

### A Letter from the Department Head

It is hard to believe that another year has gone by. For the first time in the six years of my headship no faculty retired, and none were hired. The coming year will be very busy in the area of recruitment as we will be conducting searches for faculty in experimental condensed matter physics, experimental biological physics, and theoretical astrophysics. We hope to hire up to four individuals, which would bring the professorial staff in physics to 46.

We have continued to expand the options in the undergraduate major. In addition to traditional physics courses, specialization leading to advanced work in engineering, computation, materials, education, and biology are available to students. We are offering twelve Freshman Seminars with topics ranging from "Science in Comic Books" to "Quantum Mechanics for Everyone." The Methods of Experimental Physics course, which is highlighted in this newsletter continues to draw graduate students from other departments as well as our own Physics undergraduates.

Over the summer there was a major upgrade in classroom technology. All of the lecture halls and classrooms in the building are now equipped with state-of-the-art audio-visual technology, including facilities for computer presentations as well as direct internet connections.

This past year the Abigail and John Van Vleck Lecture was delivered by Professor Horst Stormer of Columbia University. He was co-recipient of the 1998 Nobel Prize in Physics, for the discovery of a new form of quantum fluid with fractionally charged excitations.

Research in the department continues to progress. This issue highlights the experiment to send a beam of muon neutrinos underground from Fermilab towards a

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### MINOS Dedication

The MINOS (Main Injector Neutrino Oscillation Search) detector laboratory was officially dedicated at a ceremony which took place July 2nd, a half mile underground in the Soudan Mine State Park in Tower, Minnesota.

The ceremony celebrated the installation of the first half of the eventual 486 detector layers. Each layer is

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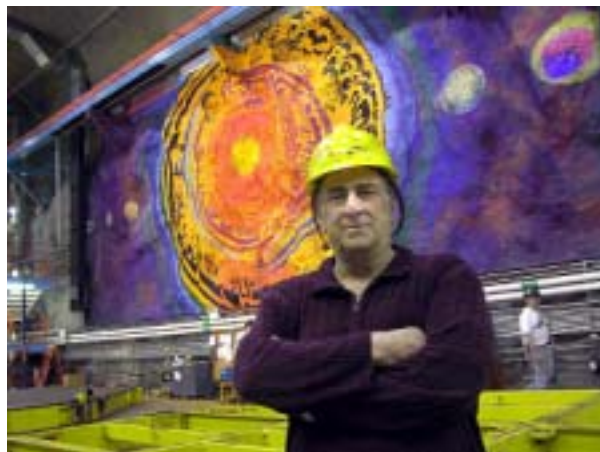


Photo by Moose Gianetti

Minnesota artist, Joseph Gianetti with the mural he painted for the MINOS laboratory.

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New Faculty Profile:

## Shaul Hanany

Observational cosmologist Shaul Hanany studies the Cosmic Microwave Background radiation (CMB), a relic from the early universe whose mere existence is one of the principal pieces of evidence for the Big Bang. Hanany and his collaborators have designed and built two balloon-borne experiments for observing the CMB. He is in the process of designing a third, is collaborating on the construction of a satellite project, and his group logs thousands of hours on the Minnesota Supercomputing Institute computers analyzing the data from CMB observations.

The CMB is, according to Hanany, “a bath of photon radiation” that differs from other background radiations because it “is truly cosmic, in the sense that its source is close to the origin of the Universe.” It is the earliest we can directly observe the Universe.” Whereas there are other types of astrophysical background radiations, none originates from the Bang itself.

The CMB was predicted in the 1940s by theorists, but little attention was paid to it until it was “serendipitously discovered,” in 1965 by two physicists at Bell Labs, Penzias and Wilson. They constructing an antenna that was to be used for a different purpose. During testing of their antenna they noticed an inexplicable extra noise. The famous story goes that the physicists puzzled for months, recalibrating the antenna, cleaning it, pointing it in different directions, comparing night versus day observations, and they still could not get rid of the same puzzling noise. Almost by coincidence they learned about a research group at Princeton that was in the early stages of building an instrument specifically to search for the CMB. A phone conversation confirmed that they had indeed discovered the dramatic after-effects of the explosion that created the Universe and they won the Nobel Prize.

According to Hanany, the earliest efforts at characterizing the CMB were aimed at determining its average intensity across the sky. Those efforts came to spectacular fruition in the early 1990s with a very clean measurement by the COBE satellite. In the last ten years most experiments were directed at mapping deviations from the average intensity as a function of position on the sky. These deviations, called the anisotropy of the CMB, are extremely small, only 50 parts per million of the average intensity. “Imagine that you are flying on a plane across the Atlantic and looking down at the sea below you. The sea happens to be very calm; the waves are only about one and a half feet in height. Detecting these small waves from the plane is a task analogous to detecting the CMB anisotropy.”



Photo by Jenny Allan

Shaul Hanany

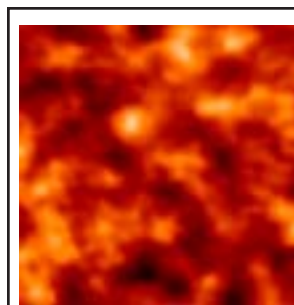
To ensure the highest sensitivity, Hanany's group uses balloon-borne experiments that rise above the Earth's atmosphere since water molecules in the air emit copious amounts of microwave radiation. They also use the highest sensitivity detectors in the world.

Hanany's group and their collaborators launched their first experiment, called MAXIMA, in 1998 (from Palestine, Texas) and published their first picture of the CMB anisotropy in 2000. From this picture, the scientists determined only about 5% of the mass and energy in the Universe takes the form of identifiable particles such as electrons, quarks, photons and neutrinos. The other 95% is yet to be identified. Physicists also interpret this result as meaning that “the Universe is flat.” Hanany explains that the geometry of space is determined by the amount of mass and energy it contains and the amount found makes the geometry exactly flat. “Space could have been curved, but it isn't!” This discovery was named by Science magazine as one of the ten most important breakthroughs for that year among all sciences, not just in physics.

Further results published in 2001 helped give support to the idea that the Universe underwent a period of tremendous expansion, right after the big bang. Theorists and data analysts use these results in their calculations and analyses and the publications have received hundreds of citations.

Hanany's group is currently involved in the race to determine whether the CMB radiation exhibits polarization properties. The group has built an experiment which is awaiting launch this month from Ft. Sumner, New Mexico.

Shaul Hanany is originally from Israel, and has lived in Minnesota since 1999. He is married to Niza and has “a truly, objectively, smart, beautiful and adorable” almost-two-year old daughter, Adi.



The anisotropy in the CMB as measured by MAXIMA. The picture represents a 5 degree by side view of the sky. Such views allowed the Hanany's group to calculate that the Universe is flat.

Photo courtesy of MAXIMA

# Awards & Announcements

## Allen Goldman Receives London Prize

Professor Allen Goldman of the School of Physics & Astronomy received the prestigious Fritz London Memorial Prize from the International Commission on Low Temperature Physics.



Walter Hardy, Russell Donnelly and Allen Goldman receive the London Prize

Goldman accepted the Prize during a ceremony at the Twenty-third Conference on Low Temperature Physics in Hiroshima, Japan on August 21, 2002.

The London Prize is given once every three years and is intended to recognize outstanding experimental and theoretical contributions to low temperature physics. Goldman is cited "for his contribution to the physics of superconductors, particularly the discovery of the gapless collective modes, and for his inventive work on superconductor-insulator transitions in ultrathin films."

Goldman shared the Prize with Russell Donnelly (University of Oregon) who was cited for his contributions in low temperature fluid dynamics and Walter N. Hardy (University of British Columbia) who was cited for his contributions in atomic and solid hydrogen and high temperature superconductivity.

Goldman will become the second School of Physics and Astronomy faculty member to receive the London Memorial Prize, the first being Professor Anatoly Lar-kin in 1990, for work done before he came to the University of Minnesota from the former Soviet Union.

Goldman's research was funded by the National Science Foundation and completed entirely at the University of Minnesota. Goldman acknowledged the importance that graduate students at Minnesota played in all stages of the research, specifically the contributions of J. Anderson, F. Aspen, R. Carlson, C. Christiansen, H. Jaeger, D. Haviland, Y. Liu, N. Markovic, and B. Orr.

## Lecture Demonstration Area Re-named

The lecture demonstration area in Tate Lab was renamed to honor George D. Freier during a ceremony on April 25, 2002. Faculty were on hand to celebrate Freier's contributions in pioneering lecture demonstration use at Minnesota and nationally.

## Pepin Receives Taylor Award

Professor Robert Pepin received the 2002 Institute of Technology George Taylor Distinguished Service Award at a reception associated with IT Commencement on May 10, 2002.

## Symposium Honors Bardeen, Harvey

The School of Physics and Astronomy hosted a symposium "Advances in Theoretical Physics: A Journey from Minnesota" on May 9. The occasion celebrated the University bestowing Honorary Doctorates on William A. Bardeen and Jeffrey A. Harvey. Dr. Bardeen (Ph.D. 1968) and Dr. Harvey (B. Sc. 1977) are alumni of the University of Minnesota with degrees in Physics.

Talks were presented by William Bardeen, Fermilab; Jeffrey Harvey, University of Chicago; Mikhail Shifman, University of Minnesota and Gregory Gabadadze, University of Minnesota.

## Student Awards Spring 2002

The annual awards ceremony was held at the last colloquia of the academic year. The ceremony included presentations by Mrs. Ardis Nier and Mrs. Kay Blair on behalf of their late husbands.

Recipient	Award
Joseph H. Dunsmore	Alfred O.C. Nier
Derek M. Lee	Alfred O.C. Nier
Aaron T. Martell	Alfred O.C. Nier
Jacob D. Haqq-Misra	Harry & Viola St. Cyr
Lisa C. Johnson	J. Morris Blair
Luke A. Corwin	Jeffrey Basford
April F. Rogoyski	Marquit-Grieser
Jesse A. Berezovsky	The Hagstrum Award
Ryan J. Stromberg	The Hagstrum Award
Ilya N. Krivorotov	Aneesur Rahman Award
Toan T. Nguyen	Aneesur Rahman Award
Aaron S. Wynveen	Aneesur Rahman Award
Kaiyan Gao	T.A. Award
Frank L. Hunte	T. A. Award

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# Research Spotlight

## Neutrino Physics Primer

"Neutrinos are the sexy particle of the decade. Last decade it was proton decay. Now, it's neutrinos," says Professor Keith Ruddick one of the physicists from the University of Minnesota who works on the MINOS project. MINOS has been devised to measure neutrino oscillations. "They're fun because they're so hard to see. They're teensy and they move close to the speed of light." Neutrinos were predicted in the 1930s by Wolfgang Pauli when energy measured in experiments with beta decays didn't mesh with the energy predicted. So theorists added a third product of the decay, the neutrino, to balance the energy. It would be two decades later before experiment confirmed the existence of neutrinos. Initially, physicists believed that neutrinos were massless and that they always moved at the speed of light. However, there have been clues along the way that made them suspect that neutrinos have mass and don't always move at the speed of light. MINOS hopes to settle the question definitively.

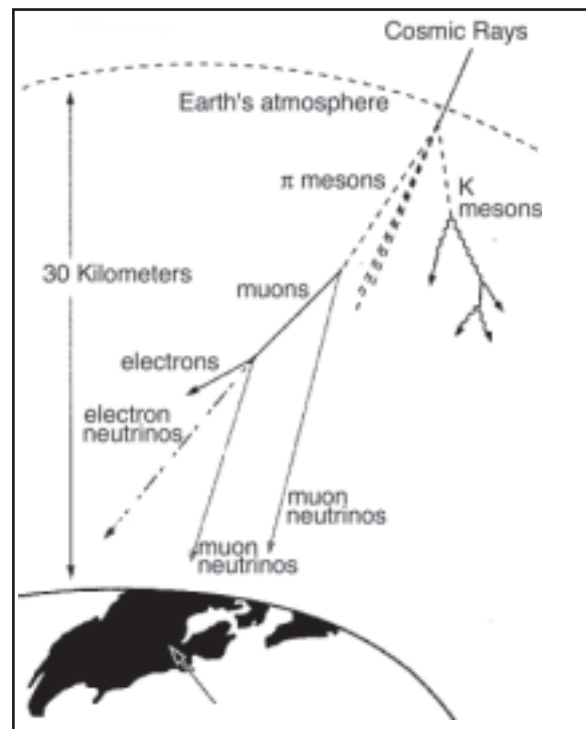
Neutrinos are solely the product of weak interactions, such as the burning of hydrogen into helium on the Sun. (In the relative terms of physics, strong interactions are those that bind the nucleus together, electromagnetic interactions are in the middle and weak interactions are those that cause nuclear decay). Neutrinos from the Sun are electron neutrinos. Experiments have shown that too few electron neutrinos reach the earth from the Sun. This was one of the first hints that neutrinos might oscillate into other types or "flavors" of neutrinos. Existing solar neutrino detectors wouldn't pick these up, since they are designed specifically to measure only electron neutrinos.

Many of the neutrinos detectable on earth are created when cosmic rays collide with  $\pi$  mesons and K mesons in the Earth's atmosphere. Then  $\pi$  mesons decay into a muon and a muon neutrino. The muon in turn decays into a muon neutrino and an electron neutrino. Because of this well-known decay formula, theorists predicted that there should be a 2-1 ratio of muon neutrinos to electron neutrinos detected on Earth. When experiment didn't yield this prediction, physicists suspected that the neutrinos were not always travelling at the speed of light and were oscillating into different flavors. They must have mass to oscillate.

Physicists hope that MINOS will be able to determine whether muon neutrinos, generated by pion decay, and shot from a beam at Fermilab, oscillate into a different

type of neutrino called the Tau neutrino, by the time they hit the detector in the Soudan Mine. The vast majority of the neutrinos will simply "barrel right through the detector," Ruddick says, just as they pass through the Earth from Fermilab. According to Ruddick, there is a small probability that a few of the neutrinos will interact with a quark while in the detector array. The detector will be able to see evidence of this, by sensing some of the light which is a by-product of the neutrino interactions with quarks. "We know the probability and that's how we knew how big to make the detector. That's why it has to be so big."

The neutrino's connection to Dark Matter, the mass of unexplained matter that makes up most of the Universe, has also, according to Laura Bautz of the NSF (during her speech at the MINOS dedication), "riveted the public's attention." Ruddick is careful to say that neutrinos are likely to make up only a small piece of the total pie that is Dark Matter. "They move too fast," Ruddick says. "A few years ago, astrophysicists realized that if all Dark Matter were neutrinos, that galaxies wouldn't have clumped together as they have and the Universe would look very different than it does."



One type of neutrino creation. This shows the 2-1 ratio of muon neutrinos to electron neutrinos that physicists expected to see in experiment, but did not.

# The MINOS Module Laboratory

## *Minos Dedication from page 1*

made up of an enormous octagonal detector module that is nearly 30 feet tall. The layers will make up the 6000 ton MINOS Far Detector, designed to intercept a beam of neutrinos generated at Fermi National Accelerator Laboratory in Batavia, Illinois. The intercepted neutrinos should help physicists determine whether or not the neutrinos oscillate and have mass. The University of Minnesota will play a key role in MINOS, a collaboration consisting of 30 physics groups in five countries.

The ceremony featured speakers such as Fermilab Director Michael Withersell and Congressman Jim Oberstar, Minnesota's 8th District Representative. Oberstar gave some historical flavor to the day when he talked about his father's experiences as an underground miner. "The underground was always fraught with danger," Oberstar said, "For a miner the most unforgettable sound was the screams of the men when the cable broke." The image had particular resonance with the audience of more than 150 who'd recently made the bumpy, dark and noisy ride down to the mine's 27th level in the cable-towed "cage" elevator.

Minnesota Physics Professor Earl Peterson, called the mine "pretty well nigh the perfect place to do a physics experiment." Peterson went on to praise the dedication and efficiency of the local construction crew, who finished the job ahead of schedule and under-budget.

Peterson recalled the day three years earlier when officials broke ground on the cavern excavation. In the mean time, the enormous cavern was dug, the steel framework that supports the experiment was built and a work area for the physicists was constructed.

This spring, Minnesota artist Joseph Giannetti also finished his large mural on the wall of the cavern. The mural and a display about neutrino physics are now a stop on the Soudan Mine State Park tour, which has taken thousands of visitors into mine.

According to the Principal Investigator, Professor Stanley Wojcicki of Stanford, the beam will be finished at Fermilab in two years and the MINOS project will be ready to operate. "It's a tribute to the people who planned this that it all came together," Wojcicki said, "and even more extraordinarily, that it works."



Photo by Jonathan Chapman

Yebio Sumere, threads fiber optic cable and glue into the scintillator modules at the MINOS Module Laboratory.

The MINOS Module Laboratory in Minneapolis is a unique factory that has built more than half of the required 2,000 detectors for the experiment. Since the product is so specialized, all the machines in the factory were designed by professors at the University of Minnesota. The factory workers too, are an unusual bunch made up of physicists, students and full-time workers who have an aptitude for the intricate process of building the modules.

The scintillator modules are 30 foot flat aluminum boxes containing a grid work of plastic doped with a chemical that increases light collection ability. Threaded through this grid are many yards of fiber optic cable. After completion and testing, these modules are shipped to the Soudan Mine in Tower, Minnesota where they are assembled into an enormous collection grid as part of the MINOS experiment.

The assembly line at the MINOS factory is very small. Each of the modules takes four days to build and the laboratory produces about 18 per week.

After assembly, the collector is moved to a table where a robotic arm moves a radioactive source back and forth across the module to test its collection abilities. Post-doc, Leon Mualem runs and monitors the tests. Mualem uses the data to ensure that modules are in working order and that the quality of the raw materials that go into the modules meets their standards. "They have to be tough to survive the journey down into the mine," Mualem said, "so far we've had very few that needed to be returned for repair."

# You Are Here

Avant Garde Theater at Tate Lab of Physics

When one thinks of the School of Physics and Astronomy, chances are, avant garde theater is not the first thing that springs to mind. Unless you happen to be Charles Campbell (no relation to Physics Professor Chuck Campbell) the writer and director of an original play called “You Are Here.” “We looked around campus for some places that had immediate public interest,” Campbell said, “and were drawn to the dome on the roof.” Campbell started out with the setting as the most important aspect of the production and built the story around it. Through a process of interviews with faculty and historical research, his script came to reflect the events in the School through an artistic lens.

Billed as a site-specific performance rather than a play, “You Are Here” is a series of vignettes with recurring characters. Some of the characters’ attributes are recognizable as certain real-life “characters” from the School of Physics and Astronomy. “Ed Ney is definitely in there,” said actress, Rebecca Myers, who wears brightly colored high tops throughout the performance.

Unlike traditional theater with its static audience and moving actors, the vignettes move from place to place on the roof of the physics building and the audience is expected to follow the action by moving with the performers. The effect is similar to moving through a historical site and watching actors portraying characters in different places. The difference is that sometimes the actors are talking but not to each other. In some cases the characters, who don’t have names, but can be easily recognized by their costumes and mannerisms, give monologues while in the same small area. The convention is similar to a split screen video where two people are talking about two different subjects, but the disparity yields a third meaning. According to Campbell, “the vignettes dramatize the discovery process.”

One of the most striking aspects of “You Are Here” are the props designed by sculptural architect, Steve Epley. One such prop could be worn like a pair of large boxy wings and alternatively used as a place for the actor to sit, making a unique transition from costume to set piece.

“You Are Here” was created and performed last May as part of the University of Minnesota Public Art on Campus series, sponsored by the Jerome and R. C. Lilly Foundations.



Photo by Jenny Allan

Actor Juliette Dannucci portrayed the Narrator, delivering her lines through a bullhorn.



Photo by Jenny Allan

Nathan Christopher played a physicist whose strange wings could also be turned into a chair. The props designed by Steve Epley, could be used as set pieces and costumes for different scenes.



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# Methods of Experimental Physics

You learn physics by doing it. That is the simple principle at work in most of the teaching efforts in the School of Physics and Astronomy. From the most basic introductory course to the most advanced graduate seminar, physics is taught primarily by solving problems and doing experiments.

One class in particular, Methods of Experimental Physics, takes this idea to its logical conclusion. This course which is required for all physics majors in their junior or senior year, teaches students methods in the first semester, then puts them to the test in the spring semester. The first semester of the laboratory deals with the use of digital and analog techniques for processing electronic signals and the use of computer instrumentation. In the second semester, students design, build and operate a physics experiment. Along the way they write proposals, give written reports, and make presentations about their work, just as physicists would in the real world.

As part of the Methods class, students create posters about their projects and present them at a poster session similar to those that is held at scientific conferences. Two students at this year's poster session, Katrina Schweiker and Lisa Johnson, had a unique project that combined physics and anesthesiology. Schweiker and Johnson then designed and built a medical device to reduce shivering in patients with induced hypothermia. Since shivering warms the patient, it is desirable to stop it in cases where hypothermia has been deliberately induced to reduce the possibility of brain damage. The device used localized heaters to warm areas of the body that have many heat receptors, such as the face and hands. Schweiker and Johnson's advisors on the project were from the Medical School's Department of Physiology and Anesthesiology. Schweiker is studying physics with a biology emphasis, and so the project was a good example of how the flexible physics major allows students to concentrate on research in areas that are specific to their career interests.

One project by Nick Moody and Steven Rice, used a process called laser doppler velocimetry to study air flows from a jet. Moody and Rice built the jet by routing pressurized air through a nozzle positioned over a vertical tube partially submerged in water. The Bernoulli effect caused the water to rise up from the basin. When water hit the air jet it was atomized, and the velocity of the water droplets could be measured. Moody and Rice created a split laser beam that was refocused at a single point. When a droplet passed this point light was reflected back to a photo detector. The two reflected beams

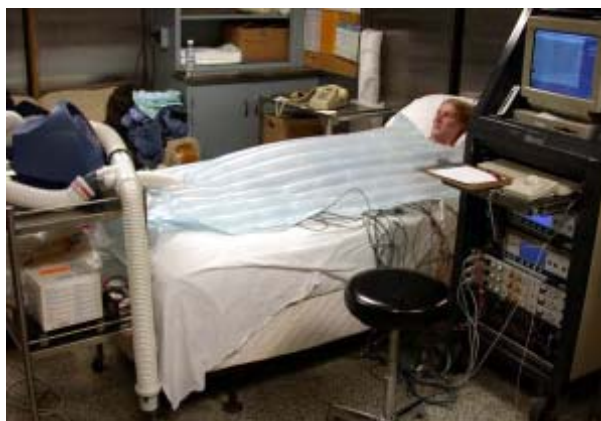


Photo by Lisa Johnson

Device built by Katrina Schweiker and Lisa Johnson to reduce shivering in patients with induced hypothermia.

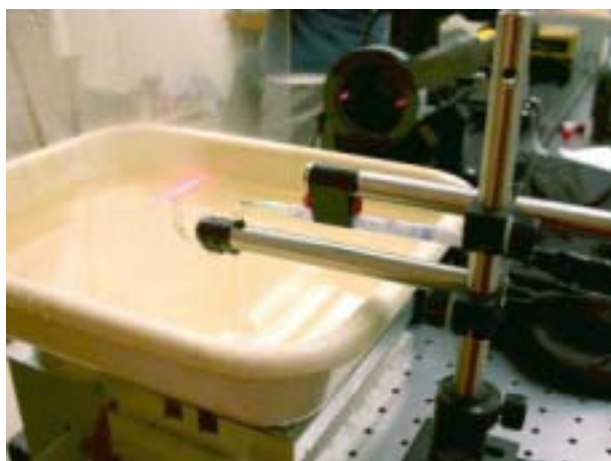


Photo by Nick Moody

Device built by Nick Moody and Steven Rice that uses laser doppler velocimetry to study jet flows.

were Doppler-shifted differently, and this difference was used to calculate a frequency and eventually the velocity of the water droplets.

The experiment coincided with expectations for the velocity of the jet, and, more importantly, students became confident in using an advanced experimental technique.

According to course instructor Paul Crowell, the experiment doesn't always end with the semester—one apparatus built by Jeanette LeLand and Mike Lorentz to measure the magneto-optical Kerr effect is still being used in Dan Dahlberg's Microscopy lab. The Kerr effect is a rotation of polarization that occurs when linearly polarized light is reflected off of a magnetized sample. The effect is important as method to determine the properties of thin films such as those used in magnetic recording.

*A Letter from the Dept. Head Cont.*

detector in the university's underground laboratory in northern Minnesota. This project is known as the Main Injector Neutrino Oscillation Search (MINOS). It also highlights the research of Shaul Hanany, who was hired in December 1998 and currently holds a McKnight Land-Grant Professorship.

One of the more spectacular events last spring was the reaction to an op-ed article in the Minneapolis Star and Tribune written by Professor James Kakalios about the physics of Spider-Man. This piece, derived from Kakalios's teaching, caught the attention of The Associated Press (AP), and many other news agencies including The London Times, CNN, BBC Radio and the CBC Radio show "As It Happens." Apart from appealing to true fans of the "Amazing Spider-Man" comic book, the commentary rode the media whirlwind surrounding the movie. Interest in Kakalios and his "Science in Comic Books" freshman seminar has moved beyond a tie-in with the "Spider-Man" movie and has been sustained by the novelty of using super heroes as a tool to teach physics.

We hope that you enjoy reading this newsletter. If you have specific questions, please do not hesitate to contact me either by telephone (612) 624-6062, or by e-mail at < goldman@physics.umn.edu > .

## Physics Force

### Public Performances

November 7 (The Next Generation)  
University of Minnesota, Tate Lab of Physics, Rm 150.  
Open to the public, time TBA.

January 14-16, 2003 (The Original Force)  
Northrup Auditorium, Four shows, times TBA.

Watch Physics Force demos online at:  
[www.physics.umn.edu/outreach/pforce](http://www.physics.umn.edu/outreach/pforce)

*Awards continued from page 2*

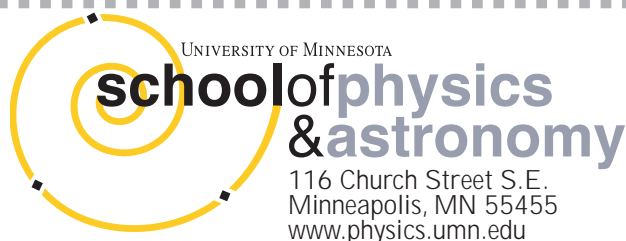
Angela J. Reisetter	TA Award
Kevin M. Renna	TA Award
Alexander W. Scott	TA Award
Ming Yan	TA Award

Also noted were the achievements of Ryan M. Chamberlain and Martha L. Boyer who had received national Barry M. Goldwater Scholarships.

### Mentor Program

The Institute of Technology Dean's office is inviting University alumni to get involved in the Mentor Program, sponsored by the IT Alumni Society. For more information on the program and online registration, see < <http://www.it.umn.edu/mentor> > .

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## Newsletter

Allen Goldman  
Head, School of Physics & Astronomy

Send article suggestions and additions/deletions for the newsletter mailing list to:

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To: