QUANTA

Newsletter of the Department of Physics and Astronomy

www.physics.iastate.edu

Iowa State University

Vol. 1, No. 2–Summer 2005

In This Issue

WELCOME BACK

We hope that you'll like this second issue of *QUANTA*. We're planning to make this newsletter a semiannual publication, and we'd like to hear your comments and suggestions.

This issue introduces three more of our newer faculty members. The term *newer* is relative, since over one-third of our faculty have joined us within the last seven years!

Providing the resources, facilities and atmosphere to allow our department to flourish is an exhilarating task, but one that has become more challenging with the decline in state support for the university in recent years. State appropriations have dropped from about 40 percent of the total revenues in 1999-2000 to less than 30 percent in 2003-2004. However, our sponsored research funding remains strong, up about ten percent over the previous year. Although the largest share of support comes from the U.S. Department of Energy and the National Science Foundation, we also have funding from the National Aeronautics and Space Administration and a significant grant from the National Institutes of Health in support of our new research initiatives at the boundary of physics and biology.

Quality space remains a very high priority. The renovation of our two large lecture halls (Rooms 3 and 5 Physics Hall) is nearing completion. Pictures of the work can be viewed on the Web (www.physics.iastate.edu/index.php?cmd=reconstruction). The effort is on schedule, and we expect to be able to occupy these rooms before the start of the fall semester. Beyond this much-needed upgrade in our teaching facilities, our next infrastructure priority is an expansion of space for faculty and graduate students. We'll have more details about this need in the next issue.

We're broadening our outreach activities to better communicate with our public constituency. In collaboration with the Ames Laboratory, members of our department have participated in the World Year of Physics, a celebration of the 100th anniversary of the publication of Einstein's seminal papers on special relativity, Brownian motion,

Eli Rosenberg

and the photoelectric effect. The goal of the World Year of Physics is to increase public awareness of the physics profession, and to this end Laurent Hodges, Paul Canfield, and I have given presentations to various

public gatherings on topics ranging from solar energy and low-temperature phenomena to the physics of baseball. More of these talks are planned later this year.

Our last issue included the sad news of the death of Dan Zaffarano, former department chair, dean of the graduate college, and vice president for research. Shortly after his death, the Iowa Board of Regents approved a proposal to rename the Physics Addition, completed in 1968, in Dan's honor. Dan was a driving force in the funding and construction the five-story building, which will now be known as the Zaffarano Physics Addition. A dedication ceremony is planned for September 21, 2005.

We appreciate your interest in the department and our people. I would love to have the opportunity to visit with you in Ames and share with you the enthusiasm of our faculty, students and staff. We look forward to hearing about your activities and your thoughts. Thanks for your support! Q

LASTING IMPACT

Joseph Shinar has developed an international reputation in organic light emitting devices.

It's just a matter of time before organic light-emitting devices (OLEDs) become major players in the display and general lighting industries. OLED-based displays are more efficient, much brighter, and have a much larger viewing angle than liquid-crystal displays (LCDs).

In 1999 Pioneer stereos became the first commercial products to incorporate OLEDs. Motorola cellular flip phones have also used the technology. Electronics manufacturers are already producing demonstration versions of OLED-based televisions. The new TVs are expected to begin appearing in stores within two years.

Joseph Shinar, professor of physics and astronomy and a senior physicist with the Ames Laboratory, thinks that major commercialization of OLED technology is almost here. When that time comes, the consumer can thank Shinar and his research group for helping to pave the way. Colleagues have described Shinar as a pioneer with a strong national and international reputation in OLEDs.

"Our effort is very strongly interdisciplinary in nature," Shinar said. "We work on three different areas: on the basic physics of organic semiconductors, which are the building blocks of OLEDs; on the applied physics of OLEDs; and on the development of OLED-based luminescent chemical and biological sensors."

In the basic physics area, Shinar's group strives "to improve our understanding of OLED material and the OLEDs themselves, particularly their efficiency, stability and potential for other applications. "We're interested in the basic scientific issues that have immediate impact on this emerging technology," Shinar said.

In the applied physics area, Shinar pushes the envelope to make more efficient, brighter, and longer-lived OLEDs. To this end, he has developed and studied novel intense white OLEDs (WOLEDs), demonstrating some of the brightest WOLEDs in the world.

In the sensor area, Shinar and his wife Ruth, a scientist with the Microelectronics Research Center (MRC), have collaborated to structurally integrate OLEDs into luminescent chemical and biological sensors. "This has become a family project," he said. "I take the lead in supervising the development of the OLEDs for use in conjunction with the sensing elements, and Ruth takes the lead in supervising

Joseph Shinar

the development of the sensing elements for use in conjunction with the OLEDs."

The team is developing OLED-based glucose and hydrazine sensors for NASA. In addition, they are collaborating with Vikram Dalal, MRC director, and Louisa Tabatabai, professor in biochemistry, biophysics and molecular biology and the National Animal Disease Center (NADC), under two National Science Foundation grants. One of the grants covers the development of an anthrax sensor. The other NSF award funds the development of a new sensor platform integrating the photodetector for the sensors with the OLEDs and the sensing element.

The Shinar-Tabatabai collaboration has also extended to the nation's food source. Together with Kelly Lager of the NADC, they have received funding to develop field-deployable OLED-based sensors for porcine respiratory and reproductive syndrome virus (PRRSV), which causes $600 million damage annually to the U.S. pork industry.

Shinar has received three U.S. patents, including one in 2001 on the new integrated OLED/fluorescent chemical sensor platform. He has more than 190 scientific publications, and his work is highly cited in the literature, averaging over 300 citations per year.

Last fall, Shinar was named one of two recipients of the ISU Foundation Award for Outstanding Achievement in Research.

REACHING A BROADER AUDIENCE

***Two Ames Laboratory physicists review progress in superconductive MgB_2 in* Scientific American.**

Two members of Iowa State University's Department of Physics and Astronomy have had an article highlighted in the April 2005 issue of *Scientific American*. Paul Canfield, professor of physics and astronomy, and Sergei Bud'ko, scientist with the U.S. Department of Energy's Ames Laboratory, are the co-authors of "Low-Temperature Superconductivity is Warming Up." Canfield is also a senior physicist with the Ames Laboratory.

The article reviews progress in magnesium diboride (MgB_2), which Canfield says "defies the once-conventional wisdom about what makes a good superconductor. It becomes superconducting near the relatively warm temperature of 40 Kelvins, which opens up a variety of applications."

Canfield, Bud'ko and other physicists at Iowa State have been involved with research in this area since early in 2001. That's when a group of Japanese researchers originally discovered superconductivity in MgB_2. The Japanese researchers have since moved onto other projects, but the Canfield group at Iowa State has continued to publish on the process.

They aren't the only ones. Canfield says numerous other research groups have focused on the topic for

Paul Canfield and Sergei Bud'ko

several reasons, including the simplicity of making relatively pure MgB_2. But Canfield's group has amassed at least 50 publications on this research activity. Although most are in traditional scientific journals, the group has reached out to a broader audience to publicize this exciting development at Iowa State University. In addition to the *Scientific American* article, the work has been published in *Physics World* and *Physics Today*. Canfield says additional publications could be in the offing.

"On the whole, the future for magnesium diboride looks quite promising," he added. "The discovery of superconductivity in magnesium diboride is like the discovery of an outlying island in a well-explored archipelago. We do not know if this is the final member of the chain or if yet another surprise awaits us out there."

UNDERGRADUATE COMRADERY

The Physics Club takes education out of the classroom.

With about 80 undergraduate physics majors, the Iowa State University Physics Club is very much alive. Aside from the social dimensions that this organization adds to the students' experience, the club also provides opportunities to assimilate physics outside the conventional curriculum.

The group's activities over the past year included a public lecture visit last fall by Brian Greene, author of *The Elegant Universe*. Club members screened his *NOVA* television series on the subject and then met privately with Dr. Green. Physics Club chair Rachel Wilkens hosted him during the visit. As part of the World Year of Physics celebration, the club also sponsored an exhibition at the Ames Laboratory/Iowa State University Science Bowl in January.

Many physics and astronomy alumni reading this newsletter may recall one of the highlights of their undergraduate experience to be a visit to the national laboratories in the Chicago area. Since memories like this are more vivid when recounted through the eyes of a student, the following narrative is Rachel Wilkens' description.

"On April 9, eleven members of the Physics Club visited Fermilab, accompanied by faculty co-adviser Jim Cochran. Fermilab is currently the site of the world's most powerful accelerator, the Tevatron, which collides protons and antiprotons at a center-of-mass energy of 1.96 TeV. Although the visit did not delve too deeply into the physics, we obtained a general flavor of research in high-energy physics.

"The tour began with a visit to Wilson Hall, a cathedralesque building housing the offices of many administrators, engineers, and scientists, as well as a 15-story Foucault pendulum.

Jim Cochran and some Physics Club members at Fermilab

"After touring the public displays, the group visited the site of a 'virtual control room' currently under construction for the upcoming Compact Muon Solenoid (CMS) experiment, which will begin taking data in 2007 at CERN in Geneva, Switzerland. This facility will allow Fermilab scientists to participate remotely in the data collection of the CMS experiment. Next we visited the control room of the NuMI (Neutrinos at the Main Injector) experiment, which studies the behavior of a neutrino beam that travels 450 miles from Fermilab to a detector in a mine in Minnesota in order to understand the nature of neutrino masses and mixing.

"The visit to the area around Wilson Hall concluded with a tour of the first few the laboratory's seven accelerators, the main control room for the entire accelerator complex, and the proton therapy cancer treatment facility.

"We then toured the NuMI experiment site located about two miles from Wilson Hall and traveled to the site of the DZero experiment, one of two large general purpose detectors that study the debris from high-energy proton-proton collisions.

"The Fermilab excursion concluded with a visit to the now-retired 15-foot bubble chamber, one of the largest ever constructed. The device was a primary trajectory analysis tool of high-energy physics from the 1950s through the 1980s."

As undergraduate enrollment takes on an even higher priority in the Department of Physics and Astronomy, the Physics Club will play an increasingly important role in the development and retention of physics majors, adding extra dimensions to their life and education on and off the campus. **Q**

ADVANCING SCIENCE

Xiaofeng Guo takes advantage of the National Science Foundation ADVANCE program.

After graduating from Iowa State with a Ph.D. in physics, Xiaofeng Guo took the traditional route of many researchers: a post-doctoral fellowship. But after spending two years at Columbia University and another two years at the University of Kentucky, Guo came back to Iowa State and taught, off-and-on, as a part-time instructor while taking time off for the birth of her son.

During this time frame, Guo was unable to focus on her research as much as she would have liked. "I didn't really quit," she said. "I certainly continued to follow my field and kept up with the forefront of the research. I was thinking about physics but just didn't have enough time to devote to physics problems."

So when an announcement from the National Science Foundation (NSF) for the ADVANCE program was forwarded to her, she jumped at the opportunity.

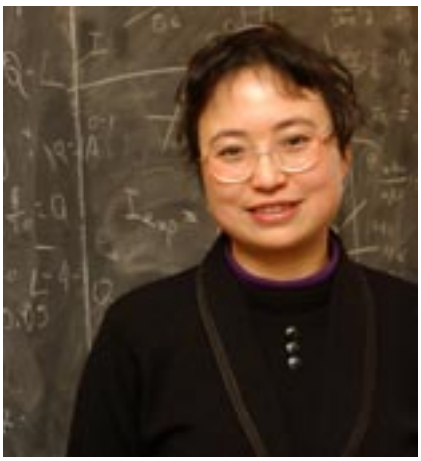
The NSF ADVANCE program seeks to increase the participation of women in the scientific and engineering workforce through the increased representation and advancement of women in academic science and engineering careers. The ADVANCE program offers opportunities for both individuals and organizations in the form of fellow awards, institutional transformation awards and leadership awards. Each award supports new approaches to improve the climate for women in U.S. academic institutions and to facilitate women's advancement to the highest ranks of academic leadership.

"I looked at the announcement and thought I was a good fit for the fellow award," Guo said. Evidently so did the NSF. Last April Guo was awarded a three-year, $395,000 ADVANCE fellow award for her proposal "Multiple Scattering in QCD [Quantum Chromodynamics] and Medium Effects in Relativistic Heavy Ion Collisions."

Guo, now an affiliate assistant professor in physics and astronomy, is investigating the dynamics of the strong interaction force. In particular, she's looking at the properties of hot and dense matter produced at the newly built Relativistic Heavy Ion Collider at Brookhaven National Laboratory in New York and the future Large Hadron Collider at CERN in Switzerland.

When heavy ions collide at extreme energies, conditions become favorable to create a quark-gluon plasma, the state of matter that existed in the first microseconds after the birth of the universe. "By studying the quark-gluon plasma, we can gain new insights to the early universe and the relationship between the most fundamental constituents of matter, as well as the complex array of particles and nuclei that make up the world around us today," Guo said.

A theoretical physicist, Guo will focus her research on multiple scattering in dense nuclear matter. She is working closely with the Nuclear Physics Theory Group. "I will calculate and predict various particle spectra and particle-particle correlations that can be observed at Brookhaven and CERN," she said. "Measuring such spectra and correlations will help experimentalists to discover the quark-gluon plasma and enable us to study its properties."



Xiaofeng Guo

In addition to her proposed research, Guo hopes to serve as a model and mentor for women physics students. "By doing that I hope to encourage young women to participate more in science," she said. Q

GET INVOLVED!

- ***Get the latest news*** on our research, education programs, faculty, and alumni at www.physics.iastate.edu.
- ***Get in touch.*** We welcome your suggestions and comments! Let us know what you think about this newsletter, about current initiatives in the department, and about ways that we could help you. Please contact Eli Rosenberg, department chair, redmount@iastate.edu, or Mark Fleming, editor and chair of the Physics and Astronomy Council, stratondmd@aol.com, with your thoughts or questions.
- ***Keep us posted*** on your career, interests, family, and contact information by updating your profile at www.physics.iastate.edu.
- ***Dig deeper.*** Are some of our initiatives of interest to you and your organization? Please contact Eli Rosenberg to arrange a briefing with the appropriate people, either by telephone or in a personal visit on campus.
- ***Contribute your time, talent, or resources.*** We could use your experience, perspectives, and hands-on help in some of our initiatives. We also welcome financial donations, either unrestricted or designated for any of a number of areas of need, including scholarships, awards, and facility improvements (see page 7).

EXPANDED HORIZONS

New faculty members contribute to the department's growing research thrusts in biological and strongly correlated systems.

The winter 2004-2005 issue of *QUANTA* introduced three scientists who joined the Department of Physics and Astronomy during the academic year 2003-2004. This issue features three more additions to the faculty over the past year.

Edward Yu, assistant professor of physics and astronomy, came to Iowa State University in 2004 from the University of California, Berkeley. He received the Ph.D. degree in 1997 from the University of Michigan, Ann Arbor, where he studied quantum mechanics and spin-spin interactions in metalloproteins. As a post-doctoral fellow at Berkeley, he used x-ray crystallography to study the structures

Edward Yu

of cellular membrane transporters.

Edward's current research focuses on the structural basis of multi-drug resistance in multi-drug membrane transporters. Because they recognize a number of structurally unrelated toxic compounds and actively extrude them from cells, these multi-drug membrane transporters interfere significantly with cancer chemotherapy and the treatment of bacterial infections. Dr. Yu's long-term goal is to elucidate the structures and fundamental mechanisms that give rise to multiple drug recognition and extrusion in these multi-drug transporters. Using x-ray crystallography and site-directed mutagenesis, he studies the structure and functional relationship of these membrane transporters. This information is expected to help in the redesign of old drugs and the development of new drugs as well as combinations of two or more drugs for greater effect.

As a step in elucidating the mechanism of drug recognition in these membranes, Edward has recently determined the x-ray structures of the bacterial multidrug efflux transporter AcrB in the presence of four structurally dissimilar agents [*Science* 300, 976-980 (2003)]. These are the first structures of any transporter in a complex with a variety of ligands that have been solved by x-ray crystallography.

Edward's research is supported by the National Institutes of Health.

Adam Kaminski received the Ph.D. degree from University of Illinois at Chicago in 2001 and spent a year on a postdoctoral fellowship there. In 2002 he received a Royal Society U.S. Research Fellowship to perform research in the United Kingdom. He joined the Department of Physics and Astronomy of Iowa State University in 2004 as assistant professor.

Adam's research is focused on the electronic properties of strongly correlated materials. Strong interactions between electrons in these materials give rise to many fascinating properties, such as high-temperature superconductivity, colossal magnetoresistive effects, and metal-insulator transitions.

Adam Kaminski

The strong interactions make it difficult to understand the physics of these materials in the framework of perturbation theory. In order to study the properties and collect experimental data that will help develop the theory of strongly interacting electron systems, Adam is constructing a high precision angle-resolved photoemission spectroscopy (ARPES) system in his laboratory, and he is a participant in the construction of the high-flux ultraviolet beamline at the Synchrotron Radiation Center in Stoughton, Wisconsin.

Bella Lake received the Ph.D. degree from Oxford University, using neutron scattering to study alternating chain antiferromagnets. Following post-doctoral positions at the University of Toronto, Oak Ridge National Laboratory, Risø National Laboratory in Denmark, and an Engineering and Physical Sciences Research Council (EPSRC) Advanced Research Fellow-

Bella Lake

ship at Oxford, she joined the faculty of Iowa State University last February as an assistant professor of physics and astronomy.

Using neutron and x-ray scattering, Bella investigates quantum magnets and superconductors. These systems are dominated by quantum mechanical behaviour, where Heisenberg uncertainty-principle fluctuations disrupt the mean-field effects that would otherwise give rise to conventional behavior. Her current work includes neutron scattering experiments from a quasi-one-dimensional spin-1/2 Heisenberg antiferromagnets. This system lies in the crossover region between a three-dimensional magnet characterised by Néel ordering and spin-wave excitations on one hand, and a one-dimensional spin-1/2 antiferromagnet characterised by spinon-pair excitations and the absence of long-range order on the other. In addition, Bella is investigating high-transition-temperature cuprate superconductors such as Sr-doped La_2CuO_4. Although the pairing mechanism in these compounds is unknown, one possibility is magnetic coupling. The results of her measurements reveal the strong differences between cuprate and conventional superconductors and demonstrate the important role that magnetic interactions play in these systems. Q

GIVING SOMETHING BACK

Contributions from alumni and friends have a lasting impact.

Three hundred physics and astronomy alumni and friends have contributed to the Iowa State University Foundation over the last year (see pages 8 and 9). Fifty-four of those donors have designated their contributions directly to the Department of Physics and Astronomy. Thank you! Your gifts, pledges, and other expressions of support make a real difference for students and faculty. They provide extra motivation for our efforts and positive affirmation for our mission.

Although the Department of Physics and Astronomy continues to build on its strengths, maintaining a position as one of the top-ranked departments in the university and the nation is no easy challenge in these financially difficult times.

As a public institution, Iowa State University receives some support from tax dollars. However, public financing for public universities has declined in Iowa and many other states. Taxpayers now underwrite 28 percent of the budget at Iowa State University, down from approximately 40 percent just five years ago. Tuition increases have covered part of the shortfall, but private contributions are taking on a more critical role in helping the department to fulfill its mission and maintain its standards of excellence.

Now, more than ever, the department needs help from alumni and friends in student recruiting, in rewarding outstanding students, and in creating a stimulating intellectual and physical environment conducive to their success. There are a number of opportunities for personal contributions to support undergraduate scholarships, graduate fellowships, seminars, visiting scholars, and student travel to conferences and symposia.

One area of continuing need is the department endowment, which permanently funds such things as scholarships, fellowships, and other awards for students and faculty. The current endowment in the Department of Physics and Astronomy is $387,000, not a large amount for an organization of this size and stature at a major research university. While the current endowment underwrites eight student awards and funds some other activities, additional capital is needed to support a department with more than 150 students and 41 faculty members.

Gifts may be directed to any of the existing endowed funds listed on page 9, or they may be designated for the Physics and Astronomy Unrestricted Fund, which provides resources for the department's greatest needs. Larger gifts or commitments can be used to establish new endowments for purposes designated by the donor.

All gifts, regardless of size, will help. They can be structured in a variety of ways, including (1) outright gifts of cash, securities, real or personal property, (2) pledges to give specific amounts on a certain time schedule, and (3) deferred gifts such as charitable bequests in a will or trust, charitable gift annuities, or permanent life insurance policies. Each gift will make a lasting impression on the quality of the department, its students and faculty.

Thanks, again, to all our supporters. If you have not designated a gift to the Department of Physics and Astronomy, please consider doing so this year! Q

The following physics and astronomy alumni, friends, and their families have contributed to the Iowa State University Foundation over the period from July 1, 2004, to June 30, 2005. Thank you for your generosity!

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** Gifts designated to the Department of Physics and Astronomy*

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1. Decide where you'd like to help.

We hope that you'll consider designating your gift directly to the Department of Physics and Astronomy! If you'd like to discuss some possibilities, please feel free to call Eli Rosenberg, department chair, at 515 294-5442.

You may want to ***contribute to the Physics and Astronomy Unrestricted Fund,*** providing the department with the greatest flexibility to finance awards and important projects.

You can also ***contribute to an existing endowed fund:***

Undergraduate scholarships and awards
- Bernice Black Durand Undergraduate Research Scholarship
- David W. Collins Memorial Scholarship
- Sam & Lavona Legvold Memorial Scholarship
- James Schirber Physics Scholarship
- Gordon Danielson Memorial Endowment Fund
- Dr. Charles Hammer Scholarship
- Physics Achievement Award

Graduate scholarships
- Fox Memorial Award Endowment (Physics)

Iowa State University Planetarium and Observatory funds
- Erwin Fick Fund
- Mather Observatory Fund
- ISU Planetarium Fund

If you're thinking about making a significant gift, you may wish to ***establish a new endowed fund*** for a purpose that you designate. For details and guidance, please refer to the Iowa State University Foundation Web site (www.foundation.iastate.edu) or contact Alsatia Mellecker, Senior Director of Development, at 515 294-6431.

2. Decide how you'd like to contribute.

Contributions may be structured in a variety of ways, including ***outright gifts*** of cash, securities, real or personal property, ***pledges*** to give specific amounts over a stated time period, ***or deferred gifts*** such as charitable bequests, gift annuities, or life insurance policies.

3. When you're ready,

- Make your check payable to *The Iowa State University Foundation.*
- Designate the gift to the *Department of Physics and Astronomy.*
- Indicate the fund to which you'd like to contribute.
- If your employer has a matching gift program, please include the appropriate documents so that the benefits of your contribution can be multiplied.
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Editor
Mark W. Fleming
Phone +1 630 983-7746
FAX +1 630 983-0719
stratondmd@aol.com

Contributing Authors
Mark W. Fleming
David Gieseke
Adam Kaminski
Bella Lake
Eli I. Rosenberg
Edward Yu

Department Chair
Eli I. Rosenberg
Phone +1 515 294-5441
FAX +1 515 294-6027
redmount@iastate.edu

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DEPARTMENT OF PHYSICS AND ASTRONOMY
12 Physics Hall
Iowa State University
Ames, Iowa 50011-3160