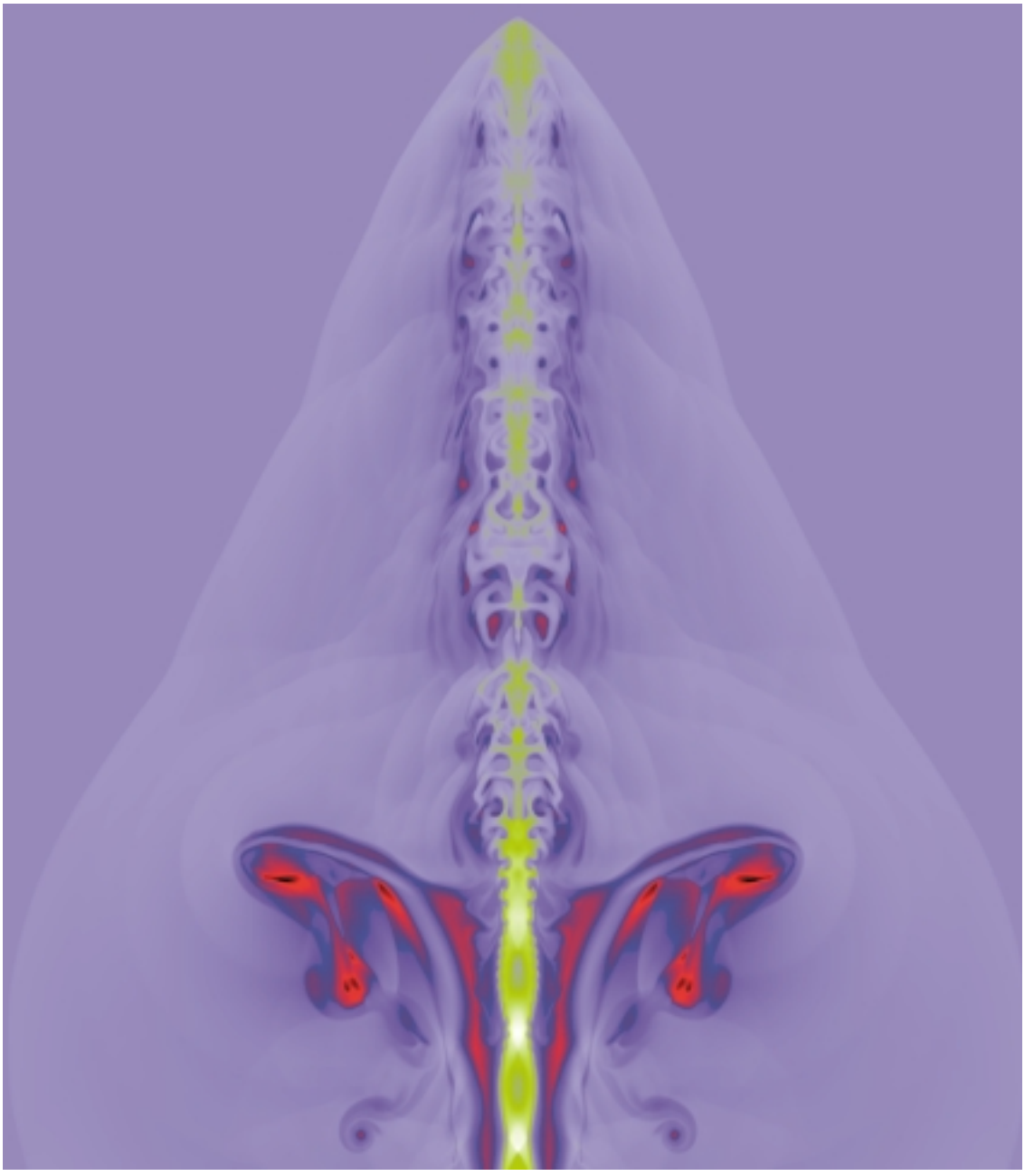
Cross Sections

DEPARTMENT OF PHYSICS AND ASTRONOMY
UNIVERSITY OF ROCHESTER
SPRING 2000



Message from Our Chair

—Arie Bodek

The previous issue of *Cross Sections* (only 10 years ago!) featured a story about Okubo Fest, a symposium to honor Susumo Okubo's 60th birthday and to celebrate 40 years of Rochester Conferences in High Energy Physics that were initiated in the 1950s by Bob Marshak. This year's feature story is about Adrian Fest, a symposium to honor Adrian Melissinos's 70th birthday.

During the past two years the department formulated a strategic plan for faculty recruitment within the University's Renaissance Plan, which provides a reduction in size to 26 faculty members in physics and astronomy. As part of this transition, the faculty has recognized that, in order to maintain excellence, we will have to interact more closely and leverage resources in more collaborative programs. A step in this direction is the shift of part of the nuclear physics program into relativistic heavy ions that is leading to the formation of a combined high energy nuclear and particle physics effort in the department. Two new faculty members. Steve Manly and Kevin McFarland joined this broad area this past year. Also, the astrophysics group has initiated a collaboration with mechanical engineering and the Laboratory for Laser Energetics on two programs, one being in high-energy dense plasmas and the other in plasmas in the domain of astrophysical phenomena, an area of particular interest to our new faculty member Eric Blackman, who joined the theoretical astrophysics group in January 2000. The condensed matter group has a newly appointed faculty member, Wenhao Wu, who is expert in experimental low-temperature physics, and is maintaining strong collaborative ties with Kodak and Xerox and with chemical engineering.

Finally, a committee consisting of faculty members from the department and from The Institute of Optics is in the process of searching for an experimenter in the field of atomic physics and quantum optics.

This past fall, the department admitted 33 graduate students, its largest entering class in 20 years. Although we overshot our planned goal by about about 50 percent, we are certainly pleased with the quality of the class, and are working on matching the research interests of the students with those of advisors inside and outside the department.

In addition to the resumption of the publication of *Cross Sections*, to keep our alumni and friends informed, we have a new and user-friendly Web page, which we urge you to visit at www.pas.rochester.edu.

You can even contribute items to the Alumni News by sending a note to alumni-news@pas.rochester.edu.

Cross Sections

Editors: Tom Ferbel and Kevin McFarland

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Cover Photo

Numerical simulation of a magnetized protostellar jet. Young stars drive high-speed beams of plasma into their surroundings. This simulation followed the evolution of a jet with an embedded magnetic field. Here we see the jet being peeled apart by the interaction of the magnetic field with the surrounding medium. Simulation performed with code written by Tom Gardiner, a graduate student in Adam Frank's research group.

"Adrian Fest" Honors Career of Melissinos

It is hard to imagine that Adrian has turned 70! He is vigorous and enthusiastic and as impossible to keep up with as ever. This past September 24–25 we gathered together his former students and colleagues to celebrate his remarkable career.

More than 125 physicists and colleagues attended the Adrian Fest Symposium on Probing Luminous and Dark Matter. Nobel laureate Leon Lederman, who worked closely with Adrian, was among the physicists from around the world who discussed future directions in particle physics. The proceedings of the symposium will be published by World Scientific.

Adrian was born in Thessaloniki, Greece, attended the Greek Naval Academy, and then joined the Royal Hellenic Navy in 1948. When his tour of duty was up, Adrian left the Greek Navy for the Charles River and MIT, where he earned his master's degree in 1956 and his Ph.D. in 1958 in the Francis Bitter Lab. He then immediately joined Rochester, where he worked on problems ranging from cosmic rays, dynamics and spectroscopy of the strong interactions to tests of the CPT theorem in kaon decay. With Leon

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Nobel Laureate Chu Joins Board of Trustees

As some of you may recall, Steven Chu, Geballe Professor of Physics at Stanford University, earned his bachelor's degree in math and physics at

Rochester in 1970. He received his Ph.D. in physics at the University of California at Berkeley with Eugene Commins in 1976. He won the Nobel Prize in 1997 for perfecting techniques to slow, trap, and study individual atoms, work that he initiated during his affiliation with Bell Labs. Steve received an honorary degree from Rochester in 1998, and he now honors the University through his service on the Board of Trustees.

Steve is a very relaxed and generous individual, and loves to tell how, as an undergraduate, he was regularly thrown out of Tom Ferbel's busy office. Tom recounts that on a recent visit, Steve once again showed up at Tom's office for some brain-picking about the University. After about 20 minutes, Tom, always in a hurry to get somewhere, looked at his watch, and showed Steve out the door. Steve responded with his usual good humor that some things never change!

McFarland Wins Outstanding Investigator Award

Assistant Professor Kevin McFarland, appointed in the department about a year ago, has won an Outstanding Junior Investigator award from the

Department of Energy. This award helps talented young physicists establish research programs, and will contribute $400,000 to Kevin's five-year program of research at the CDF detector at the Tevatron at Fermilab. Kevin's main fascination is with the origin of mass, an issue he hopes to clarify through studies of the details of production and decay of the massive top quarks.

Currently, Kevin and his team of seven graduate and postdoctoral students, including two from our department, are participating in preparations for the upgrade of the CDF detector and the increase in luminosity of the Tevatron. Kevin is leading the construction of a system to analyze data from collisions in real time. His team is building and programming a "farm," or cluster of hundreds of personal computers, to make massively parallel decisions. The project corresponds to building a tremendous supercomputer out of equipment that can be purchased at your favorite computer store. The computer farm will analyze and filter the digitized data collected by detectors, and then select the most interesting 10 percent of the collisions for further analysis.

Kevin has approximately 500 colleagues on CDF, and so he will have to share the limelight if something unusual is discovered about the top quark. But it's a small price to pay for the possibility of gaining greater

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Koshiba Wins the Wolf Prize

The Wolf Prize for physics, awarded by the Wolf Foundation of Israel, will be shared this year by Raymond Davis, Jr. of the University of Pennsylvania, and Masatoshi Koshiba, of the University of Tokyo. "Toshi" received his Ph.D. with Mort Kaplon in our department in 1955 on studies of high-energy cosmic rays. (He was also our Susumu Okubo's roommate during graduate school.) The prize will be presented at the Israeli Knesset on May 21.

Since 1978, the Wolf Foundation has awarded the prestigious prizes, second only to Nobel Prizes, to the world's outstanding scientists and artists for achievements in the interest of mankind. The prizes in science are in the fields of agriculture, chemistry, mathematics, medicine, and physics. Each prize carries a $100,000 award, with the winners selected by international committees of renowned experts in each field.

Toshi pioneered studies of proton decay and of detection of neutrinos from astrophysical sources. He initiated the Kamiokande experiments in Japan, where he led the design and construction of the detectors that observed neutrinos emitted from Supernova 1987a. Subsequently, he went on to discover what is now accepted as the oscillation of neutrinos among their different species, implying that neutrinos have finite mass.

Krishnaswami Receives Apker Award

The American Physical Society has named Govind Krishnaswami the nation's best undergraduate researcher from a Ph.D.-granting university. Govind is one of two recipients of the Leroy Apker Award, the APS's highest award for undergraduate research. The $5,000 award ranks him among the brightest young scientists in the nation. The department will also receive $5,000 in support of undergraduate research. Govind, who graduated last May, is now a first-year graduate student in physics. He was one of seven finalists who squared off in Washington, D.C., presenting their research to a panel of the nation's top scientists. The work he presented to the APS has already been published in the journal *Physics Letters B*, and was reported at the National Conference on Undergraduate Research earlier this past year.

Govind is the first student from the University to win the Apker Award, which coincidentally is named for a 1941 Rochester alumnus. The Department of Physics and Astronomy nominated Govind based on research he conducted with Professor Rajeev, which explored the structure of the proton. In particular, Govind and Rajeev studied the momentum distribution of quarks within the proton, which they calculated from first principles. This is one of the key problems in understanding the strong interaction. Now as a graduate student, Govind continues to explore the structure of the proton with Rajeev. He was also awarded a Robert L. and Mary L. Sproull fellowship, one of the most prestigious fellowships held by Ph.D. students at the University.

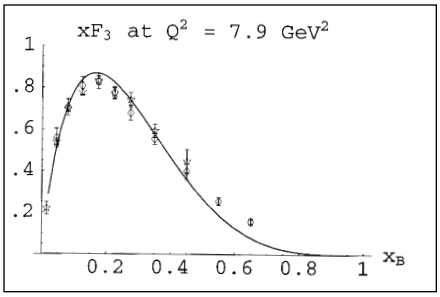
Govind is an extraordinary young man, passionate about physics, with enormous enthusiasm and creativity. He came to Rochester four years ago from Madras, India, knowing something about the University: 35 years prior, his uncle (N. Mukunda) earned his Ph.D. in theoretical physics from our department, and he is now a professor in India. Other scientists whom Govind found inspiring include Nobel laureate Richard Feynman and his own advisor. In turn, Rajeev is equally impressed by his talented student, and claims that Govind was the best undergraduate that he has seen anywhere.

—Adapted from an article in *Currents* by Susan Murphy

Undergraduate Research: A Personal Perspective

—by Govind Krishnaswami

I spent the summer of my sophomore year working on the NuTeV experiment at Fermilab, which studied the deep inelastic scattering of neutrinos on nuclear targets. Among the many parameters of the Standard Model that NuTeV measured, were the parton distribution functions of the proton. These describe the shape of the proton in terms of the distribution of quarks and gluons inside, just as the wave function of electrons describes the shape of an atom. Subsequently, when I spoke to Professor Rajeev, the problem of understanding and predicting the structure of the proton appealed to me greatly. The structure can, in principle, be described by quantum chromodynamics (QCD), which governs the strong "color" force that operates between quarks and gluons. While solving QCD, even within an approximation scheme, remains a challenging problem, Professor Rajeev had made progress with an approximation to QCD that is appropriate to the kinematical regime of deep inelastic scattering experiments. By finding solutions to this theory, we were able to calculate the distribution of the "valence" quarks in the proton (xF_3). This agreed reasonably well with experimental measurements, as can be seen in the accompanying figure.



The momentum distribution of valence quarks in the proton, xF_3, as predicted by Krishnaswami and Rajeev's work, compared to experimental data

In working on this problem, it has helped us greatly to understand the same theory from both the QCD point of view and a simplified many-body perspective called the parton model. The challenge has also been to put together several pieces of the puzzle in order to have a consistent picture that in addition makes experimentally verifiable predictions. We continue to be interested in a theoretical understanding of the structure of the proton. Studying the strong interactions is particularly exciting since they are very different from the electromagnetic and gravitational interactions. For instance, the force between quarks diverges at large distances and vanishes at small distances. Yet, looked at the right way, the interactions can appear quite simple. These exciting ideas will occupy us for a long time to come.

Thorndike Receives Panofsky Prize

Edward H. Thorndike won the 1999 prestigious W. K. H. Panofsky Prize in Experimental Particle Physics from the Division of Particles and Fields of the American Physical Society for his research on the "b" or "bottom" quark. The award recognizes Thorndike's nearly 20-year study of the quark and his leadership of the CLEO collaboration in its pursuit of its detailed properties.

Since the late 1970s Ed has been focusing his attention on the Cornell Electron-positron Storage Ring (CESR). As many of you know, this particle accelerator sits 60 feet beneath an athletic field at Cornell University, and is the site of the CLEO detector. Although Ed has served many years as head of the CLEO collaboration, a group of 200 physicists who use this NSF-supported facility, his greatest enjoyment comes from his direct involvement in both the construction of the hardware and in the analysis of the data. He often competes with his junior colleagues in figuring out novel ways to uncover the properties of the b quark.

Ed is best known for his analysis of the rare decay of the b quark into a strange quark and a photon, a process thought to proceed through what is known as a "penguin diagram." Such penguin decays are expected to be especially sensitive to new physics beyond the current Standard Model of particle physics.

After a Ph.D. with Dick Wilson at Harvard, Ed joined the University in 1961 and promptly established his own research program at the 130-inch cyclotron. After that closed, Ed chose to work on photon physics at Cornell, and subsequently on electron-positron collisions at CESR. In 1969, he won a National Science Foundation senior postdoctoral fellowship to work at CERN, where he participated in studies of meson spectroscopy. He took a break from the b quark in 1987 to spend a year at the electron storage ring in Japan as a Guggenheim fellow.

The recognition from the APS came as a surprise to Ed, who learned about the prize while answering his e-mail one Saturday morning. Suspecting a prank, he skeptically read the message requesting the title of his acceptance speech, and remained unconvinced until the official letter of notification arrived in the mail on the following Monday.

—Adapted from an article in *Currents* by Susan Murphy

Melissinos

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Lederman, he performed several important experiments on muon scattering at Brookhaven Laboratory. In the early 1970s, he pioneered studies of diffractive production at Fermilab, and in the late 1970s Adrian sampled the CLEO Collaboration. Since the 1980s, Adrian's attention has been focused on experimental activity outside the confines of the traditional accelerator environment and on application of novel technical ideas to some of the most fundamental issues in particle physics, such as axions, gravitation, sparking of the vacuum, and the use of laser "targets" and laser acceleration in particle physics. He was one of the first physicists to forge ahead successfully in these new scientific directions.

Many of us have come to regard Adrian as a true Renaissance particle physicist. His broad range of interests and combination of technical skill and ingenuity have led to many fascinating and novel investigations. In addition, he has always been an enthusiastic teacher. His books on first-year physics, on technology and industry, on quantum mechanics, and especially on methods in experimental physics are classics in demand everywhere. At last sighting, he was off simultaneously to Fermilab, SLAC, and BNL to attend to his latest interests.

University Sesquicentennial Weekend October 12–15, 2000

During the year 2000, the University of Rochester is celebrating the 150th anniversary of its founding. Alumni are invited to attend the many special celebrations being planned this year. Of particular interest to the department is a session during the Sesquicentennial Weekend highlighting quantum optics that will include presentations by Nick Bigelow, Steven Chu, and Ian Walmsley. There will also be an open house for all our friends in Bausch & Lomb Hall. Please check the University's Web page at www.rochester.edu/sesqui for any late-breaking news, and let us know if you will be attending the festivities.

MELIORA
ONE HUNDRED FIFTY YEARS

If It's Tuesday, This Must Be . . . Minsk?

This past September was a tough month for Dan Green (B.S. '64, Ph.D. '69), currently at Fermilab and serving as the Technical Director and Project Manager for the U.S. contingent of the Compact Muon Solenoid (CMS) detector being constructed for the Large Hadron Collider (LHC) at CERN, the European particle physics laboratory in Geneva, Switzerland. He was glad to return from a grand tour that saw him on the road for 15 of 20 days, from Fermilab to the Republic of Belarus to Birmingham, England, and back. The tour was necessitated by a strike in Bulgaria that prevented delivery to Spain of brass plates, required for completion of wedges of absorber material to be used in one of the CMS calorimeters. In dealing with the problem, Dan relied on one of his newly developed skills as commodity broker. He kept a particularly sharp eye on the daily vicissitudes of copper and the Swiss franc, and struck his bargain when it was advantageous for exchange in US dollars, thereby saving a great amount of money for the CMS project. Although he has spent the past 30 years of his scientific career accumulating an ensemble of skills completely different from the requirements of project management, he is certainly doing well in this new capacity. It will likely take this kind of shrewdness to assure that the entire LHC will come in on budget and on time!

Members of our high energy physics group have been working closely with Dan on the construction of a hadron calorimeter for CMS. The calorimeter is being assembled by technical staff members from Rochester and Fermilab under the supervision of Rochester's Senior Research Associate Pawel de Barbaro (Ph.D. '90), who is serving as the subproject manager. The calorimeter uses the new technology of scintillating tiles that are read out with wavelength-shifting optical fibers. That technology was developed in a collaborative effort between Rochester and Fermilab for the upgrade of "plug" calorimeters for the Collider Detector at Fermilab (CDF). The CDF calorimeters, built by Arie Bodek and his colleagues, served as the prototypes for the CMS calorimeter.

—Adapted from a *Fermi News* article by Mike Perricon

R.C.Q.I. Holds Workshop on Quantum Information

The Rochester Center for Quantum Information (RCQI) at the University of Rochester held a Workshop on Fundamental Issues in Quantum Information at the end of October. Joe Eberly and Carlos Stroud of the Department of Physics and Astronomy are two of the principal members of the Center. The RCQI is directed by Ian Walmsley of The Institute of Optics.

The workshop had two tutorial lectures that were open to the University community: Krzysztof Wodkiewicz from the University of Warsaw (Ph.D. '77) spoke about "Interference, Entanglement and Nonlocality in Phase Space," and Peter Knight from Imperial College spoke on "Quantum Communication and Quantum Information Processing." Peter is a former Rochester postdoc and a recently appointed Fellow of the Royal Society.

The workshop was held to provide an overview of the topic of quantum information, and to provide a forum for discussion of the issues, as well as to identify open questions and future directions. The subject covers quantum teleportation, computing, and cryptography. One possible application is the development of computers that are able to perform more complex functions that are either impossible or too time-consuming with today's "classically limited" machines. Another application is the transmission of encoded signals, whose security is guaranteed by the Uncertainty Principle, and has obvious application in the exchange of information. Some of the world's leaders in the field of quantum information and measurement attended the workshop and lectured on their specialties.

Astrophysicists Launch Outreach Program

Thirty years after the NASA launch that put man on the moon, one of our astrophysicists and his students plan a launch of their own. They've won funding to develop an outreach program that will put astrophysics on the desktop, allowing amateur astronomers, students, and others to design and conduct their own experiments.

A team led by astrophysicist Assistant Professor Adam Frank has secured $650,000 from NASA and the National Science Foundation to continue its astrophysical research and to develop a stripped-down version of the complex computer codes that they run every day on supercomputers to simulate events like stellar birth and death. The program will be available for use by the community at a specially designed kiosk at the Strasenburgh Planetarium at the Rochester Museum & Science Center on East Avenue. The centerpiece will be a personal computer equipped with the program, dubbed "Astroflow," surrounded by several large, striking photos of the heavens taken by the Hubble Space Telescope.

Adam feels that with this program kids will be able to tinker with a star. For example, they will be able to watch stars evolve according to their own instructions, or see what happens when a star squirts out a monstrous amount of gas in a very short time. They might request an explosion twice as large, and then learn about the conditions needed for that to happen, or they might change the velocity of a gas jet and see what results from that.

Adam's students unveiled a prototype of the program at the May 1999 meeting of the American Astronomical Society in Chicago, and they hope to have the final product ready by this June when the University and the Rochester Institute of Technology host the AAS annual summer meeting.

—Adapted from an article in *Currents* by Susan Murphy

American Astronomical Society to Meet in Rochester

On June 4–8, 2000, the University of Rochester and RIT will co-host the 196th meeting of the American Astronomical Society (AAS). The event will be held at the Rochester Convention Center, and some 1,000 astronomers are expected to converge on our city. There will be invited speakers and topical sessions, in addition to the usual contributed oral and poster papers. The time of this meeting corresponds to a critical period in planning for the Space InfraRed Telescope Facility (SIRTF), to be launched December 2001. The call for SIRTF "Legacy" proposals is essentially contemporaneous with that date.

Legacy Science Projects are to be major coherent investigations based on measurements with SIRTF, and of lasting importance to the astronomy community. There has been no proprietary period set aside for the release of SIRTF Legacy data, and calibrated measurements will therefore be placed immediately in a public archive in order to promote follow-up investigations by guest observers. A large fraction of the observing time is expected to be allocated to Legacy. A topical session as well as an exhibit is planned for the AAS meeting around these programs.

Among other topical sessions proposed for the AAS meeting are those devoted to research in laboratory astrophysics using facilities at the Laboratory for Laser Energetics, and a session on bipolar outflows—a local specialty.

University of Rochester astronomers, led by Professors Bill Forrest, Judy Pipher, and Dan Watson, have been developing sensitive infrared (IR) detector arrays for SIRTF instruments since 1984. They have contributed especially to the construction of near-IR and mid-IR cameras. In addition to supporting instrument development and testing, they are working on their already guaranteed observing time for their science programs on topics ranging from surveys for brown dwarfs, study of circumstellar disks, halos around spiral galaxies, starburst galaxies, and the evolution of young stellar clusters.

Faculty Profile: Wenhao Wu

Wenhao Wu joined the faculty in December 1997. He received his B.S. degree in physics from Nanjing University in 1983, his M.S. degree in physics from the Chinese Academy of Science in 1986, and his Ph.D. in physics from the University of Chicago in 1992. From 1992 to 1995 he held postdoctoral positions, first at Louisiana State University and then at Michigan State University.

His research interests are mainly in the low-temperature behavior of disordered and low-dimensional condensed-matter systems, such as disordered magnets, ultrathin superconducting films, as well as sub-micron structures of these disordered materials fabricated through electron-beam lithography.

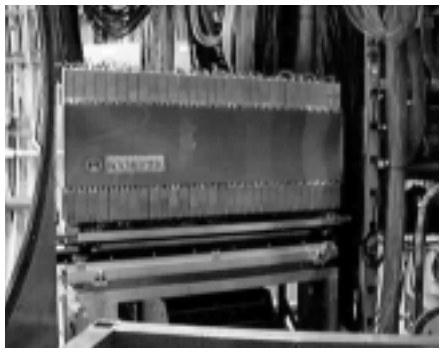
There are two types of fundamental questions Wenhao and his students are trying to address. First is how electrons conduct current in disordered low-dimensional systems. Not

only is this important from the point of view of basic research, but understanding electron transport in such systems is also vital for technology, because the microelectronics industry is being rapidly transformed toward the fabrication of smaller, thinner, faster, and more sensitive devices. The second question concerns the collective behavior of a large number of particles, of order of 10^{20}, that interact with each other via a long-range force such as the dipole coupling between magnetic moments or the Coulomb repulsion between electrons. In a highly disordered system, one of the most challenging questions in physics is what is the ground state of such a system.

During the past year, Wenhao and his students have been studying superconductivity in ultrathin films with a thickness of about 10 angstroms. These films are made by quench-condensing vapors of metallic elements onto insulating substrates held near liquid helium temperature. Due to the very low atomic diffusivity at such a low temperature, ultrathin and electrically continuous films can be formed to study the physics of highly disordered two-dimensional systems. Currently, Wenhao and his students are measuring the transport and tunneling characteristics of ultrathin films of low-mass superconducting elements. Specific questions to be addressed include how superconductivity is suppressed in ultrathin films and how the density of electronic states near the Fermi energy of these ultrathin films differs from that of the bulk materials.

Going Back in Time at RHIC

With the commissioning of the Relativistic Heavy-Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) in the spring of 2000, Rochester physicists will start looking back in time at conditions in the universe that existed a few microseconds after the Big Bang. Steve Manly, Frank Wolfs, and their research associates and students are collaborating with scientists from several other institutions on the PHOBOS experiment, one of the four approved experiments ready to run at RHIC. PHOBOS will have the first look at the extreme energy densities that will be created when relativistic gold nuclei collide head-on at RHIC. It is believed that a new state of matter, the quark-gluon plasma (QGP), will be formed in these collisions. In a QGP, the neutrons and protons of ordinary matter coalesce to form a primordial "soup" of their constituents, quarks which carry the charge of the proton and gluons which carry the force that binds quarks together into protons, neutrons, and nuclei. PHOBOS will study this new state of matter, and the observed properties of the QGP are expected to provide unique insight into the state of the very early universe. Due to its inherent simplicity, PHOBOS has the potential of making a major scientific discovery during the initial running period of RHIC.



One of the PHOBOS time-of-flight sections installed at RHIC, replete with the Rochester seal

The Rochester group is responsible for several hardware and software components of PHOBOS. The group received funding from the Major Research Infrastructure program of the National Science Foundation for the construction of two time-of-flight sections, which double the acceptance of PHOBOS. This construction project was completed on time and on budget, and the time-of-flight wall (see picture) is currently installed at RHIC and is waiting for the first collisions. Support for the relativistic heavy-ion program in the department is provided by both the Department of Energy and by the National Science Foundation.

New Faculty Profile: Eric Blackman

The department is pleased to report the successful recruitment of an outstanding new member of the faculty.

Eric Blackman, a theoretical astrophysicist, has joined the department as Assistant Professor of Physics and Astronomy. The recent search for a theoretical astrophysicist brought many extraordinarily talented applicants to visit the department, but Blackman's creativity, breadth of interests, and talent as a scientist made him a standout.

Eric's principal interests focus on problems involving astrophysical plasmas and magnetic fields. His work on the origin of magnetic fields in settings as diverse as the sun, galaxies, and disks of gas surrounding massive black holes have opened new windows into the nature of interactions between plasma motion and fields. Eric has also worked in high energy astrophysics, including issues such as the mysterious gamma ray bursts.

Eric comes to the department after an impressive period of training at some of the world's finest institutions in astrophysics. He received his undergraduate degree in physics and math from MIT in 1990, and a degree in applied mathematics at Cambridge University in 1991. He completed his Ph.D. in theoretical astrophysics at Harvard in 1995, and has held postdoctoral fellowships at Cambridge and at Caltech. Eric also plans to take part in the department's new program (with the Laboratory for Laser Energetics) in high energy-density plasma astrophysics.

It is noteworthy that Eric is a Rochester native and an alumnus of the Harley School in Brighton. Along with his interests in all things cosmic, he is an accomplished athlete and a particularly wicked basketball player. He plans to take full advantage of the new and improved University athletic facilities.

Mees Observatory Gets Face Lift

The 24-inch telescope at our C. E. K. Mees Observatory is undergoing its first major upgrade since its installation in 1966. A new pointing and tracking system, complete with new encoders, secondary-mirror (focus) drive, drive controllers, and a control computer with pointing, tracking, and autoguiding software will be completed by March 2000, just in time for the lifting of winter cloud coverage at Rochester. Gone will be the days of locating objects by "finding charts" and manual offset guiding, tasks that often require the touch of a professional astronomer. Students as well as experts should be able to use the upgraded telescope efficiently. The work is being carried out by DFM Engineering of Longmont, Colorado, which specializes in retrofits to such telescopes.

Most of the incentive for the upgrade comes from the teaching needs of our undergraduate astronomy program. The upgrade will make astronomical results accessible even to beginning and non-science students. The improvements will enable our students to get twice the data in the same amount of time. We also plan to exploit the simplified telescope operation in a new Quest course, Astronomy Through Inquiry (AST 171Q and 172Q), to be offered for the first time next fall. The upgraded facility will also be used during the summer by undergraduate students doing research in our department. There are still several areas in astronomy in which such small telescopes can make important contributions, such as those requiring large fields of view and/or sensitivity to diffuse emission in observations of open stellar clusters or interstellar matter in the solar neighborhood.

Funding for the upgrade was provided by the College, our department, and the Center for Imaging Science at the Rochester Institute of Technology, our collaborator in this project. The RIT astronomy group is also providing a 2048x2048 CCD camera as a facility instrument for the upgraded telescope.

Kevin McFarland

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insight into the fundamental nature of matter.

Kevin also believes strongly in the importance of educating the public about the research conducted at Fermilab. This past summer, as part of the QuarkNet program, a national program that partners high school teachers and scientists, he served as a mentor at Fermilab to two high school teachers from the Rochester area. Next summer, these two teachers will be stationed at the University, one of 12 QuarkNet centers, to show 10 other high school teachers how to implement physics research projects into their curricula.

In addition to winning DOE's Outstanding Junior Investigator award, Kevin's research earned him recognition as a Sloan Research Fellow in 1998, the same year he joined Rochester. Kevin earned his doctoral degree in physics from the University of Chicago and his bachelor's degree in mathematics and physics from Brown University. Before coming to Rochester, he held an appointment as a Lederman Fellow at Fermilab, where he worked on neutrino scattering.

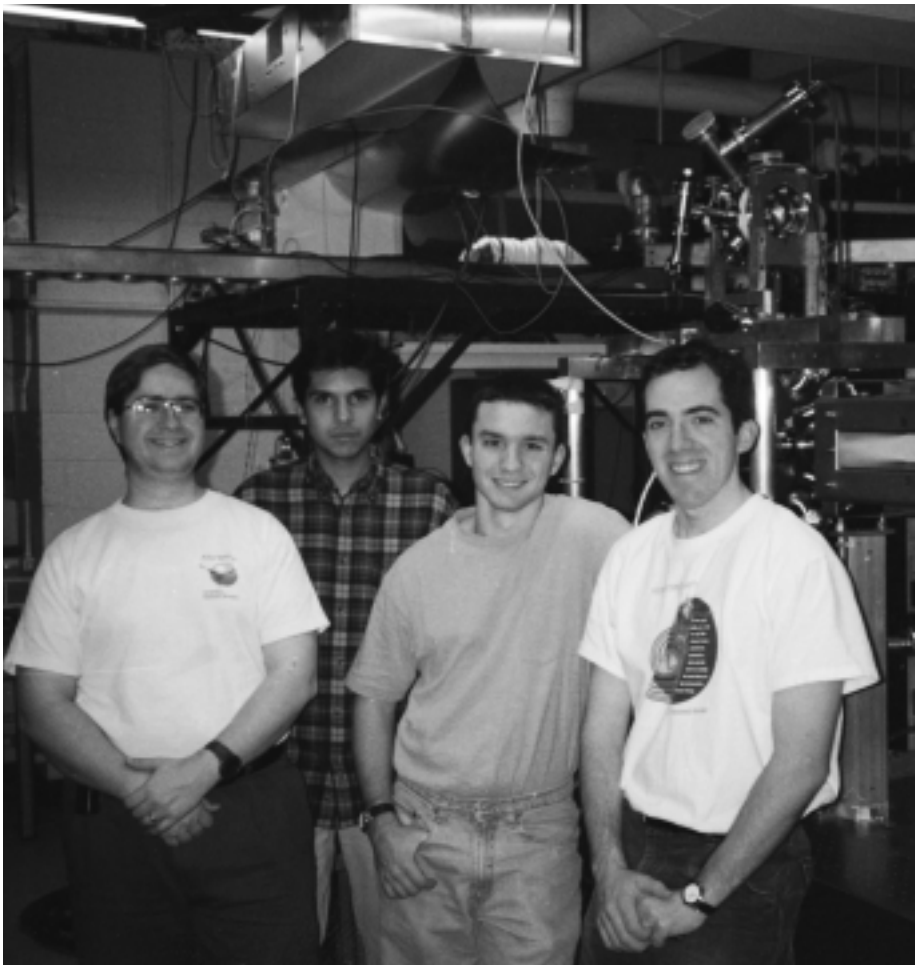
—Adapted from an article in *Currents* by Susan Murphy

Graduate Student Research: Towards BEC in Our Own Backyard

—by Ben Weiss

In the basement of Bausch & Lomb Hall, in a small vacuum chamber resembling a Star Wars warship, atoms are regularly cooled down to temperatures one million times colder than lake-effect snow. A few years ago, members of Nick Bigelow's Cooling and Trapping (CAT) Group would boast that our atom traps were the "coldest spots in the universe." These days, 100 micro-Kelvin seems downright sweltering. With the realization of Bose-Einstein Condensation (BEC) in dilute alkali gases, physicists have been able to produce traps with temperatures less than 10 nano-Kelvin! At these ultracold temperatures, atomic motion is slowed to a snail's pace, the thermal deBroglie wavelength becomes comparable to the interatomic spacing, and quantum mechanical effects dominate atomic interactions. BECs have opened the door to a wide range of studies, from matter-wave interference and superfluid-like vortices to coherence phenomena and the atom laser. One might say that BECs are the hottest thing in cold physics today.

Graduate students in Bigelow's CAT Group are working hard to make BEC a reality here at Rochester. For several years, the CAT Group has been engaged in studies of heteronuclear ultracold collisions in two species magneto-optical traps (MOTs) of both Na+Cs and Na+Rb. Recently, this work has focused on the production of heteronuclear molecules of sodium and rubidium. The hope is to extend this work on two-species traps to a new low-temperature regime by creating the first two-species BEC (TBEC).



Graduate students (l to r) Michael Banks, Pedro Quinto Su, John Janis, and Ben Weiss pose in front of the coldest spot in Rochester.

Multicomponent BECs have unique features that cannot be observed in the single species varieties. For example, interspecies interactions in a TBEC of sodium and rubidium lead to phase-separation between the component species. Probing these ground state structures might also provide a way to observe a macroscopic quantum transition in this system.

The chamber mentioned above is part of a two-chamber apparatus designed to first capture and cool atoms from a background gas and then transport them to a low-pressure region where further cooling leads to condensation. The procedure is as follows: A MOT is set up in each chamber, above and below a vertical connecting tube. Atoms collected in the upper MOT are pushed through the tube into the lower chamber with an

on-resonant laser beam, and captured in the lower MOT. This cycle is repeated many times until the lower MOT is completely saturated. At this point, the lower chamber holds well over one billion atoms at micro-Kelvin temperatures. This is a reasonable starting point for the BEC cooling cycle.

Intuitively, we expect BEC to occur when the mean deBroglie wavelength is greater than or equal to the interparticle spacing. This criterion turns out to be very difficult to meet with standard cooling and trapping techniques. In order to reach BEC, magnetic trapping and evaporative cooling must be employed. Magnetic trapping is possible because atoms have an intrinsic magnetic dipole moment, and can therefore be trapped with static B-fields. Evaporative cooling takes place in conjunction with magnetic trapping, and refers to a process of "boiling off" the hottest atoms in the trap with radio-frequency radiation. As the atoms rethermalize, their temperature is lowered, slowing them down and increasing their deBroglie wavelength. At the same time, the trapping fields are ramped to provide tighter confinement. In this way, both the mean deBroglie wavelength and particle density are increased. If this procedure is carried out carefully, the criteria for BEC can be satisfied.

It won't be too long before BEC makes its Rochester debut. When the setup procedure is completed, our apparatus will enable us to carry out many interesting experiments, several of which were mentioned above. But scientific curiosity is not all that motivates us. After all, it seems only fitting that the home of the "coldest place in the universe" should be right here in Rochester.

Update of a Classic Work Published Posthumously

This past October, some two years after receiving the University of Rochester's Distinguished Alumni Medal

of the College, our former graduate student Charles E. Swenberg died at the Mayo Clinic at the age of 59 as a result of complications due to a 30-year-long sequence of illnesses. Almost at the same time, the second edition of his book with Martin Pope entitled *Electronic Processes in Organic Crystals and Polymers* was published. Eagerly awaited, the 1,328-page volume updates the original 1981 edition that had become a standard reference for the field. Swenberg made his very substantial contributions to the completion of the new edition largely from the confines of a hospital bed.

After completing a thesis in theoretical condensed-matter with Bob Knox in 1967, Swenberg went to the University of Illinois for a postdoc and on to New York University as a faculty member. Working first with organic crystals and later with photosynthetic systems, he pioneered the development of exciton fission and fusion as diagnostic tools for uncovering structures and mechanisms for energy transport. Moving on to the Armed Forces Radio biological Research Institute (AFRRI), the only government laboratory devoted to studies of the impact of ionizing radiation on biological systems, he worked on mechanisms of DNA radiolysis, on improving radioprotective agents, and on differentiating the impact of neutrons and gamma rays on biological systems. In his new capacity as an experimenter, he held posts as Chief of the Division of Physical Radiobiology and Project Manager in the Radiation Biochemistry Department at AFRRI.

Swenberg coauthored a volume on medical physics with Arthur Damask and was planning a new book on that subject, an area in which he had no peers in experience. His former colleague Jack Dow once described him as "the true bionic man." Crohn's disease had ravaged his intestinal tract and for some time, even while co-organizing and attending NATO schools, he lived by virtue of a feeding tube inserted into his chest. He bore many other burdens associated with strong pain killers, and had to manage his body chemistry at all times. He earned the admiration of his physicians, who often remarked on his unique and towering courage.

Swenberg's professional interests and activities seemed boundless. He was instrumental in bringing together biologists and statisticians to achieve essential interpretations of data on membranes, and was keenly interested in neurobiology and medical physics. He was a fellow of APS, always kept current on physics, and was working on a Ph.D. in mathematics (topology) at the time of his death. In all, he authored or coauthored 3 books, edited 4, and wrote 93 research papers and 23 chapters in various other books.

"We'll Take the Physical Challenge"

—by Aaron Reichman

Showing no respect for the elders who taught them about Maxwell's Equations, wave propagation, and how to correct spherical aberration in a telescope, the SPS seniors slapped a glove to the face of their professors, challenging them to a duel of wits. In a Jeopardy-type quiz bowl, undergraduates Davis Doherty, Nora Macey, Damen Provost, Aaron Reichman, Nick Rogers, Rich Sarkis, and Jason Sickler led a Napoleanic charge against the faculty to prove that a Ph.D. meant nothing. Unfortunately, the powerhouse team of professors—Nick Bigelow, Tom Ferbel, Steve Manly, Lynne Orr, Steve Teitel, and Dan Watson—proved worthy of their doctorate status in defeating the undergraduates by a "smallish" margin of 20 (+/- 15) points.

Questions were developed by the department's graduate students. Categories, included Sports, Movies, Art, and the University of Rochester/Bausch & Lomb Hall. In an attempt to liven up the game, each team was given an opportunity to force one of the opposing team members to answer a question. Also, teams were given the opportunity to take a "physical challenge" if they did not know the answer to a question. While the undergraduates used this option to advantage, the professors did not fare quite as well.

So indeed, the faculty was able to defeat the team of undergraduates, but nonetheless, SPS is still proud of its effort. After all, the students proved to be far better dancers. . . .

The students engage in a misguided attempt to regain their dignity by "Shuffling Off to Buffalo."

In Brief

Initiation of Robert E. Marshak Postdoctoral Fellowships

This past December, the department approved the initiation of a new postdoctoral program of prestigious fellowships in nuclear and particle physics. Named in honor of Robert E. Marshak, these will be open to both experimenters and theorists, reflecting Marshak's impact and keen interest in all aspects of the field. The intent is to bring to Rochester exceptional young individuals to help continue the department's historic excellence in nuclear and particle physics. While funds to start the program are already available, contributions are being sought to bring it to its full potential. Anyone interested in contributing should tick off the appropriate box on the form printed on the last page of this issue of *Cross Sections*.

Frederick Lobkowicz Thesis Prize Established

This prize, established by friends and colleagues of Fred Lobkowicz, is awarded to graduating Ph.D. students in experimental high-energy nuclear or particle physics whose accomplishments best reflect the high standards and exceptional quality of research of the late Professor Lobkowicz. The prize includes a monetary award of $600.

Lynne Orr Honored for Excellence in Teaching

Particle theorist Lynne Orr, promoted this past summer to Associate Professor in the department, received the G. Graydon and Jane W. Curtis Award for Excellence in Teaching by a Non-Tenured Faculty Member in Spring 1999. Orr, whose specialty is the phenomenology of particle physics, joined the faculty in 1993. Her interests are in understanding the contribution of gluon radiation to top quark production and to production of jets from the perspective of the theory of quantum chromodynamics.

Emil Wolf Does It Again!

Emil Wolf, our distinguished Wilson Professor of Optical Physics and Professor of Optics, received honorary doctorates from the Universite de Franche-Compte in France and from Aalborg University in Denmark for his broad range of contributions to physical optics. His classic book, *Principles of Optics*, which he wrote with Max Born, has just been republished in an expanded seventh edition. The recent awards bring to seven the number of honorary degrees Emil has received. He has been similarly recognized by universities in England, Canada, Scotland, the Netherlands, and the Czech Republic.

Wolf is an expert on the behavior and physics of light. His extensive contributions are documented in more than 300 scientific papers that have had broad impact in areas ranging from holography, laser science, medical imaging, ultrasound, cryptography, radio astronomy, the search for long-buried dinosaurs, and even our understanding of the history and development of the universe. Of course, Emil has also been the recipient of many other prestigious awards in both the United States and abroad and is one of the most revered members of this field of physics.

Magic Flutes

For the past several years David Douglass's Physics of Music class has spread holiday cheer in the foyer of Bausch & Lomb Hall prior to the annual departmental party with their annual "Flute Choir" concert.

The students make these flutes, as one of the laboratory experiments in the class, out of plastic pipe and corks from wine bottles. The tone holes are positioned to produce a note to within half a semi-tone as determined by a reference tone or spectral analysis. Students in the class compose and arrange the musical score and conduct the choir.

In Memoriam

Betty Cook with (l to r) students Stephan De Bievre (Ph.D. '86), Sarah Eno (Ph.D. '90), and John Mansour (Ph.D. '90).

Betty Cook, who retired in July 1993, died suddenly this past summer (August 21, 1999). Betty worked in the department as Graduate Student Counselor from September 1963 until her retirement. Over that 30-year period, she was more "mother-in-residence" to our graduate students than just a department administrator. We have indeed lost a family member.

Peter Koehler (Ph.D. '67) has stepped down as Dean of the College of Arts and Sciences at the University of Pittsburgh. After 12 years of service in that capacity, he is now teaching full time, and finding it both challenging and rewarding.

Rex Adelberger (Ph.D. '69) has been a leader in developing teaching and research activities at small colleges. He has been Chair at Guilford College, and is the current editor of the *Journal of Undergraduate Research*. This year he is on sabbatical leave in Hawaii, working on the Maui Space Surveillance Telescope.

If you think you've been seeing a younger version of **Joel Berlighieri** (Ph.D. '70) on campus lately, you're right. Son Joel, Jr. is a freshman, majoring in engineering. Dad has for many years been on the physics faculty at The Citadel in Charleston, South Carolina.

After finishing a thesis on particle physics with Fred Lobkowicz, **Jon Abramson** (Ph.D. '75) decided to sample the field of biophysics. Following a stint as a postdoc at the University Medical Center, he joined the Physics Department at Portland State University in Portland, Oregon, where he has been professor since the late 1980s. Jon has been the recipient of a highly esteemed Established Investigatorship from the American Heart Association and a Fulbright Fellowship for study in Israel. He writes that he loves biophysics—the experiments

are far less expensive, and they don't take a decade to complete. His main interest is in proteins that transport calcium and control muscle contraction in both skeletal and cardiac muscle.

Michele Migliuolo (Ph.D. '88, and younger brother to Stefano, Ph.D. '77) just reported that he is the Vice President for Sales and Marketing at XACTIX, a company located in Pittsburgh that makes MEMS (microelectromechanical systems) biomedical devices, and special processing equipment.

After completing her Ph.D. in 1990 on the AMY experiment in Japan, **Sarah Eno** did a postdoc at the University of Chicago on CDF. Subsequently, she joined the physics faculty at the University of Maryland and the D0 experiment. She was promoted this past fall to associate professor.

Mark Battle (Ph.D. '94) earned his degree in experimental particle physics on the CLEO experiment. He then changed fields, and moved into atmospheric science. He held postdoc appointments at the University of Rhode Island and Princeton, where he studied the global carbon cycle through precision measurements of oxygen concentrations in snow core samples he obtained at the South Pole. Mark has recently joined the Physics Department faculty at Bodoin College.

A rising young star in particle physics, after a postdoc position with the University of Pennsylvania, **Cathy Cretsinger** (Ph.D. '95) decided to try Berkeley Law School and a career in patent law.

Spied on the streets of Georgetown in Washington, D.C., were **Eliza Stefaniw** (M.S. '96) and **Emile Ettedgui** (Ph.D. '95). Emile is currently with the Rand Corporation. Eliza, after working at NRL (Lab for Comp Physics & Fluid Dynamics) and then in science policy and arms control at various government agencies, including the U.S. Patent Office, is now attending law school. She is currently working on a degree in patent law.

Gordon Watts (Ph.D. '95) has joined the physics faculty at the University of Washington at Seattle, where he plans to continue his work on the D0 experiment at Fermilab.

Jianming (Jim) Cao (Ph.D. '96) joined the faculty of the Department of Physics at Florida State University this past fall. Jim did his thesis on femtosecond dynamics of electrons at metal surfaces. After graduation, he went to Caltech to help develop picosecond gas-phase electron diffraction in the group of Ahmed Zewail, winner of the 1999 Nobel Prize in chemistry. Jim is now working hard to build his own lab and equip it with state-of-the-art ultrafast lasers and surface-sensitive probes.

Kathy Fatyga (Ph.D. '96) is currently a member of the technical staff at Lucent Technologies in Naperville, Illinois. She is very generous in her claim that her career as a software developer at Lucent has been successful primarily because of the training she received as a member of the Rochester group on the D0 experiment at Fermilab. She lives in Warrenville, Illinois, and periodically joins her former associates for functions at Fermilab.

Phil Koehn (Ph.D. '96) is a postdoctoral fellow at the Ohio State University, where he is building a fast processor that will provide selective triggering on charged tracks for the upgraded CDF experiment at Fermilab.

This past fall, **Michael G. Nichols** (Ph.D. '96) became Assistant Professor of Physics at Creighton University in Omaha, Nebraska. Prior to joining Creighton, Mike spent three years as a postdoctoral research associate in the laboratory of Watt Webb in Applied Physics at Cornell.

After graduation, **Charlie Freeman** (Ph.D. '97) and **Diane Brian** (Ph.D. '97) married and decided to remain in the Rochester area. Charlie took a position as Assistant Professor in Physics at SUNY Geneseo, which is also Diane's undergraduate alma mater, and Diane joined Kodak, where she is working on digital imaging and analysis. We understand that the commute has not posed any problems to their marriage nor to their careers.

Edward L. Hull defended his Ph.D. thesis in May 1999 and was subsequently appointed Senior Scientist at Rio Grande Medical Technologies in Albuquerque, New Mexico. Ed is working on the design of optical instruments to be used in medical diagnostics.

Departmental Funds

The department has established several funds that greatly benefit departmental activities. They are:

The David L. Dexter Memorial Fund. Established in 1981 to honor the memory of the late Professor Dexter, this fund supports an annual lecture by an outstanding scientist.

The Robert E. Marshak Memorial Fund. This fund will be used to support the newly created postdoctoral Robert E. Marshak Research Fellowships, intended to attract the most talented young nuclear and particle physicists to Rochester to continue their research in the department.

The C. E. Kenneth Mees Observatory Fund. Established in 1977, this fund is for the discretionary use of the director of the University's Mees Observatory in support of observatory activities, such as the recent upgrade to the facility.

The Elliott W. Montroll Memorial Fund. Established in 1984 in memory of the late Professor Montroll, this fund supports the Montroll Memorial Lectures in Physics.

The Physics and Astronomy Alumni Fund. Established in 1968, this fund is for the discretionary use of the chair of the Department of Physics and Astronomy in support of departmental activities.

Contributions from alumni and friends are the dominant source of income to these funds. If you would like to support the Department of Physics and Astronomy, please mark the appropriate box on the form below and send it with your contribution. Donations may be tax-deductible, and donations of appreciated securities may also carry significant tax advantages. The department is grateful for any help you may wish to give.

I wish to contribute to the following fund:

- ❑ *The David L. Dexter Memorial Fund*
- ❑ *The Robert E. Marshak Memorial Fund*
- ❑ *The C. E. Kenneth Mees Observatory Fund*
- ❑ *The Elliott W. Montroll Memorial Fund*
- ❑ *The Physics and Astronomy Alumni Fund*

Enclosed, please find my contribution in the amount of $ _____

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Address _____

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Year/Degree _____

If donating by check, please make your check payable to the "University of Rochester," indicate on the check that it is for the "Department of Physics and Astronomy," and please indicate the specific fund to which your donation should be applied. Gifts of appreciated securities are also gratefully accepted. Please send your contribution and this form to:

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University of Rochester
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