

A Letter from the Department Head

Dear Physics Alumni and Friends:

This newsletter will be the first of many that will inform those interested in the physics educational and research programs of the School of Physics and Astronomy (SPA). Since this is our first newsletter in more than a decade, the first task is to play “catch-up” so as to bring readers up to date on several aspects of the state of physics at University of Minnesota.

You might first ask, what has changed that now permits us to afford a newsletter, and the answer is that for the first time since the period of retrenchments in the early 1990’s, which stripped us of infrastructure support, we have had resources made available to us that permit a higher level of communication with our stakeholders. This newsletter is only the beginning. You should see further changes on our website (www.physics.umn.edu) in the coming weeks. The School is a very exciting place in terms of its high-level activities in research, teaching and service and we will be able to do a better job of communicating this to you in the future.

For those of you who knew us some time ago, we are very different than we were. First, as a personal matter, when I came here many years ago, as the youngest faculty member in the department, I had no way to envision the circumstance that thirty odd years and forty two Ph.D. advisees later, I would be in my sixth year as department head, and that almost all of my colleagues from the time would be retired! The School has come through a period in which large numbers of faculty have retired, and we are going through the process of replacing them, which amounts to a major renewal.

The retirements have been fast and furious. There have been 12 just during my tenure as Head, and Professors Hosotani and McLerran left for greener pastures. The replacement process has been ongoing, and its rate



Tony Gherghetta



Alex Kamenev

is actually limited by the supply of start-up funds. We have added nine new faculty. The two most recent additions, Kamenev and Gherghetta are pictured above—and there is a profile of another of our new faculty, Yong-Zhong Qian on page six of this newsletter. This year we are searching for two additional faculty members, and we should be able to add at least six over the next three years without additional retirements.

The significant research areas in the department are now particle theory and experiment, condensed matter theory and experiment, nuclear theory, space physics and observational and theoretical astrophysics. A new area is biological physics, in which we have three faculty and are searching for a fourth. In this newsletter, the Research Spotlight focuses on spintronics and

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Demonstrations of Gravity

Physics Force at Northrop

"This is real physics. Isn't it great?" Hank Ryan says, stretching a high-powered slingshot to its limit before firing an egg at his colleagues, Jon Barber, a retired high school physics teacher, and Jack Netland, a physics teacher at Maple Grove Senior High. The point of the demonstration is to explain that collisions which take place relatively slowly experience less force than those that happen quickly. It's obvious that Ryan, a physics teacher at Mounds View High School, is enjoying playing with the toy. The feeling is contagious, and it's a safe bet that there's not a kid in the packed house at Northrop auditorium who wouldn't love to have a try at that slingshot.

Many of the demonstrations combine slapstick comedy with physics. One routine, which always gets a big audience reaction, has School of Physics & Astronomy Professor, Dan Dahlberg, pretending to crash a fire extinguisher-powered rocket car. He returns to the stage carrying a bent wheel and brings down the house. De-



Photo by Paul Doege

Dan Dahlberg explains rocket propulsion and gets laughs before an audience 3,000 elementary school children.

performed for many thousands of school children and has appeared at Epcot Center, on *Newton's Apple* and German television.

During one week in January 2002, the Physics Force played to about 10,000 K-12 students at three matinee performances. Before and after each show, Dahlberg worked the crowd, talking to teachers and students. He got high fives from kids as he stopped to ask about their school science projects.

The group also performed a public show in the evening at Northrop. Publicity from a local television news program helped bring in another 2,500 people to the show. The public performance was a testament to the Physics Force's appeal to varying age groups and backgrounds. Ten-year-old Shelby Jones of St. Anthony Park Middle School, attended with her father. They both enjoyed the show and Shelby was particularly impressed with the gravity demonstration in which Hank Ryan was dropped from a platform 20 feet in the air. "I'm way more interested in physics now," Shelby said.

There is a second group of Physics Force called the Next Generation that includes SPA faculty members Jim Kakalios and Cindy Cattel. This group also travels to elementary and secondary schools around the state performing their own version of the act.

A schedule for Physics Force upcoming performances can be found on the back page of this newsletter.



Photo by Tom Foley

John Barber pounds a nail into a log while Jack Netland explains that he can't feel the force of the nail because a mass at rest (the log) will tend to stay at rest.



The Physics Force has a web page:
www.physics.umn.edu/pforce

Awards & Announcements

2002 Abigail and John Van Vleck Lecture

Horst L. Stormer will deliver this year's Van Vleck Lecture. Stormer is a Professor of Physics & Applied Physics at Columbia University and Adjunct Physics Director at Bell Laboratories. He was a co-winner with Dan Tsui and Robert Laughlin of the 1998 Nobel Prize in Physics for "discovery of a new form of quantum fluid with fractionally charged excitations." The title of his public lecture is "Fractional Charges and other Tales from Flatland" and will be held at 4:00 p.m., Thursday, April 4th, 2002 in the Van Vleck Lecture Hall, Room 150 Physics. There will be a reception following the lecture in Room 216 Physics.



Dr. Tom Duff, Bell Labs, Lucent Technologies

A computer-generated cartoon of the correlated electron state in the conditions of the fractional quantum Hall effect. The electrons, pictured here as orange spheres, are living in *Flatland*—a two-dimensional layer near the interface of a semiconductor heterostructure. The motion of the electrons is like a group dance, with strongly correlated positions of the participants. *Flatland* is the topic of Professor Stormer's upcoming Van Vleck Lecture.

Stormer received his Ph.D. in 1977 from the University of Stuttgart and joined Bell Labs as a postdoc shortly after. From 1983 to 1992 he headed the Semiconductor Physics Research Department and became the Director of the Physical Research Department of AT&T Bell Labs in 1992. In 1997 Stormer moved to the position of Adjunct Physics Director at Bell Labs and be-

came a Professor in the Physics and the Applied Physics Department of Columbia University. Stormer has worked extensively on the properties of lower-dimensional electron systems.

Outstanding Achievement Award

Heinrich Jaeger of the University of Chicago will be presented with the University of Minnesota Outstanding Achievement Award. The award will be presented at a reception in Professor Jaeger's honor on Wednesday, February 20th at 3:00 p.m. in 101 Walter Library. Immediately following the award ceremony, Professor Jaeger will present the Erickson Lecture at 4:00 p.m. in Room 131, Physics.

This award is presented to Professor Jaeger in recognition of his scientific accomplishments in three research areas of condensed matter science, the study of granular media, vortex dynamics in superconductors, and mesoscopic physics. Professor Jaeger received his Ph.D. (1987) and M.S. (1982) degrees in Physics from the University of Minnesota.

Honorary Degrees

Drs. **William A. Bardeen** (Ph.D. 1968) and **Jeffrey A. Harvey** (B. S. 1977) have been selected to receive the University of Minnesota's highest honor at the Institute of Technology Commencement on May 10th, 2002.

William A. Bardeen, senior staff member at Fermi National Laboratory, is recognized for his "seminal contributions to many parts of the Standard Model of the Structure of Matter; for his leadership role in furthering advancement of physics as head of the theory group at Fermi National Accelerator Laboratory and for the important part he has played and continues to play in fostering international cooperation in scientific research." the award to Dr. Bardeen is somewhat unusual in the his father, the late Professor John Bardeen was also awarded an honorary degree.

Jeffrey A. Harvey, Louis Brock Professor of Physics at the Enrico Fermi Institute of the University of Chicago, recognized for "his pioneering research in 'Beyond the Standard Model' physics, a program that seeks unification of particle physics with gravity; co-originator of Heterotic String theory and major contributor to the role of solitons in string theory and intellectual leader in orbifold compactification, black-hole physics and 'brane' physics."

More Awards...

Continued on page 8

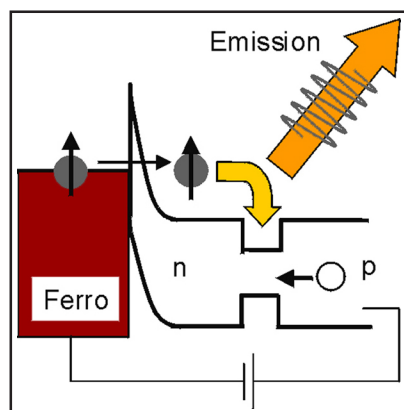
Research Spotlight

Spintronics/Magnetic Heterostructures

Physicists at the University of Minnesota have teamed up with colleagues in Electrical Engineering and Chemical Engineering and Materials Science to tackle a fifty-year-old problem in physics. The mystery is a well-known phenomenon called exchange bias, which occurs when a thin film of ferromagnetic material is placed next to a layer of antiferromagnetic material, which tends to create a favored direction for the ferromagnetic layer's magnetization. This pinning of the magnetization has been used since the mid 1990's in creating computer hard drive read heads, which are made from "club sandwiches" of different types of magnetic and nonmagnetic materials. Although an entire industry has been built around the phenomenon, no one really knows in detail what causes it.

Paul Crowell, Professor of Physics, said that the industry which mass-produces these sandwiches for use in hard drives does so on the basis of a lot of educated guesswork. If the physics of the phenomenon were better understood, it would certainly be possible to improve the density of the magnetic information on a hard disk and increase hard drive capacity.

One of the barriers towards compiling data and eventually a better theory of exchange bias has been that most of the interfaces between the layers of the sandwiches used by industry are rough. This increases the exchange bias, but the complex geometry makes it difficult to understand the phenomenon. That's where Allen Goldman's superconductor group comes into play. For years Goldman's group has created very smooth films for their work in superconductivity. Through a process called molecular beam epitaxy, Goldman's group is able to create a much simpler interface geometry using magnetic oxides that makes it easier to study the physical causes of exchange bias.



At Left: spin injection of electrons from a ferromagnetic metal into a semiconductor heterostructure. The electrons re-combine with holes in the quantum well. The polarization of the resulting emission probes the electron spin state at the end of the injection process.

Dan Dahlberg and his research group then use a property known as anisotropic magnetoresistance to analyze the exchange bias evident in these smooth interface samples. According to Dahlberg, "part of the problem has been that [scientists] have been measuring the wrong thing for forty years." The traditional approach to analyzing pinning was to flip the spin of the electrons in the ferromagnet and then see how much energy it takes to cause the pinning. The problem with that approach occurred to Dahlberg while working on a different topic, the problem of giant magneto-resistance. "The surprise was that the pinning energies we calculated were off by a factor of ten from traditional measures." The reason for the discrepancy was that the traditional approach was measuring the weakest link instead of the average energy required to cause the pinning. Dahlberg explained further that it is analogous to dominoes. If you knock one domino over and they are all the exact same size they all require the same amount of energy to be pushed past the angle where they can recover. But if one domino has a slightly narrower base it will require less energy to push it over, because it will topple at a smaller angle. There are certain domains or groups of electrons that are analogous to the narrow domino. They take less energy to pin. For years scientists were measuring the domain that was pinned the easiest and not the average of all the domains.

Dahlberg's data will be put into a computer model by Randy Vitoria, a Professor in the Electrical Engineering and Computer Science Department. Eventually the model will help predict the most efficient way to construct the magnetic heterostructure "sandwiches," but not before a final piece of the puzzle is put into place by Paul Crowell's research group. Crowell's group is able to use a process called time-resolved ferromagnetic resonance to further analyze the sample. This process uses two infrared laser pulses, that can be spaced in time as little as 200 femtoseconds apart. The first pulse creates a magnetic field, while the second pulse probes the sample in order to get a snapshot of what happens. As the spacing between the pulses is varied, a movie of the magnetic behavior is obtained in which the time between movie frames is on the order of $1/100^{\text{th}}$ of a nanosecond (one nanosecond is a billionth of a second). The data from these experiments will also be added to the computer model in order to get a complete picture of the coupling mechanism that causes exchange bias.

Research on the physics of magnetic heterostructures has begun in Crowell's group in another important area

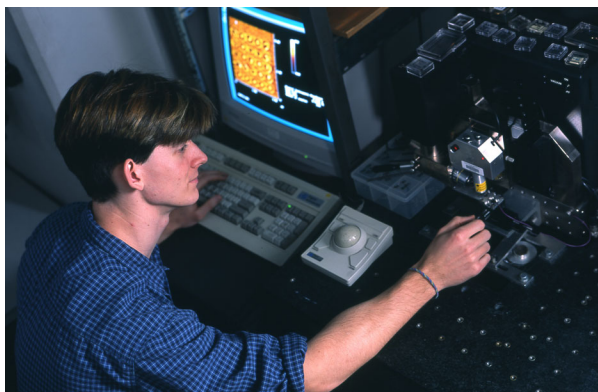


photo by Jonathan Chapman

Pete Eames works an magnetic force microscope which Dahlberg's research group uses to analyze heterostructures.

called spintronics. Spintronics studies the problems associated with structures made up of layers of alternating semiconductors and ferromagnets. "If a semiconductor and a ferromagnet could be coupled successfully, one could imagine a device that was not just merely on and off like the traditional semiconductor chip, but would have two positions of on, 'spin-up' on and 'spin-down on,' as well as off."

According to Crowell, the chief barrier to creating such devices is the problem of spin-injection. As it stands now, one can easily pass a current through a semiconductor into a ferromagnet, but not the other way around. All of the resistance to current passing between the two layers is at the interface. Theoretically, an electron can pass through this barrier through a process known as tunneling. Crowell, along with Chris Palmström, a Professor of Chemical Engineering and Materials Science, are trying to exploit this tunneling process as a means of transferring spin from the ferromagnet into the semiconductor. In order to detect the injected spin, the tunneling electron is forced to combine with a "hole" inside the semiconductor, emitting a flash of light. This flash can be analyzed in order to read the spin-state of the injected particle. According to Crowell, "once we are able to get the spin into the semiconductor, we can manipulate it using a combination of electrical fields and light. In principle, it would be possible to design logic devices that would be ingredients in a new generation of computers."

The research of all of the University of Minnesota physicists and engineers mentioned in this article is being supported by a Materials Research Science and Engineering Centers (MRSEC) grant from the National Science Foundation.

A Letter from the Department Head

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magnetic heterostructures.

The educational enterprise continues to function well. The transition to a new semester calendar was accomplished in 2000-2001 without serious mishap. Under semesters we now offer a more open undergraduate major. This allows, in addition to traditional physics courses, specialization that can lead to advanced work in engineering, education and biology. Outreach activities have achieved new heights and incredible visibility at SPA. The Physics Force, which now plays to audiences of thousands, is featured in this newsletter.

Not all of the news over the past year has been positive. We were greatly saddened by the death of Jack Winckler, of the Space Physics Group. Even in retirement, he was continuing his distinguished research, which had earned him election to the National Academy of Sciences.

I hope that you find this newsletter useful. It should henceforth appear regularly twice a year. We welcome suggestions for articles, and for changes that would improve its quality.

With our best wishes for 2002,
Allen Goldman

Faculty Changes

<u>Retirements</u>	<u>Research Field</u>	<u>Year</u>
Hans Courant	High Energy Experiment	96/97
Steve Gasiorowicz	High Energy Theory	96/97
Yau Chien Tang	Nuclear Theory	96/97
Russell Hobbie	Biophysics	97/98
Paul Kellogg	Space Physics	97/98
Roger Jones	Physics Education	98/99
Erwin Marquit	Philosophy of Physics	98/99
Benjamin Bayman	Nuclear Theory	99/00
William Zimmermann	Condensed Matter Experiment	99/00
Dieter Dehnhard	Nuclear Experiment	00/01
Clayton Giese	Chemical Physics	00/01
Roger Stuewer	History of Physics	00/01
Walter Weyhmann	Condensed Matter Experiment	00/01
<u>New Faculty</u>	<u>Research Field</u>	<u>Year</u>
Paul Crowell	Condensed Matter Experiment	97/98
Shaul Hanany	Observational Cosmology	98/99
Alexander Grosberg	Biophysics	99/00
Yong-Zhong Qian	Nuclear Theory	99/00
Jon Urheim	High Energy Experiment	99/00
Michael Duvernois	High Energy Experiment	00/01
Michel Janssen	History of Physics	00/01
Joachim Mueller	Biophysics	00/01
Alex Kamenev	Condensed Matter Theory	01/02
Tony Gherghetta	High Energy Theory	01/02

New Faculty Profile:

Yong-Zhong Qian

There are approximately 100 elements in the universe, but exactly how nature produces all these elements is still largely a mystery. Yong-Zhong Qian, who joined the School of Physics and Astronomy faculty in 1999, studies the origin of the elements in connection with the evolution of the universe.

The universe was born approximately 15 billion years ago with two major primordial elements, hydrogen and helium. During the subsequent evolution, stars were formed and lit up the universe by burning special fuels. The first fuel is the primordial element hydrogen which is burned into the heavier element helium. When hydrogen is exhausted, helium is ignited and burned into the still heavier elements carbon and oxygen, the essential ingredients of all biological forms. This process of burning lighter elements into heavier ones constitutes the basic cycle of a star's life. At present, the sun shines by burning hydrogen into helium. Approximately ten billion years from now, the hydrogen in the sun will be exhausted and helium burning will start. However, the heavier elements are less efficient fuels and are harder to ignite as they are the ashes of the lighter elements. A star as small as the sun cannot ignite the ashes of helium burning and gradually dies out after helium is burned up.

By contrast, a star ten times more massive than the sun comes to the end of its life only when iron, the ash of the ashes, is produced. Such a star then collapses under its own weight and dies a glorious death in an explosion called a "supernova." During the explosion, new processes occur to produce additional elements heavier than iron, such as gold. These elements and those produced prior to the explosion are ejected by the supernova into space, enriching it and the next generation of stars to be formed with non-primordial elements. The largest of the enriched stars become new supernovae in due course and initiate a new cycle. The small ones survive to this day and are the fossil records of the composition of the universe at the time of their birth.

Qian's research deciphers the origin of the elements based on observations of stars that were formed throughout the history of the universe. There has been a rapid accumulation of data on the distribution of elements in stars with the advent of large telescopes such as Hubble and Keck. Taking advantage of this observational progress, Qian has initiated a novel approach studying the origin of the elements. Just as the diversity among human beings is the manifestation of a finite number of genomes, various distributions of elements in stars of different ages can be understood in terms of production

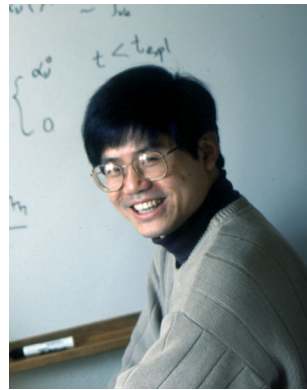


Photo by Jonathan Chapman

Yong-Zhong Qian

templates that are intrinsic to several distinct types of supernovae. Only the elements in the surface layers of a star can be observed. In general, the surface composition of a star also reflects the composition of its birth material, which was enriched by the products from many supernovae. However, there is an unusual case when the surface of a star is enriched by a single supernova. This can occur in a system where a small star has a big companion. The big star would explode as a supernova. During the explosion, a fraction of the supernova products would be directly painted on the surface of the smaller star. If the explosion did not disrupt the system, the small star with the special enrichment on its surface would now have a dark companion that is the remnant of the original big star. A search for such systems may provide golden opportunities to extract the production template for an individual supernova. In collaboration with Gerald Wasserburg at Caltech, Qian has predicted that a couple of stars with unusual surface compositions were enriched exactly in this manner. This prediction should have a strong impact on future observational efforts.

Qian was born in the People's Republic of China, and moved to the United States in 1989. He received his Ph.D. in 1993 from the University of California, San Diego. He was an Oppenheimer Fellow at Los Alamos National Laboratory and was recently named a Department of Energy Outstanding Junior investigator. He is married and has two daughters.

Qian is one of the principal organizers of the upcoming workshop, "Low Z at low z and high z : Early Chemical Evolution" which will take place in Minneapolis, from March 21-23, 2002. The workshop will bring together theorists and observers who are studying Low Z stars (those which are very old and have low metallicity or "Z") in our galaxy and neighboring galaxies.



The Low Z Workshop has a web page:

www.tpi.umn.edu/lowz

Physics Open House

Every fall, the Physics Open House uses hands on demonstrations to inform undecided undergraduates about the possibilities of a physics major. This year more than 120 students viewed demonstrations, heard lectures and took tours of various physics research and teaching laboratories. According to the event's coordinator, Professor Prisca Cushman, the Open House is an opportunity "to demonstrate the broad range of employment options available to physics graduates, whether they go on to graduate school or not."

The Society of Physics Students took turns manning an information table and giving tours of various lab facilities. On one tour of the Experimental and Modern Methods Laboratories, Kurt Wick showed a prospective major, Army Nuddin, first how a Geiger counter is used and then the working lab where students learn to build their own experimental equipment. "It's a lot more technical than I thought," Nuddin commented as the tour concluded. "I didn't realize you would have to build your own equipment."

While students snacked on pizza, they listened to lectures by University of Minnesota Physics Alumni such as Dr. Stephen J. Willett who explained how he uses his undergraduate physics degree in his job at Eastman Kodak.

The open house gave undergraduates a chance to meet with School of Physics & Astronomy faculty, graduate students and undergraduate physics majors. Al-



Photo by Jenny Curtis

Prospective student, Dat Nguyen checks out the demonstration table at the Physics Open House.

though many of the attendees were undecided on their majors, some, like Stephanie Mma, an Aerospace Engineering major, were thinking of adding physics as a double major. Tour leaders like Dave Engebretson used the occasion to recruit undergraduates to work in research laboratories. "It's an excellent opportunity for everyone. It's good experience for an undergrad, much better than working stock shelves, and it's always good to have more people working in the lab." Engebretson is part of Paul Crowell's Spin Dynamics and Magneto Optics Laboratory, and gave a demonstration of an infrared laser and the properties of liquid nitrogen used to cool semiconductors to low temperatures.

TIGER balloon breaks record



Photo and Trajectory by Dr. Eric Christian USRA/NASA/GSFC

Above: Filling the TIGER balloon before launch at McMurdo Station, Antarctica. Inset: TIGER's trajectory around the South Pole.

TIGER, a balloon that collects data to help physicists discover the origins of cosmic rays, has broken a record for the longest balloon flight ever. Scientists in the University of Minnesota Space Physics program are part of the team that put together the Trans-Iron Galactic element recorder or TIGER, which was launched on December 20th, 2001 and was cut down on January 21st after making two trips around the South Pole. According Physics Professor, Jake Waddington, "It will have travelled some 10,000 miles and collected about four million cosmic ray iron nuclei."

TIGER's total flight time was 31 days 21.5 hours, a new record for a zero pressure balloon (a balloon that is open at the bottom and typically loses gas every night). Its flight was aided by the circumpolar winds that blow at this time of year. TIGER landed about 300 miles away from its launch point and is expected to be recovered this year.

Physics Force Schedule

February 19 (The Next Generation)
Chaska, 10 a.m. (K-6th grade); 1:30 p.m. (high school).

February 21 (The Original Force)
Boy Scouts, Capitol Hill School, time to be announced.

February 26 (The Original Force)
Centennial Middle School, 1:10 p.m.; 7:00 p.m.

March 7 (The Original Force)
Chippewa Middle School, 1:40 p.m.

March 12 (The Original Force)
Highland Elementary School, 9:30 a.m.

March 14 (The Next Generation)
North Star Elementary School, Minneapolis, two shows, times to be announced (TBA).

March 21 (The Original Force)
Cornelia Elementary School, Edina, 7:15 p.m.

April 11 (The Original Force)
St. Cloud State University, 1 p.m.
There will also be an evening show, open to the public, time to be announced.

April 19 (The Original Force)
Fred moore Middle School in Anoka, time TBA

April 22 (The Original Force)
Sunset Hills Elementary School, time TBA.

Awards

Continued from page 2

Professors Arkady Vainshtein and Mikhail Shifman received the 2000 American Physics Society (APS) Sakurai Prize for theoretical particle physics. Professor Mikhail Voloshin shared the 2001 APS Sakurai Prize with Nathan Isgur and Mark Wise.

Professor Anatoly Larkin, will receive the 2002 APS Lars Onsager Prize for his work in theoretical statistical mechanics.

Professor Leonid Glazman was named to a McKnight Presidential Chair in 2000 and Professor Shaul Hana-ny, was named a McKnight Professor for 2001-2003.

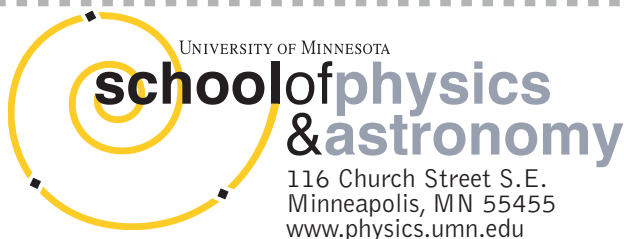
Professor Charles E. Campbell, was presented with the Institute of Technology's George W. Taylor Award for Distinguished Service last spring.

Physics Alumni

Please feel free to drop us a line with suggestions/comments on the newsletter or updates to our mailing list. We're also putting together an alumni section for our webpage. We'd love to add a link to your site.

alumni@physics.umn.edu
www.physics.umn.edu/outreach/alumni

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Newsletter

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To: