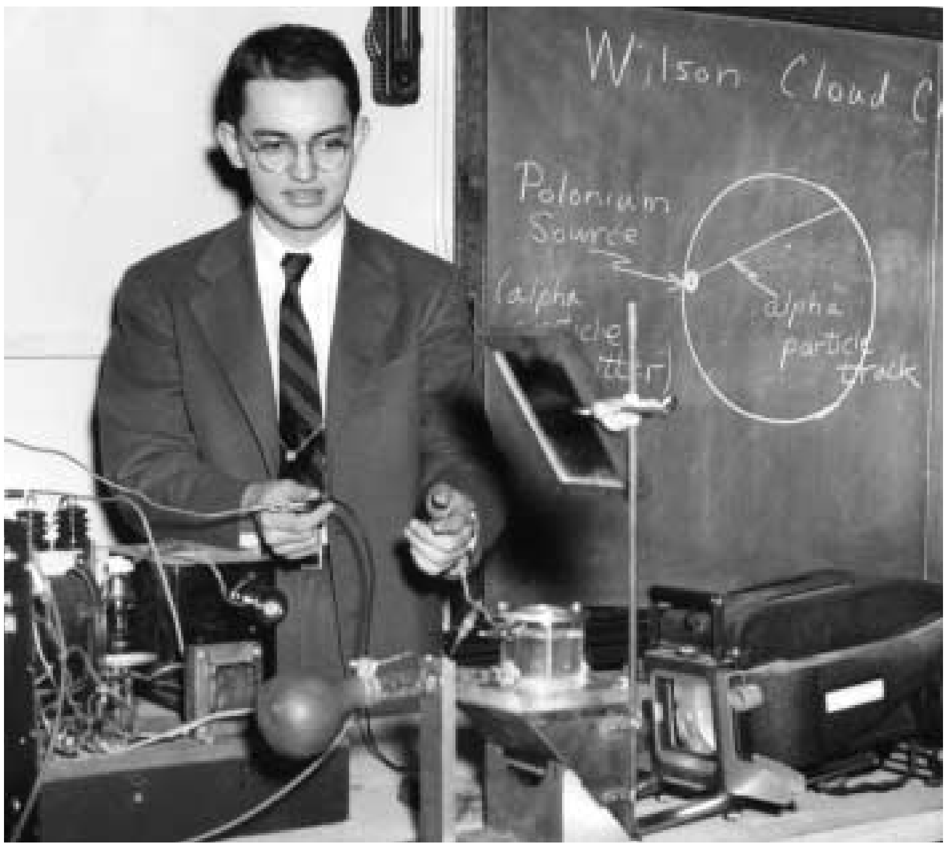
his "original and creative applications of the magnetic resonance techniques to elucidate the microscopic properties of condensed matter systems including, especially, super-conductors." Further recognition has come from the International Society of Magnetic Resonance (ISMAR; Triennial Prize, 1986), the National Academy of Sciences (Comstock Prize, 1993), and the U.S. Department of Energy (awards for materials science research in 1984, 1992, and 1993).

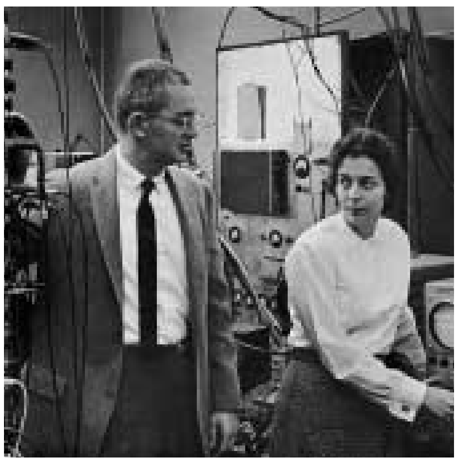
In addition, Slichter served on the President's Scientific Advisory Committee (1965–69), the President's Committee on the National Medal of Science (1969–74), and the President's Committee on Science and Technology Policy (1976), as well as on the National Science Board (1976–84).

Born in Ithaca, New York, Slichter grew up in Cambridge, Massachusetts. His father, a professor of economics, joined the Harvard faculty in 1930. Slichter said that following an academic career "seemed natural." In addition to his father, two uncles and both grandfathers were professors. The Earth & Planetary Science Building at UCLA is named after his uncle, Louis Slichter, and a dormitory at the University of Wisconsin is named after his paternal grandfather, who was a distinguished mathematics professor there. But it was in his first physics course that Slichter realized that he wanted to be a physicist. His higher education progressed quickly after that.

"1941 was my freshman year in college—Pearl Harbor," he remembers. "I was an undergrad at Harvard (at 17). Because of the war, they compressed my two-year introductory physics course into one."

After America entered the war, Slichter knew they would need scientists and took all of the electronics courses available at Harvard to prepare for war work. At the end of his sophomore year, he left school to work on a war project at the Woods Hole Oceanographic Institute in Massachusetts. There, he utilized his physics and electronics background to study the effects of underwater explosions from depth charges.





(left) Charles Slichter giving an elementary physics lecture in the early 1950s.

(above) Slichter in the laboratory with another of his students, Judy R. Franz (MS, '61; PhD, '65). A professor of physics at the University of Alabama, Franz has served as the executive officer of the APS since 1994 and was elected last fall as the secretary-general of the International Union of Pure and Applied Physics.

"Group research was a real goal," he noted. "We wanted to be successful contributing to the war effort."

Slichter returned to Harvard in January 1946. Having received some college credit for his war work, he graduated the following summer and immediately entered graduate school. At the suggestion of his undergraduate adviser, Professor John H. van Vleck, Slichter asked to do his thesis with Edward M. Purcell. Purcell, who was born in Taylorville, Illinois, had earned his undergraduate degree at Purdue before going to Harvard for his physics PhD. In 1952, Purcell shared (with Felix Bloch) the Nobel Prize in Physics for discovering nuclear magnetic resonance.

Slichter's thesis was on "electronic spin resonance," surprising in hindsight, because he was the only one of Purcell's students who was not working on NMR at that time. After earning his PhD in 1949, Slichter was recruited by Wheeler Loomis, coming to Urbana right out of graduate school.

"Loomis had come through Harvard and knew Purcell," Slichter remembered. "I was also aware that Fred Seitz was considering coming to Illinois as well. I came to the U of I because I wanted to work in physics and have the freedom to pick what scientific problems to study." At the time, the University had the betatron, and nuclear physics was a major focus.

When Loomis offered him the job, Slichter asked if he could wait to see if Seitz was coming before accepting. "Working with Fred Seitz was more important to me than salary or benefits," he added. "That turned out to be the greatest good fortune."

Although he had never taught a class before, Slichter understood that while Illinois was a research university, it was still a university, and teaching was a requirement. He taught two sections of elementary physics during his first semester. While he is most comfortable interacting with people—be it students or fellow scientists—he initially dreaded lecturing.

"In my early days as an instructor, I was so nervous that I couldn't eat breakfast before getting up in front of a class," Slichter recalled. "But once I got started, and people started asking questions, I enjoyed it." He established his teaching style early. He didn't want to tell students the answers. He wanted them to ask questions so he could help them understand. His textbook, *Principles of Magnetic Resonance,* now in its 3rd printing, has served as the standard in the field for three and a half decades.

The list of PhD and postdoctoral students who have studied with Slichter is an impressive "Who's Who" of both physics and NMR. His first thesis student, Richard Norberg (AM, '47; PhD, '51), recently joined six other distinguished Illinois faculty and alumni who have won the ISMAR prize (see article, *Physics Illinois News,* 2003, No. 2).

"I was already beginning to learn NMR from Erwin Hahn when Chas arrived on campus," Norberg recalled. "He picked up students very quickly, and we were all working on NMR. It was exciting stuff. I learned all my NMR from Hahn and from Slichter."

His work with Slichter also provided Norberg with an entrée to Washington University, where he served as a professor for more than 50 years. "At that time, there was another group doing NMR research headed by George Pake at Washington

University," Norberg remarked. "Every other year, Slichter's group would visit the Pake group in St. Louis and they would come to Urbana on the alternate years." In 1954, as Pake was preparing for a leave of absence, Norberg—who by then had become an assistant professor at Illinois—was asked to assume leadership of the group.

According to Norberg, who is also "retired" but still works a full day in the lab, "We didn't invent NMR, but we certainly invented applications of it that led to its impact on science and medicine."

"We came at the same time in '49," recalled David Lazarus, longtime friend and physics professor emeritus. "Charlie's work has been absolutely magnificent. He has probably been the most important person in the country in applying NMR to solid states."

It was that reputation that helped attract other talent to Illinois. In 1962, a young English physicist named Peter Mansfield came to Illinois to work as a postdoctoral research associate with Slichter. Some years later—in 2003, to be exact—Sir Peter Mansfield shared the Nobel Prize in Medicine or Physiology with UI Professor Paul Lautebur for "seminal discoveries concerning the use of magnetic resonance to visualize different structures."

"I got my PhD under Charlie in 1958," explained Ted Castner, another early Slichter student. "I was one of a small group of Charlie's students who did ESR rather than NMR, although I later did some ENDOR. I was very impressed by his teaching. We all owe a great deal to Charlie as our mentor."

To gauge his impact on physics in general, and magnetic resonance in particular, you have to talk to his students. Slichter cannot help. He is both too modest and too busy encouraging, guiding, and helping them focus on the work at hand.

"Graduate students want to work on something that you think will make a difference," he explained. "Very rarely will a student propose his own thesis topic. *How* it should be done is most important for me to determine." As an adviser, he does enjoy "thinking about *what* they should do," and watching the lore of what's going on in the lab passed from one student to the next, with himself serving as the constant in the equation.

"What thesis work should do is teach you how to start in an area you don't know anything about, learn about it, and tackle a significant problem," Slichter explained. "That's the essence of what you are trying to do.

"As you get more involved in the University, you get further away from hands-on research," he added. "Your role as an adviser also changes over time, and students manage the details of research."

Over his career, Slichter has supervised 63 PhD students, which he usually managed four at a time—two who were just starting their work, and two who were nearing completion.

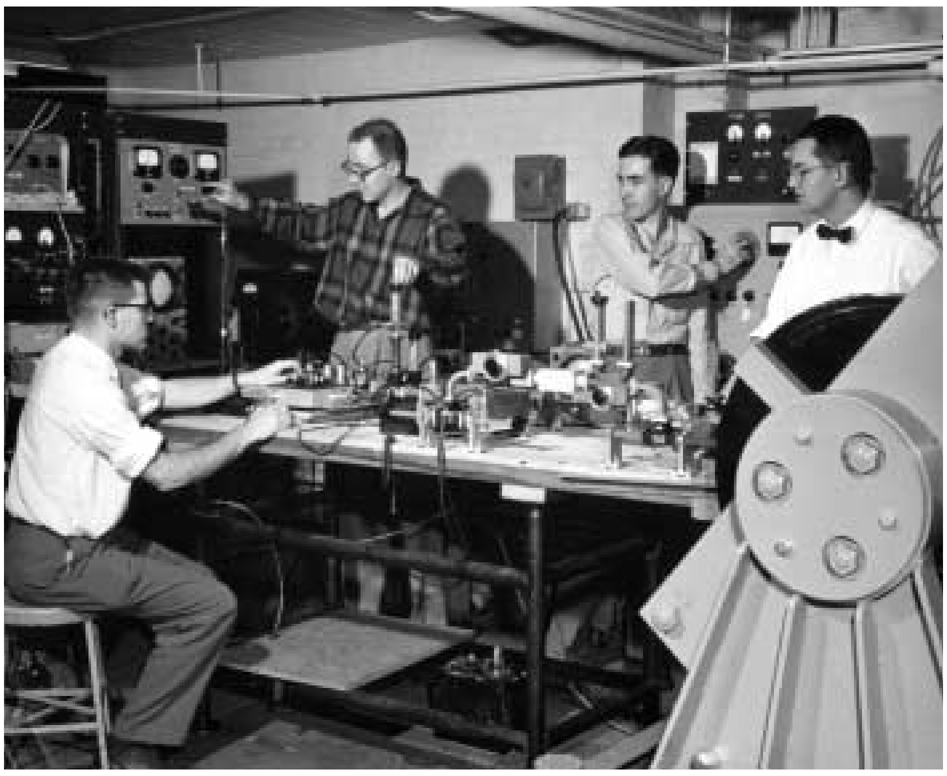
"I really love doing physics; the personal connection is the way I love to do it. If I were not in a university setting, I would have to find students to work with.

"I really love working with students on research," he said with a gleam in his eye. "It is intensely interactive. Just down the hall where the labs are, there are people thinking about the same scientific problems you are. If my student or I get a new idea, we're just down the hall from each other and can immediately talk about it. I love physics and I enjoy human interaction."

"Well, I had a lot of fun talking to Charlie during lunch in the lab," recalled Arnaud Comment, Slichter's last graduate student. "He always exhibited great dexterity in swapping his chopsticks for a pen in order to give me a brilliant interpretation of the data I had. And, of course, he never forgot to let me know the name of the 'NMR guy' who had first come up with the idea behind such an interpretation."

"It gave me an opportunity to work with university administration without having to do it full-time," he said. As a member of the Corporation, Slichter helped guide Harvard through an era of rapid change. While serving on the Corporation Committee on Shareholder Responsibility, he encouraged joint meetings with faculty, students, and concerned alumni as part of the process of developing Harvard's policies on such thorny issues as investments in tobacco companies and U.S. businesses operating in South Africa. A founding member of the Joint Committee on Appointments of the Governing Boards, which reviews faculty and senior administrative appointments university-wide, Slichter championed the needs of junior faculty in career development and counseling.

Professor Emeritus Edwin Goldwasser, who served on the physics faculty with Slichter in the early years, returned to campus as vice chancellor after an 11-year stint at Fermilab. "As a Harvard alumnus, I was very aware of and appreciative of the job



(left to right) Postdoctoral research associate George Newell and graduate students Ted Castner (MS, '55; PhD, '58) and Chuck Hebel (MS, '54; PhD, '57) work with Slichter (note the white shirt and trademark bowtie) in the lab during the mid-1950s.

Overall, Slichter thinks that "process" is key, as graduates will eventually work on projects outside their thesis topic, especially in industry. "It is so much fun to see what they (past grad students) do after they leave." Many of his colleagues and former students are expected to return to campus next October as part of the *Symposium in Honor of Charles P. Slichter and the Early Years of Condensed Matter Physics at Illinois.*

Although he has spent his entire career at Illinois, in his heart Slichter was never far from Cambridge. For 25 years, he was a member of the Harvard Corporation—the university's governing board and the oldest corporation in America—finally retiring from that service in 1995.

he did—not just here on the campus—but as a member and head of the Harvard Corporation," Goldwasser said. "Then when I came back here as vice chancellor, Charlie and I talked about some of the challenges we had. His judgment was very good, I thought; I value his opinion."

What does he plan to do going forward? "Well, I have six kids, and my two youngest sons are currently at Harvard. It's great fun to keep in touch with all of them." When asked about hobbies, he claims to have a great collection of albums and CDs of old-time jazz and alludes to an interest in playing guitar and woodcarving.

"There's lots of interesting things going on here, so I'll just keep going day-by-day." ▪

Alumni News

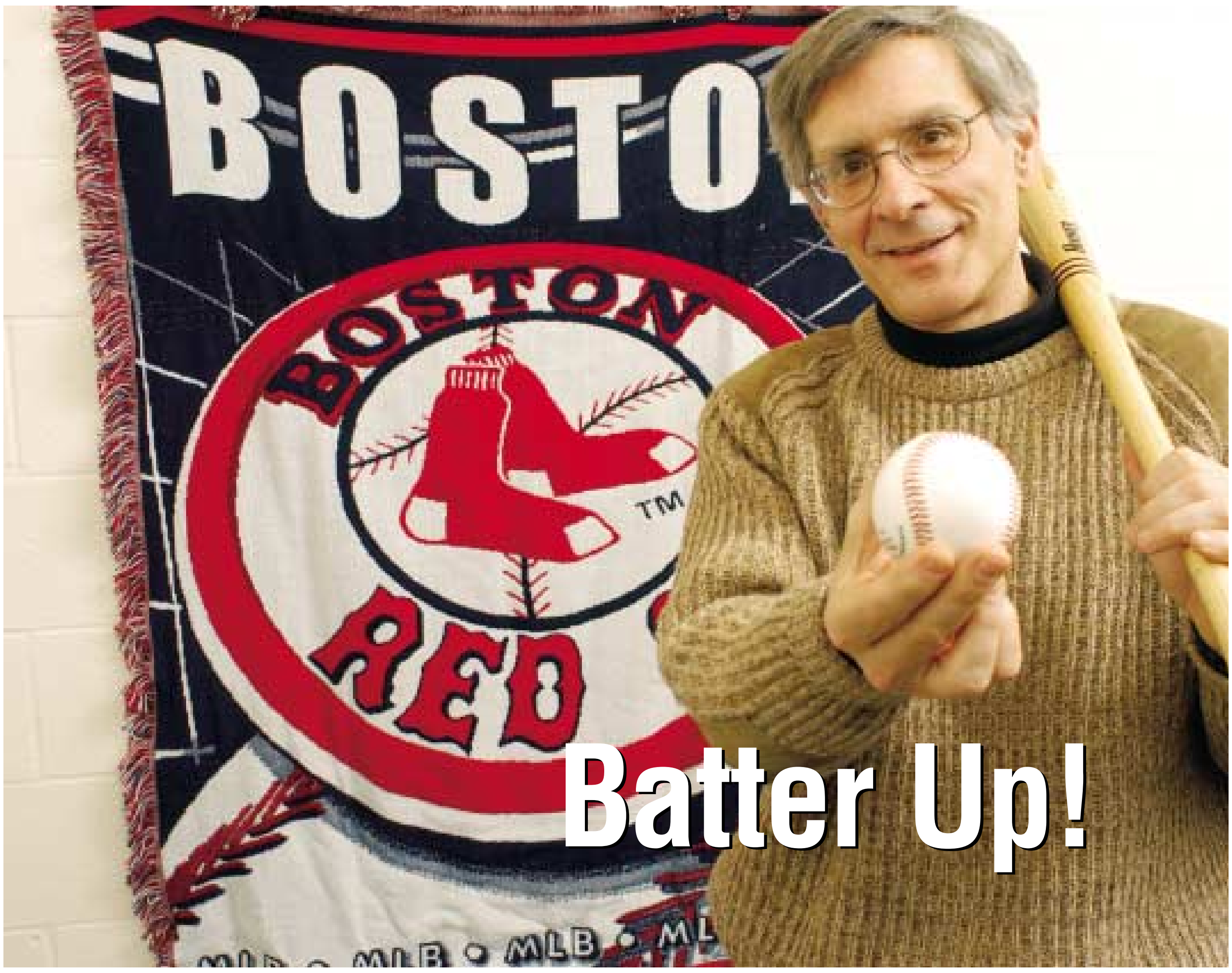
Alumni Elected to National Academy of Engineering

Triple-alumnus P. Daniel Dapkus (BS, '66; MS, '67; PhD, '70) and double-alumna Joan L. Mitchell (MS, '71; PhD, '74) were elected to the National Academy of Engineering (NAE) on February 13, 2004, one of the highest professional distinctions accorded to an engineer. Academy membership honors those who have made important contributions to engineering theory and practice, pioneered new fields of engineering, or made major advancements in traditional fields of engineering, including engineering education.

Dapkus, the William M. Keck Chair in Engineering, holds appointments in the departments of electrical engineering/electrophysics and materials science at the University of Southern California and directs USC's Center for Photonic Technology. He was recognized for his contributions and leadership in the development of materials and technologies for photonic devices.

"Dan has been a pioneer in the field of using light—photons—to perform tasks that previously were done by electrons and is now a pioneer in the emerging field of nanotechnology," said USC Dean of Engineering C.L. Max Nikias. Dapkus directs the Compound Semiconductor Laboratory, which has designed many novel photonic devices based on optical microresonators. In addition, Dapkus has created ultrasmall vertical cavity surface emitting lasers, and his group has been a leader in the development of efficient light sources for fiber optic systems.

Mitchell, an IBM Fellow, was honored for her leadership in setting standards for the formation of photographic fax and image compression. Mitchell has been a prolific inventor throughout her engineering career at IBM. She holds more than 30 patents, making her one of the top 20 inventors in IBM's research division. Her work has been crucial to the development of coders and decoders used to implement the CCITT Group III compression standard that is used in facsimile machines, the JPEG (still-image) compression standard that enables transmission of images over the Internet, and the newer JBIG (binary image) compression standard, which is replacing Group III in fax machines. She is the coauthor of two popular books—*JPEG: Still Image Data Compression Standard* (Van Nostrand Reinhold, New York, 1993) and *MPEG Video Compression Standard* (Chapman & Hall, New York, 1997). ▪



Batter Up!

Following major league baseball is a hobby for many physicists. Of course, when it comes to actually playing the game, the physicists have some "inside information." Over the past several years, Professor Alan Nathan has done considerable research on America's favorite pastime and has created a very comprehensive website, "The Physics of Baseball" (www.npl.uiuc.edu/~a-nathan/pob).

Nathan is especially interested in the collision between ball and bat. He has developed elaborate equations to capture that instant when the ball strikes the wood, causing the bat to vibrate in complex patterns like a violin string. Such work suggests that the "sweet spot" most batters prefer is different from the point on the bat that sends the ball sailing the farthest—a finding that could warrant subtle changes in batting strategies.

The sweet spot problem reminds Nathan of his main professional pursuit: experiments in which high-energy electrons are shot at an atomic nucleus to determine its structure. "It's basic physics," Nathan said. "Conservation of momentum and angular momentum, conservation of energy—these things apply no matter what kind of collision you're talking about."

What began as a diverting topic for lectures to lay audiences eventually grew into a rich research project and several papers. His article, "Dynamics of the Baseball-Bat Collision," appeared in the November 2000 issue of *American Journal of Physics* (Am. J. Phys. 68, 979, 2000).

According to Nathan, the complex calculations needed to understand the post-impact speed of the ball must go well beyond treating the bat as a rigid body. The vibrations of the bat are also important, just as they are in many fields of physics. It is the interplay among many factors, including these vibrations, that determines the location of the sweet spot of the bat.

After writing a computer program to account for these many effects, he concluded that a ball will travel fastest off a 34-inch bat if it strikes about six inches from the tip, with the efficiency dropping off quickly in either direction. To test his results, Nathan worked with another researcher, Rod Cross—in Australia, of all places—who recorded the precise speed of a ball connected to a pendulum when it struck various spots on a suspended bat. The agreement between theory and experiment was satisfyingly good and has led to an excellent understanding of how a baseball interacts with a wood bat.

With this much understood, Nathan has recently been tackling more complicated problems, such as the differences between wood and aluminum, the benefits (or not) of a corked bat, the role of friction in inducing spin on the hit ball, and the role of spin in the aerodynamics of a ball in flight. As a result of much of this work, he regularly consults with bat manufacturers and the various governing bodies of the game, such as Major League Baseball, the NCAA, and the Amateur Softball Association.

Another of Nathan's papers, "Characterizing the Performance of Baseball Bats," published in the *American Journal of Physics* (Am. J. Phys. 71, 143, 2003), developed the formalism that has been adopted as the basis for a variety of techniques used by these bodies to characterize and regulate the performance of bats.

And what is the ultimate goal of all this? "Well," says Nathan, "I still have this fantasy that someday the Boston Red Sox will ask me to advise them on baseball bats and that, together, we will finally break the curse." ■

A remarkable photo of the ball and bat just after the collision, showing the bat undergoing a large amplitude bending vibration.

That's the Way the (Soft)ball Bounces!

Spring is in the air, and a physicist's mind turns to… softball! After having a great season in the Urbana Park District League last year, the Physics softball team, the Isotopes—known affectionately by their fans as the *'Topes*—are warming up for 2004.

According to Jeff Reifenberger, one of the team managers, the 'Topes finished the 2003 summer season with a third-place ranking and earned a second-place ranking for the fall schedule. Their overall record in the two seasons was 16 wins and only 5 losses as they outscored their opponents by an average of seven runs.

"We are one of the few teams from a University department," Reifenberger noted. Although he remembers a game against a team from the Chemistry Department, most of the games are played against teams sponsored by local businesses.

"We used to play in the Urbana City League, but they cancelled it this year," he added. "We just signed up for the Champaign City League, so we will be playing this summer, starting at the end of April."

As Reifenberger recalled, the Isotopes first formed in the Summer 2000 season. "Dean Eckhoff and I started coaching the team, and every year we pick up a few players from the incoming class of grad students. Each year we get a little bit better as we get experience and add to the roster." ■

Physics Demos Highlight Engineering Open House

"Engineering Ingenuity Experience!" was the theme for Engineering Open House 2004, which was held on March 12 and 13. Planning and participating in EOH is a memory shared by many Physics alumni, with this edition marking the 84th year in a long tradition. But did you know that EOH was actually started by Physics?

In 1906, the Department of Physics held its first annual open house, becoming the precedent and inspiration for the present-day EOH. The public was invited to Engineering Hall—where Physics was located at the time—to tour laboratories and view demonstrations. The exhibits centered around light, sound, wireless telegraphy, and other electrical operations, featuring lectures on the principles involved.

Today, EOH is one of the largest student-run events at the University of Illinois, showcasing a myriad of engineering marvels and scientific mysteries and teaching a broad variety of audiences about how science and engineering affect their lives.

Lynn Greetis, Physics Society vice president, was the EOH coordinator this year. Physics demonstrations included a "pyrophone," which used a Bunsen burner to heat air inside a series of different-sized PVC pipes, creating a pipe organ powered by fire, and a demonstration of the Coriolis force, where volunteers seated on a rotating board tried and failed to toss a ball into a basket at the center of the pivot. An electromagnetic linear accelerator demonstrated many basic concepts of magnetic machines, and a *Farnsworth Fusion Reactor* allowed audiences to see protons fuse before their very eyes in a working fusion reactor.

In a demonstration of laser computer networking, the students showed how computers can "talk" to each other across a room on beams of red laser light—no wires, fibers, or radio waves allowed! This exhibit demonstrated a new type of wireless communication technology that will become more popular in coming years. As always, the highlight was the *Rube Goldberg Machine*. This year's was a complicated device to answer a ringing telephone. Good thing Alexander Graham Bell didn't use this many steps!

Funding for EOH exhibits comes from the Excellence in Physics fund. For further information about the fund, contact Celia Elliott, cmelliot@uiuc.edu. For the entire EOH 2004 story, visit eoh.ec.uiuc.edu/eoh.cfm. ■

(above left) Physics Society's EOH Coordinator Lynn Greetis demonstrates her Rube-Goldberg telephone answering machine.

(above) Visitors to EOH 2004 watch as Physics Van crew members Jennifer Cutts and Anthony Karmis use liquid nitrogen and balloons to demonstrate how matter changes phase.

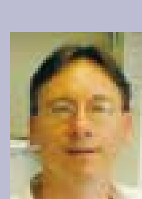
Our New 2003 APS Fellows!

In December 2003, three faculty members and eight alumni were elevated to Fellow status in the American Physical Society. The APS Fellowship Program recognizes members who have made advances in knowledge through original research and publication, or who have made significant and innovative contributions in the application of physics to science and technology. Fellowship may also be granted for significant contributions to the teaching of physics or to service and participation in the activities of the Society. Each year, no more than one-half of one percent of the then-current membership of the Society are recognized by their peers for election to the status of Fellow.

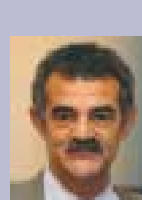
Congratulations!

Faculty

S. Lance Cooper (MS, '84; PhD, '88)
For imaginative use of Raman and other optical techniques to study ordering, spin and charge dynamics, and their couplings to lattice dynamics in strongly correlated electronic systems.



Duane D. Johnson
For theoretical and computational contributions to our understanding of physical properties of disordered alloys that have uncovered the microscopic underpinnings of the thermodynamics and phase transformations of alloys.



Jochen K. Wambach
For fundamental contributions to many-body theory, especially nuclear collective excitations and the pairing gap in neutron stars, and for calculations which explain the excess dileptons in the CERN CERES experiments.

Alumni

Ricardo Alarcon (postdoctoral research associate, 1985–89), Arizona State University
For outstanding contributions to, and leadership in, the development of instrumentation for experiments investigating the fundamental properties of nucleons and few-body systems.

Joe Charles Campbell (MS, '71; PhD, '73), University of Texas, Austin
For leading contributions to the development of high-speed, low-noise, long-wavelength avalanche photodiodes.

Antonio H. de Castro-Neto (PhD, '94), Boston University
For contributions to the theory of strong correlations, fluctuations, and inhomogeneities in high temperature superconductors and quantum magnets.

P. Daniel Dapkus (BS, '66; MS, '67; PhD, '70), University of Southern California
For important contributions to the development of metalorganic chemical vapor deposition and its application to quantum well laser devices.

Rui Rui Du (PhD, '90), University of Utah
For his seminal contributions to the physics of the fractional quantum Hall effect, and especially, through his original experiments, to our understanding of the properties of composite fermions.

Hai Qing Lin (postdoctoral research associate, 1991–95), Chinese University of Hong Kong
For his contributions in developing and applying computational methods to quantum many body systems.

David Paul McGinnis (MS, '83), Fermi National Accelerator Laboratory
For his important contributions to increasing the performance of the Fermilab accelerator complex.

Aihua Xie (postdoctoral research associate, 1987–90), Oklahoma State University
For her outstanding contributions to experimental studies of protein dynamics, in particular the use of time-resolved infrared studies to probe the dynamics of photosensitive proteins.

Faculty News

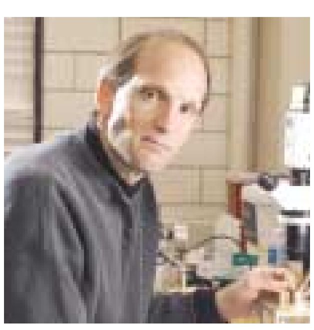
Xerox Junior Faculty Research Award to Bezryadin

Alexey Bezryadin is one of three assistant professors in the College of Engineering to be honored with the 2004 Xerox Award for Faculty Research. The awards, which recognize outstanding research achievements by junior faculty, were presented at the annual Engineering Awards Convocation on April 23, 2004.

Bezryadin is developing innovative fabrication techniques to enable novel investigations of the properties of superconducting systems with dimensions approaching 5 nm, a size scale at which macroscopic quantum effects have a strong impact on superconducting devices. He has fabricated some of the world's tiniest nanowires, loops, and SQUIDs by using carbon nanotubes as substrates for deposited metallic films. New approaches utilizing DNA templates (instead of carbon nanotubes) and a focused electron beam "sculpting"technique have been invented by his group.

Bezryadin's group is currently working on experiments in two critical and related areas of the physics of low-dimensional nanoscale systems: macroscopic quantum phenomena in low-dimensional superconductors at ultralow temperatures and Aharonov-Bohm effects in multiwall carbon nanotubes. In each case, Bezryadin has pioneered novel experimental approaches to probe the behavior of these ultrasmall structures. ■

Cooper Chosen as Sony Faculty Scholar



Professor S. Lance Cooper (MS, '84; PhD, '88) has been chosen as the first Sony Faculty Scholar from the Department of Physics. His three-year term runs from August 2003 to August 2006.

According to Jeremiah Sullivan, "Lance is an outstanding faculty member in regard to all three missions of our University—teaching, research, and service."

Funding for Sony Faculty Scholars comes from a longstanding Sony endowment to the University of Illinois. To be eligible to be a Sony Faculty Scholar, the faculty member must be either an associate professor or a recently promoted full professor. Cooper was promoted to professor in August 2001.

In his nomination letter, Sullivan highlighted some of Cooper's accomplishments and contributions to the Department. "Over many years, Lance has played a leadership role in the development of our new introductory physics courses that are taken by all engineering and physical science students,"Sullivan stated. "He was the original developer of the laboratories for P111: Mechanics. More recently he has been involved in the two, half-semester introductory physics courses P113: Fluids and Thermal Physics and P114: Waves and Quantum Physics.

"Lance's ideas and innovations now reside in many parts of our calculus-based introductory physics sequence. Most recently, Lance has been working with David Hertzog to take over the Physics 398 Introduction to Physics Research sequence that David pioneered."

Cooper's research area is experimental condensed matter physics, where he is an expert in the use of optical probes, including Raman and infrared spectroscopic techniques. His research is supported by both the Department of Energy (DOE) and the National Science Foundation (NSF).

"In a real sense, Lance has taken over the 'optical effects in solids' mantle long carried by his thesis adviser, National Academy of Sciences member Miles Klein,"Sullivan added. Cooper's imaginative use of Raman and other optical techniques to study ordering, spin and charge dynamics, and their couplings to lattice dynamics in strongly correlated electronic systems was recognized by his peers recently when he was elected Fellow of the American Physical Society.

In addition to his teaching and research, Cooper has been an undergraduate adviser for students in the engineering physics curriculum for almost all of his 12 years on the faculty, and he was chief adviser for engineering physics for several of those years as well. He has been a member of the departmental Graduate Student Recruiting Committee, a heavy responsibility according to Sullivan. He also served as chair of the organizing committee of the 50th Anniversary Midwest Solid State Physics Conference that convened on campus in October 2002.

In each future year, Physics will appoint one new Sony Faculty Scholar from its ranks for a three-year term, and the Department of Electrical and Computer Engineering will do the same. Thus, there will be a total of six Sony Faculty Scholars in steady state. ■

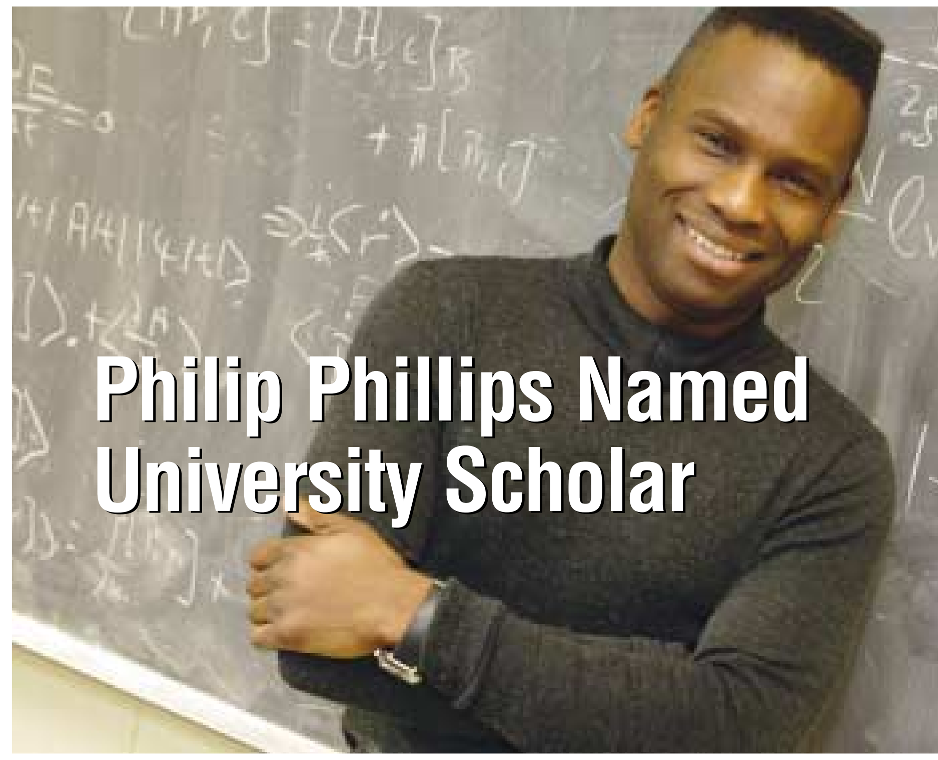


Photo by Bill Wiegand

Philip Phillips Named University Scholar

Professor of Physics Philip W. Phillips has been selected as one of six 2003–04 University Scholars at the University of Illinois at Urbana-Champaign. Now in its 17th year, the program recognizes excellence, while helping to identify and retain the University's most talented teachers, scholars, and researchers.

"A University Scholar designation is the highest honor we bestow upon our young faculty," said Chet Gardner, vice president for academic affairs for the University. "This recognition is especially meaningful since recipients are nominated and selected by their peers. These awards not only acknowledge the superb accomplishments of the recipients, but also symbolize the University's commitment to foster outstanding people and their work."

Phillips' research focuses on one of the central and most highly competitive areas of modern condensed matter theory: the nonperturbative physics of disordered and/or strongly correlated electron systems. His bold and creative theoretical contributions—characterized by their close ties with experiment—have had far-reaching and lasting impact on a broad range of problems in seemingly quite distinct physical systems.

His first major contribution to condensed matter theory was the elucidation of the "random dimer" model. This theoretical mechanism avoided the Anderson localization in low-dimensional solids and explained the unexpected physical behavior of conducting polymers.

A second elegant piece of work was Phillips' investigation of the size dependence of the Kondo problem in magnetic materials, which showed that a previously unrecognized cancellation caused by the feedback of spin scattering on weak localization led to a complete cancellation of the hitherto expected diverging resistivity. Phillips predicted the resulting form of the size-dependent correction to the Kondo resistivity, which was confirmed in subsequent experiments motivated by his work. In further work on the Kondo problem, Phillips showed how magnetic impurities with Kondo temperatures above the superconducting temperature, T_c, can enhance T_c.

A third significant contribution was a novel explanation for the unexpected new conducting phase discovered in a dilute two-dimensional electron gas. Intellectually, this work was a natural extension of his earlier demonstration of how localization can be evaded for the conventional understanding of the 2D electron gas—based on weak localization theory—required that it be an insulator (in the presence of any disorder, as inevitably occurs in real materials). Philips' creative explanation—that this new conducting phase is actually superconducting—has stimulated extensive experimentation and generated considerable debate. Whatever the ultimate solution to this problem, Phillips has played a central role in identifying important experimental issues and subjecting theory to further experimental test.

Most recently, Phillips has woven together all of his earlier work in a remarkable theoretical demonstration that a phase glass is a metal, thus explaining the experimentally observed metallic phase that intervenes between an insulator and a superconductor in thin metal film alloys. This novel theory represents the first time a metallic phase has been shown to exist in two dimensions in the presence of disorder (see cover article).

Throughout his career, Philips has confronted challenging problems on the cutting edge of condensed matter physics, using experiment to inform theory and catalyzing debate on important issues for both. His many contributions were recognized in December 2002 by his election to Fellow of the American Physical Society.

Phillips joins Physics colleagues Douglas H. Beck (2001), David W. Hertzog (2000), Tony M. Liss (1999), and Dale J. Van Harlingen (1998) as the department's most recent University Scholars. ■

The Physics Department Family is Growing… Literally!

Farah Sofia Khadra Willenbrock was born on January 30, 2004, to Associate Professors Aida El-Khadra and Scott Willenbrock. Her proud parents report that Farah is healthy, happy, and keeping them busy and constantly delighted.

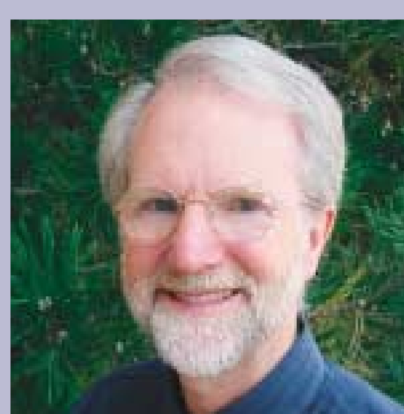
Willenbrock joined the Department in 1993. A specialist in elementary particle theory, he is a world-recognized expert on the physics of high energy colliders, including the physics of the top quark, intermediate vector bosons, and Higgs particles.

El-Khadra joined the department in 1995, and is a leader of one of the most successful lattice QCD groups in the world. She was named a Beckman Fellow in the Center for Advanced Study from 1998 to 1999.

As Willenbrock relates, "We met when we were both working at Brookhaven National Laboratory in 1989, and we married in 1991 when we were both at Fermilab. So it was a national-lab romance."

We're expecting Farah to bring great joy to her parents' (supersymmetric) universe.

Wolfe Receives the 2004 Frank Isakson Prize



At its March 2004 meeting, the American Physical Society (APS) presented Professor James P. Wolfe with the Frank Isakson Prize for Optical Effects in Solids, sponsored by Elsevier Science Ltd. Wolfe was cited *"for contributions to the fundamental understanding of excitonic matter and ballistic phonons in semiconductors, made possible by pioneering development of graphic imaging techniques."* He is considered by many to be the world's leading experimentalist in the subject of optically created excitonic matter. A colleague wrote of him, "He has guru status in a very fractious field and is immensely admired by theorists and experimentalists alike."

In addition to giving an invited lecture at the meeting, Wolfe was feted at the APS Presidential Reception honoring this year's award recipients.

Wolfe is a professor of physics and an investigator in the Frederick Seitz Materials Research Laboratory. He received his bachelor's and doctoral degrees in physics from the University of California, Berkeley. He remained at Berkeley as an assistant research physicist in Carson Jeffries' group, where he and co-workers studied excitons in semiconductors and obtained the first photograph of an electron-hole droplet. He joined the Department of Physics at the University of Illinois in 1976.

Wolfe's research group pioneered techniques to image diffuse clouds of electron-hole droplets and discovered striking anisotropies in droplet transport caused by a "phonon wind." Using optically calibrated strain gradients, they measured mobilities of droplets and excitons, they extracted thermodynamic properties of excitonic matter employing strain-confinement techniques, and they developed time-resolved-imaging methods to characterize the transport of photoexcited carriers in bulk crystals and quantum wells.

His group also devised a method to image ballistic phonons directly. Phonon imaging has since provided graphic insights into such topics as phonon focusing, lattice dynamics and ultrasound propagation. The method has been used to study the scattering of phonons from electrons, interfaces, superlattices, and defects, as described in his book, *Phonon Imaging* (Cambridge, 1998).

Wolfe is a Fellow in the American Physical Society. He has directed multi-investigator research grants for the National Science Foundation (1991–95) and the Department of Energy (1989–91) at the Frederick Seitz Materials Research Laboratory. He received a Senior Scientist Award of the Alexander von Humboldt Foundation in 1989 and a Japan Society for the Promotion of Science Fellowship in Japan in 1991. Between 1999 and 2002, he served as the department's associate head for graduate programs. Most recently, he has been heavily involved in the curricular revisions for Physics 113–114.

Wolfe joins fellow faculty member Miles V. Klein and alumnus David E. Aspnes (PhD, '65) as recipients of the prestigious Frank Isakson Prize. ■

Guggenheim Fellowship Awarded to Hertzog

Professor of Physics David W. Hertzog has received a prestigious Guggenheim Fellowship for the 2004–05 academic year. He will use the fellowship for extended, focused research on two high-profile projects in precision electroweak physics, μLan and *g*–2.

Hertzog is the co-spokesman and creator of the μLan project at the Paul Scherrer Institute (PSI) in Villigen, Switzerland. This experiment is designed to determine the Fermi constant, G_F, (the weak interaction strength) by a measurement of the muon lifetime to a precision of 1 ppm, a 20-fold improvement over previous efforts.

The μLan experiment is simple in concept. A stream of approximately 20 muons is brought to rest in a thin target during an accumulation period of several microseconds. The muon beam is then "switched off," and decays are recorded by a surrounding detector during a measuring interval lasting approximately 10 muon lifetimes (22 μs). This cycle is repeated until more than 10^{12} decays are recorded. The time-structured muon beam is created artificially at PSI by a new custom kicker.

During the measuring interval, the Michel positrons are recorded by a multi-segmented, symmetric spectrometer, which features 170 independent scintillator tile pairs arranged in an icosahedral geometry. Each element is read out by a photomultiplier tube whose signal is sampled at 500 MHz by a dedicated waveform digitizer. The time of arrival and energy deposited in each tile are derived from a fit to the signal shape. Decay time histograms are constructed from coincident hits and are then fit to extract the lifetime.

Hertzog will also work on a proposal for a suite of modest upgrades to extend the reach of Brookhaven National Laboratory (BNL) experiment E821, the groundbreaking *g*–2 experiment. The upgrades would allow researchers to reduce the uncertainty on the muon anomalous magnetic moment measurement by a factor of 2. The improvements will be aimed at increasing the data rate; the current configuration requires an unacceptably long run to increase the statistics. Hertzog has been a central collaborator on E821 and expects to take on a greater leadership role in the future effort.

The John Simon Guggenheim Memorial Foundation was established in 1925 by United States Senator Simon Guggenheim and his wife as a memorial to their son. The Fellowships are awarded to men and women who have already demonstrated exceptional capacity for productive scholarship or exceptional creative ability in the arts. ■

(left) Members of the μLan team with the partially assembled detector built at illinois (counterclockwise from top left), Andrea Sharp, Brendan Kiburg, David Hertzog, David Webber (seated), Dan Chitwood.

(above) David Hertzog is pictured looking through the exterior of the novel μLan detector, which was designed and fabricated at Illinois before being shipped to Switzerland last fall.

Answer to the Physics Quiz on Page 2

How Many Laureates? Seven! Besides Tony Leggett, Chen Ning Yang, who was a postdoctoral research associate in 1952–53 (along with T.D. Lee), returned as a visiting professor in 1964. John Bardeen, two-time laureate, was of course a professor of physics from 1951 until his death in 1991. Emilio Segrè was a visiting professor (1951–52), as was Murray Gell-Mann (1952–53). J. Robert Schrieffer, who received his PhD from Illinois in 1957, was an assistant professor from 1959 to 1961 and an associate professor in 1962. And Norman Ramsey, winner of the 1989 Nobel Prize in Physics, came to Illinois in September 1940 as an assistant professor, intending to spend the rest of his life here (see www.nobel.se/physics/laureates/1989/ramsey-autobio.html). He left for "temporary" war-related work at the MIT Rad Lab in November, never to return—the shortest "permanent" appointment in departmental history.

Other Nobels associated with the department are Wheeler Loomis' student, Polykarp Kusch (PhD, '36), Maurice Goldhaber's student Rosalyn Sussman Yalow (PhD, '45), and postdocs Murray Gell-Mann (1951), T.D. Lee (1952–53), Leon Cooper (1955–57), Sir Peter Mansfield (1962–64), Tony Leggett (1964–65), and Brian Josephson (1965–66).

Education and Outreach

Saturday Astrophysics Honors Program Debuts

Working through the UI Center for Theoretical Astrophysics (CTA), the Physics Department—together with the National Center for Supercomputing Applications (NCSA) and the Department of Astronomy—presented a new Saturday Astrophysics Honors Program for high-school students this spring. The new program is modeled on the very successful Saturday Physics Honors Program that has just completed its eleventh year (see article in *Physics Illinois News,* 2003, No. 2).

"This new program is intended to stimulate the curiosity of high-school students interested in the physical sciences," stated Professor Susan Lamb, who is administering the program. "It will have a strong emphasis on astrophysics, particularly those topics amenable to exploration and modeling using computer simulations."

"We intend to hold this lecture series each spring, to complement the Saturday Physics Honors Program that takes place in the fall," Lamb added. Although the program is designed for high-school students, it is open to the general public—including teachers, parents, or siblings—so students can participate as a class, individually, or with their families. Prior knowledge of physics, astronomy, or computing is not necessary.

Topics for the Spring 2004 lectures and their presenters were:

Exotic Objects of the Cosmos: Neutron Stars, Pulsars, and Black Holes
Professor Frederick Lamb, Physics and Astronomy

Astrophysics in the Early Universe: Ingredients of the Primordial Soup
Professor Brian Fields, Astronomy and Physics

When Galaxies Collide: Star Formation and the Feeding of Black Holes
Professor Susan Lamb, Physics and Astronomy

The Formation of the Largest Objects in the Universe
Professor Paul Ricker, Astronomy and NCSA

The inaugural series, which ran from February 14 to March 13, also included a tour of the NCSA Visualization Facilities and an introduction to NCSA by Dr. Radha Nandhumar. Abstracts of the lectures can be downloaded from the website www.physics.uiuc.edu/Outreach/CTAhonors/index.html. ■

George Gollin Receives 2004 Scott Rose Award for Teaching Excellence

Professor George D. Gollin, a high-energy experimentalist who has served on our faculty since 1989, has received the 2004 Rose Award for Teaching Excellence. The award is intended to foster and reward excellence in undergraduate teaching in the College of Engineering. In endowing the award, Scott Rose (BS, Computer Engineering, '87) said, "Good teaching is crucial to the development of exceptional engineers. I want the award to recognize teachers who excel at motivating undergraduate students to learn and appreciate engineering."

Gollin was recognized for his work in tackling the problem of the wide variation in the preparation that engineering students bring to our introductory calculus-based physics sequence each year. Some students, who come from large urban schools, often take two high school physics courses; others, from smaller rural schools, may not have had any physics at all. (More than 20 percent of the high schools in Illinois do not even offer physics, and of those that do, more than 50 percent of the classes are taught by teachers whose primary certification is in a field other than physics!) While our faculty recognized early on that the underprepared students needed assistance to be successful in the introductory physics classes, it took Gollin's insight to recognize that the "overprepared" students needed attention, too.

Gollin thus created an "honors" section to complement the introductory electricity and magnetism course, Physics 112. In his course description, George writes, "Electrodynamics is a beautiful subject which has, at its heart, the fever-dream alienness of special relativity. The subject offers students their first opportunity to see how profoundly different physical reality is from our familiar (and grossly inaccurate) classical world." For a snapshot of George's breezy, engaging approach to physics teaching, review his "Special Relativity in 14 Easy (Hyper)lessons" (http://web.hep.uiuc.edu/home/g-gollin/relativity).

George's initiative—and the extremely positive response of the students who took his course—nucleated the successful creation of honors sections for Physics 111, General Mechanics, Physics 113, Thermodynamics, and Physics 114, Quantum Mechanics. His own teaching excellence has stimulated his faculty colleagues to reproduce his success in their own courses.

Gollin received his PhD in physics from Princeton University in 1980, after having received an AB in physics from Harvard in 1975. He was a McCormick Fellow at the University of Chicago from 1980 to 1982, and served as an assistant professor at Princeton from 1983 to 1989. He came to the University of Illinois as an associate professor in 1989, and was elevated to full professor in 1996. ■

CAPE Award

Dennis J. Kane (BS, '72), senior' specialist in automated education, was presented with a 2004 Chancellor's Academic Professional Excellence (CAPE) Award at a special ceremony on April 7. As the sole author of the software that drives our web-based interactive physics courseware, Kane has made deep and lasting contributions to the fundamental educational mission of our department through his creativity, insight, persistence, and plain hard work.

The new introductory-physics pedagogy pioneered at Illinois has replaced the didactic teaching tools of lecture and textbook with interactive computer-assisted methods that promote collaborative learning, improve communication skills, and develop higher-order thinking competencies. It was Kane's job, nearly single-handedly, to figure out how to do all of this for nearly 2000 students each semester, incorporating faculty ideas about conceptual course content into innovative instructional methods that TAs could master and undergraduates could understand.

Drawing on his extensive, more than 25 years' experience with computer-aided physics instruction, gained first with PLATO and then with Nova-Net, Kane has created two key pieces of educational technology software: the "Physics" *Gradebook* and *Tycho,* an intuitive software suite for delivering, grading, recording, and analyzing student coursework, including our new "Socratic dialogue" interactive homework problems.

Working on his own, Kane created the Physics web-based *Gradebook,* which is being used, as of this semester, in the 20 or so large-enrollment physics, chemistry, and biology courses and in many smaller courses on this campus, involving more than 8000 students and 40 faculty.

A second remarkable Kane achievement is *Tycho,* an integrated suite of software drivers, forms, and databases that, among other uses, allows students to complete physics coursework online. In addition to traditional homework problem sets, Kane has worked with faculty to develop variations to meet specific instructional objectives—on-line quizzes, which students complete asynchronously, at their own pace at their own time, and "preflights," pre-lecture quizzes that allow instructors to determine the baseline of student understanding and misconceptions prior to delivering a lecture. Economics Professor Larry DeBrock, himself an experienced practitioner of computer-based instruction, enthusiastically remarked about *Tycho,* "Denny Kane is the Michael Jordan of computer-based education."

Tycho has been enthusiastically adopted not only by our own faculty, but also by physics departments around the state and across the country. Every day, more than 1800 students in 34 separate courses at 14 institutions log on to the Internet to do their homework or take the quizzes and exams that their instructors, with Kane's assistance, have placed on a server located here in our department. In addition to many Illinois community colleges and undergraduate institutions, users include physics departments at Cornell, Rochester, and the Ohio State University. Kane has also helped set up *Tycho* servers at Purdue, the University of Washington, Seattle, and the University of Wisconsin, Madison.

The annual CAPE Award winners are selected for their outstanding contributions in their professional fields, work units, and the campus and for the positive impact each has had on colleagues, students, and the public. Denny Kane's award is long overdue. ■

Physics is Easy as "1-2-3"

"The point of Physics 123 is to give future elementary school teachers some knowledge and confidence in basic physics," explains Professor Mats Selen. The class, which is being taught for the first time this spring, is designed for students in elementary education and early childhood education.

"We interact a lot with elementary teachers and realize that many have a minimal background in science. As a result, we have found that teachers in the primary grades often shy away from science, even in the way they answer questions. If teachers think science is hard, their students get that same message, and it sets that idea in their minds."

"Our goal is to help them learn some physics and have a good experience," Selen explained. His enthusiasm is infectious. "This class is very inquiry-based, and we make up many of the lessons as we go along—based on what the students know and how they learn. That does make it a lot of work, but it is also a lot of fun."

And speaking of "fun," don't be surprised to see some Play-Dough figures in the middle of his office desk—destined to be his version of Letterman's regular "Will It Float" sketch. "Each week's session is totally driven by what the students do," he said. "I design the Wednesday (lecture-discussion) class based on what they do. It is absolutely the most fun of any class I have ever taught."

Although he describes the format as somewhat "free-form," there is a definite structure. Over the course of the semester, students cover a variety of concepts and principles, such as "Uncertainty and the Nature of Science," "Properties of Matter," "Forces, Motion, and Machines," and "Electricity and Magnets."

According to Selen, "We do a three-hour lab at the beginning of each week, where they work in groups of four doing hands-on projects—things they will be able to keep and use later in their teaching to demonstrate principles. By the time they leave the lab, they have figured out a bunch of concepts that they can use later." In addition to the weekly lecture-discussion, Selen listens to his students and monitors their progress through on-line quizzes, later devising demos to fill in the gaps.

As a final project, class members work in groups of four to create a 30-minute hands-on lab that they will administer to their classmates as though they were an elementary school class. Project preparation includes a complete lab write-up for students, teacher's notes explaining the procedure and the physics, and a list of materials needed to do the lab.

Since coming to Illinois, Selen has been a prime mover behind the massive curriculum revision of the calculus-based introductory physics courses (Physics 111–114), and he was the first lecturer in the new sequence. Sharing his enthusiasm for physics often takes Selen outside the classroom.

Ten years ago, he started the Physics Van, the Department's award-winning community outreach program (see article in *Physics Illinois News* 2003, No. 2). And every Wednesday he is featured as the "Whys Guy" on Champaign's CBS affiliate, WCIA Channel 3. In his made-for-TV demonstrations, Selen crushes, smashes, and blows up objects as a way to teach basic scientific concepts to an often-intimidated public. (See his video clip archives at www.whysguy.net.) ■

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EDITOR
Celia M. Elliott

COPY EDITOR AND PRODUCTION
Rick Kubetz

ART DIRECTION & DESIGN
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cmelliot@uiuc.edu
(217) 244-7725

Physics Illinois News
215 Loomis Laboratory of Physics, MC-704
Department of Physics
University of Illinois at Urbana-Champaign
1110 West Green Street
Urbana, IL 61801-2982 USA

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2004 Collins Award for Innovative Teaching to Gary Gladding

Professor of Physics Gary E. Gladding has received the 2004 Collins Award for Innovative Teaching for his development of asynchronous, web-based interactive lectures for Physics 100. The award is named after W. Leighton Collins, a faculty member in the College of Engineering at Illinois from 1929 to 1965, who was a pioneer in the American Society for Engineering Education and helped shape engineering instruction in the United States. It recognizes outstanding development or use of new and innovative teaching methods.

Originally offered in 1999, Physics 100 is designed to give underprepared students the skills, problem-solving strategies, and confidence to be successful in the calculus-based introductory physics sequence. (See article in *Physics Illinois News* 2003, No. 2.) Gladding has continued to refine the course over the past five years, based on student requests and outcomes. Predictors have been developed for at-risk students, and follow-up and additional supportive assistance—in the form of added optional discussion sections based on the Physics 100 model—have been provided to Physics 100 "alumni" as they move through general mechanics, E&M, thermodynamics, and waves and quantum physics.

The results have been spectacular; drop-out and failure rates have been more than halved for minority students taking Physics 111, and Physics 100 alumni, who were more at-risk for failing Physics 111, perform as well or better than the average Physics 111 students.

Despite these successes, one problem seemed intractable. The Physics 100 students repeatedly requested that a lecture section be added to the course, but because the half-semester course is deliberately scheduled to start in mid-semester, it was impossible to find a common time for all 120 students who typically enroll. Gladding thus turned again to the web and developed a series of interactive lectures incorporating audio commentary and controlled navigation that students "attend" prior to their weekly tutorial sessions.

The most innovative features of the lectures are the interactivity and controlled navigation. At three or four points in the lecture, a question is presented that the student must answer correctly before he or she can proceed to the next slide. If an incorrect answer is submitted, a Socratic dialogue is initiated, whereby a series of simpler questions are posed that lead the student to the correct answer and reinforce concept-based problem-solving strategies.

To fully appreciate these lectures (and brush up on Newton's laws), try them yourself. Go to http://online.physics.uiuc.edu/courses/phys100/fall03, and click on the "Log In" link; when prompted, enter **phyug/guest** as your netid and **guest** as your password. Once you have successfully logged on, you will be returned to the course homepage, where you click on "Lectures" to access the lectures. Gladding has created eight of these interactive lectures, which were introduced in Fall 2003, to overwhelmingly positive student response.

Gladding, a high energy experimentalist, joined the Department as an assistant professor in 1973, after receiving his PhD from Harvard in 1971. He is currently involved in experiments using the silicon vertex detector (CLEO II) at the Wilson Synchrotron Laboratory at Cornell University to study charmed meson decays, and he leads the Physics Education Research Group at Illinois. ■

"Physical Revue: XXX Preprints"

The ESB theorists, thwarted in their nefarious attempt to retake Loomis, look on the bright side—they still have the ultimate espresso machine. (left to right, Mike Stone, Philip Phillips, the espresso machine, Tony Leggett, Paul Goldbart, Eduardo Fradkin)

On the evening of December 11, 2003, the Illini Union Ballroom was once again transformed by the far, far off-Broadway production of Physical Revue—XXX Preprints. The annual extravaganza of skits, spoofs, and music, created by physicists for physicists, is traditionally held the Thursday before fall semester final exams and showcases student and faculty talents (or appalling lack thereof) in the performing arts.

Master of Ceremonies Eric White—who masquerades as a graduate student most days—opened the show, introducing music by Rodeo Girl Collective, poetry by Don Ginsberg—a regular feature at PR—and "The Prelim" (Towards a Transformative Hermeneutics in Bovine Field Theory) by the Wild and Crazy Physicists. Lyn Leithliter joined Mats Selen in "The Whys Guy Song" and The Regulars+1 offered their contribution of "Applied Humor."

The smash hit of the evening was the first-ever physics animated movie, created by Soren Flexner, Eric White, Joshua Rubin, and Aaron Andrus, "ESB II: The Theorists Strike Back." Chronicling the on-going saga of the diaspora of the condensed matter theorists who were exiled to the Engineering Sciences Building in 2003, the movie reveals their twisted machinations to retake Loomis, which are heroically thwarted by Mike Weissman and a rag-tag band of courageous graduate students. Although the movie was unaccountably overlooked at the 2004 Oscars, we're hoping it will make Roger Ebert's local film festival some year.

Performances included nods to Tony Leggett in "Nobel Time," and "Are You Sure Leggett Done It This Way?"; unfortunately Tony was in Stockholm at another engagement and missed the show, which was probably just as well. Other acts included "I Got Funding," a little tune by G Clef and h-bar (Laura Greene and Ian Hobson), a sparkling piano solo by Ed Rogers, and a selection of physics haiku, including "The Road Not Taken" *(Once I lost myself/GPS notwithstanding/Physics did not help).*

You can see highlights of the show at www.physics.uiuc.edu/people/PhysicalRevue/2003. ■

Nigel Goldenfeld (center) reveals himself as the evil genius behind the theorists' plot to retake Loomis. Mike Weissman (left), Alan Nathan (right), Steve Errede (mask), and Paul Kwiat (bow tie) look on. The heroic graduate students who, led by Mike Weissman, will save the day are shown on the left.

Physics Illinois

not a place, a habit of mind…

Department of Physics
University of Illinois at Urbana-Champaign
215 Loomis Laboratory of Physics
1110 West Green Street
Urbana, IL 61801