

Hands-On Physics Research for Undergraduates

By Carol Rabuck

Inside the University of Michigan’s College of Literature, Science, and the Arts, the Physics Department generates some 25% of the federal funding for research. With more than 60 faculty members and an annual research budget of about \$14.4 million, a wide range of exciting research projects are being pursued. Many physics undergraduates supplement their classroom education by taking part in this cutting-edge research.

There are several avenues for University of Michigan Physics undergraduate students to begin their research careers. Physics students are often exposed to research for the first time through the University’s Undergraduate Research Opportunity Program (UROP), or the Physics Department’s Research Experience for Undergraduates (REU) Program. Participation in these programs often leads students to long-term research positions where they work side by side with Physics faculty members.

UROP

Many Physics Department faculty members are eager to serve as mentors to undergrads. They often do this through UROP, which brings together first- and second-year students with faculty mentors. UROP can provide Physics undergrads with the opportunity to continue their research throughout all four years at Michigan.

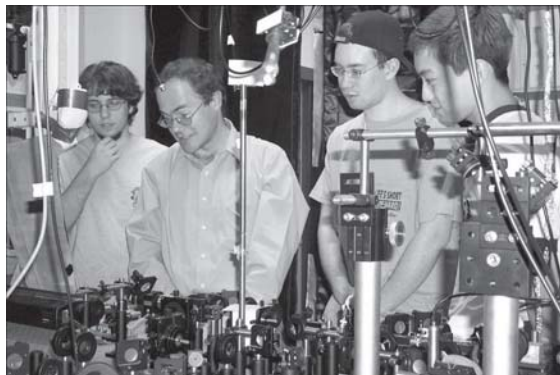
Participating in UROP allows students to work with a faculty mentor and build a relationship with faculty outside of a classroom setting, which helps students better understand the academic, social and research climate of the University very early in their academic career. Students develop a keen understanding of how research is conducted and applied, are better able to talk with faculty about academic concerns, learn to know students with similar interests, identify academic and career interests, and are privy to many special events and activities which enrich a student’s university experience.

Professor Timothy McKay has been a mentor to several UROP students. He says, “UROP helps to jump start our students’ undergraduate research careers. Projects which begin through UROP often evolve into paid research assistantships during students’ junior and senior years.”

REU Program

Another research path taken by some students is participation in the NSF Research Experiences for Undergraduates Program. The Department hosts undergraduates from the University of Michigan and other universities and colleges for ten weeks during the summer to carry out research with Physics Department faculty members in the fields of astrophysics, atomic, molecular, and optical physics, biophysics, condensed matter physics and high energy physics.

Participating students are awarded a stipend. The Department helps match prospective researchers with faculty mentors. REU participants are automatically enrolled in the Physics



Physics Department Photo

Physics Professor Georg Raithel with undergraduate students studying cold atoms trapped in optical lattices.

In This Issue...

LETTER FROM THE CHAIR	2
ON THE PATH TO DISCOVERY	3-4
FACULTY AWARDS	5
STUDENT AWARDS	6
FEATURE STORY CONTINUED	7
PHYSICS EVENTS	8
FACULTY RETIREMENTS	8
ALUMNI CORNER	9-10
YOU CAN HELP!	11

(continued on page 7)

Letter From the Chair

Photo by Carol Rabuck

It is my particular pleasure to welcome you to this newsletter – our biannual window into Physics at the University of Michigan. The first few months of my term as Chair of the Department have been exciting; this is a very special place filled with gifted people operating in state of the art facilities. More and more undergraduate concentrators (now over 100!) are becoming aware of the value of a rigorous scientific discipline as part of a Liberal Arts education, and our incoming Graduate class is the largest and best qualified in years. I am enjoying learning more about the work and successes of my colleagues, and I am becoming more appreciative of the dedication and skill of the Department staff. This Department truly exemplifies what “The Michigan Difference” makes.

The United Nations Assembly passed a resolution declaring 2005 to be the International Year of Physics. This is partly to celebrate the centennial of Einstein’s three 1905 papers on relativity, the photoelectric effect, and Brownian motion. The Department is preparing for this celebration in several ways. In March we will be hosting the one-woman drama “Manya – A Living History of Marie Curie” by Susan Marie Frontczak. The Michigan Center for Theoretical Physics is planning a series of Einstein lectures by local faculty. In the fall 2005 term, we will celebrate the century of progress with a physics oriented Literature, Science and Arts theme semester entitled “One Hundred Years Beyond Einstein”. We are developing two new courses to be offered during the theme semester, one will be a new interdisciplinary course on “Origins” which will include discussions of the origin of the universe in the big bang, the growth of stars and galaxies, the formation of the Earth, and the evolution of life. The second course will be to introduce first year students to experiments in the advanced labs. This lab will provide hands on experience to advanced equipment such as a scanning tunneling microscope, and classic experiments such as the photoelectric effect, neutron activation and atomic spectra.

One highlight of this past year was the election of Professor Philip Bucksbaum to the National

Academy of Science (NAS). The NAS is a non-profit society of distinguished scholars engaged in scientific research. The NAS has a mandate to advise the federal government on scientific and technical matters. Professor Bucksbaum’s election to the academy is well deserved recognition of his outstanding work in non-linear optics, precision measurements, and ultra-fast laser physics.

Saturday Morning Physics (SMP) is now a well established physics public lecture series regularly attended by more than 300 members of the Ann Arbor community on 18 Saturdays through the academic year. The fall 2005 SMP lecture series will highlight the International Year of Physics. The lecturers for this series will be drawn from the physics faculty, with the possible inclusion of several guest lecturers. For several years the SMP lectures were videotaped and re-broadcast throughout the Ann Arbor area on Comcast Channel 22. They have been remarkably popular, with each lecture broadcast dozens of times. Unfortunately, budget constraints cut the video production; however, we are hopeful that next year we may be able to again make recordings for broadcast and distribution.

It is my great honor to have been selected Chair of the Physics Department. At the same time it is humbling to be in the same position once occupied by Harrison Randall and David Dennison. The Department has a rich tradition of education and research, but we are facing major challenges in securing the resources needed to carry out our most important efforts, and meeting these challenges will not be easy. Our outstanding faculty, our dedicated staff, our current innovations in teaching and progress in front-line research tell me the Department will remain among the leaders and the best.



Sincerely,
Myron Campbell
Chair of Physics



On the Path to Discovery

Intergalactic Highway of Dark Matter Particles

University of Michigan Astrophysicist Katherine Freese has discovered a new view to potentially detect the mysterious *dark matter* in the universe. The Milky Way is currently gobbling up the Sagittarius galaxy. This small galaxy pulled inside our own Milky Way is raining dark matter particles onto our solar system which we can try to detect.

The Sagittarius galaxy is being torn to shreds by the gravitational pull of the Milky Way. Recently, two streams of stars have been detected that are being torn off the central main body of Sagittarius. One of these streams is headed for the solar system, and probably contains dark matter.

As the Milky Way consumes Sagittarius, it not only rips the stars from the smaller galaxy, but also tears away some of the dark-matter particles from that galaxy. We may be able to directly observe that in the form of a dark-matter highway streaming in one direction through the Earth.

Scientists believe that about 90 percent of the mass in the universe is made of dark matter. This is based on an unseen gravitational pull on the stars, but observations to directly detect dark matter have been unclear. Twenty experiments worldwide are building detectors to search for candidate particles, known as WIMPs--Weakly Interacting Massive Particles--that may be responsible for the missing mass of our galaxy. As Earth orbits around the center of the galaxy, the planet flies through this cloud of dark matter. As that happens, billions of these weakly interacting (and therefore difficult to detect) particles could be passing through each of our bodies every second.

Astrophysicist Katherine Freese of the University of Michigan, together with colleagues at Rensselaer Polytechnic and the University of Utah, suggests the stream could provide another route to the detection of dark matter.

“Along with the stars being ripped from the Sagittarius dwarf galaxy, there would be a large amount of dark matter and that would provide a WIMP highway that’s coming right down onto the Earth,” according to Professor Katherine Freese.

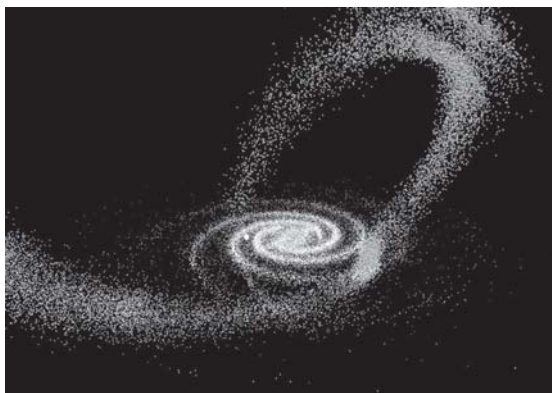
This WIMP highway could be seen in dark matter detectors as a step in the energy recoil spectrum, i.e., a sudden drop in the count rate at a certain cutoff energy. Additionally, the location of this step moves with the time of year. As highlighted in the BBC article on this research, “The seasonal variation in detection would then depend on whether the Earth’s orbit around the Sun is taking us upstream or downstream in this flow of extragalactic debris.” One experiment that already has data, the Italian Dark Matter Experiment, may be able to find this step. Finding this stream would represent a smoking gun for dark-matter detection.

Photo courtesy of Katherine Freese



Freese

Courtesy David Law, University of Virginia



The thin flat spiral represents the disk of our Milky Way galaxy. The stream of stars from the shredded Sagittarius dwarf is raining dark matter on the Sun. Sagittarius debris can be seen extending from the dense ‘core’, wrapping around the galaxy, and descending through the Sun’s position.

(See <http://www.astro.virginia.edu/~mfs4n/sgr/sgr.flyaround.mpg> for video.)

On the Path to Discovery (Continued)

A Solution to the Black Hole Information Paradox from Michigan

According to recent news released by *New Scientist*, Steven Hawking has announced that the puzzle of the information paradox is solved and black holes are not black anymore. Dr. Malcolm Perry, a University of Cambridge, England physicist who is visiting at the Michigan Center for Theoretical Physics (MCTP) during the fall semester, attended the seminar given by Hawking in Cambridge. He gave a talk about the new Hawking theory at the MCTP Conference on String Phenomenology this past August in Ann Arbor. Our colleague in the Physics Department, Professor Yukio Tomozawa, had been working on this subject during the past two decades and had reached the same conclusion in the 1980s. Although the arguments for the conclusion seem to be different, both claim that the information paradox does not exist.

The point made by Hawking will not be clear until his paper is available. The argument of Professor Tomozawa in 1985-89 was the following. The gravitational potential acquires a repulsive component at short distances due to quantum effects, from the uncertainty principle applied to the

kinetic energy. He had shown this result by solving the Einstein Equation including quantum effects on the expectation value for the energy momentum tensor. Then, a test particle entering a black hole through the horizon gets bounced back by repulsive forces at short distances. Next, using a property of the Penrose Diagram that describes the space-time structure of such a black hole system with repulsive forces, he concluded that the test particle comes back to the same universe. Therefore, there is no information paradox.

After his work on this subject, Professor Tomozawa initiated an undergraduate course on general relativity in the Physics Department, Physics 435. Since 1990, this course has been one of the popular courses among the electives in the Physics Department.

For references to the information paradox by Professor Yukio Tomozawa, please see his biographical sketch on the Physics Department website, <http://www.physics.lsa.umich.edu/department/directory/bio.asp?ID=337>.

Photo by Jens Zorn



Tomozawa

The New Scientist news release, <http://www.newscientist.com/news/news.jsp?id=ns99996151>

Interlacing Music and Physics

Photo courtesy Chris Monroe



Monroe

How do music and physics mesh? Quite easily, according to **Physics Professor Christopher Monroe**, who is teaching over a hundred students in “The Physics of Music” class this fall. Started years ago by Physics **Professor Emeritus Gabriel Weinreich**, the class has continued to be a favorite among undergraduate physics and music majors, as well as the broad campus population. Starting from a simple description of sound waves, the students learn the basics of the musical scale and why certain combinations of tones sound pleasing. After studying the physical basis behind most musical instruments, the students delve into the phenomenon of psychoacoustics and musical perception.

Augmenting regular class work, some students opt for a more advanced version of the course, creating a special project related to the subject matter. One student will physically modify his cello with a variety of string types in order to measure the vibration characteristics (overtone series) the cello produces. Another student who is a car stereo buff will model the subwoofer response in his car presumably in order to figure out how he can better rock the Ann Arbor street diners out of their seats.

Professor Monroe was raised in a musical household, with both parents very good amateur pianists. He began playing by ear in the second grade, and by the fourth grade, could play many of the Scott Joplin Ragtime piano pieces that were popular at the time. Unfortunately, four years of formal piano lessons were not to his liking, and by high school he turned to playing percussion instruments of all sorts, including the marimba, timpani, and drum set. Chris spent a summer at the Interlochen Arts Academy as an orchestral percussionist, and was a percussionist with the MIT Symphony Orchestra from 1983-1987. Nowadays, Chris has returned to his love of the piano, and although he claims his technique is lacking, he enjoys playing some of the Beethoven sonatas for his three daughters.

Professor Monroe says, “You are really exposed when you teach this class. You can’t rely on your knowledge of predefined calculations at the chalkboard.” Students peer inside instruments, analyzing every inch. An avid listener to classical music, Professor Monroe frequently illustrates concepts with recordings played on the excellent sound system in the lecture hall, as well as with live-instrument demonstrations by him and students. One student demonstrated the electronic Thereminvox, invented by Russian physicist Leon Theremin and made popular in science fiction and Alfred Hitchcock thrillers in the 1950s. Recently, the class analyzed the didgeridoo, a ceremonial instrument of the Australian aboriginal people, including a discussion of circular (perpetual) breathing, and an impromptu demonstration by a student who has played this instrument.

The class visits musical icons such as the 165-foot high belfry of Burton Tower on Michigan’s Central campus, the third largest carillon in the country, and the U-M Music Department’s Blanche Anderson Moore Hall, an organ recital hall with a magnificent tracker action organ. The group will also go to Hill Auditorium, one of the world’s top ten concert halls to participate in acoustical mapping exercises.

Faculty Achievements

Professor James Allen

Joaquin M. Luttinger Collegiate
Professor of Physics

Professor Christopher Monroe

Fellow, Institute of Physics, UK

Professor Citrad Uher

Vice-President, International Thermoelectric
Society, 2004-2006

Professor Philip Bucksbaum

Member, National Academy
of Sciences

Professor Mark Newman

Harold C. Early Research Award

Adjunct Professor Craig Davis

Named one of the 2004 Scientific American 50
Research Leaders

Professor Michael Duff

Mexican Meeting Medal, Mexican
Academy of Arts & Sciences

Professor Franco Nori

Fellow, American Physical Society



Congratulations to Assistant Professors **Cagliyan Kurdak** and **James Wells** who have been promoted to Associate Professor with tenure while Associate Professors **Georg Raithel** and **Franco Nori** have been promoted to full Professor.

Twenty Years in the Department

Beth Demkowski, High Energy Research Secretary in the Physics Department, recently celebrated twenty years with the Department! When Physics Professor Byron Roe hired Beth in August, 1984, Emeritus Professor Larry Jones was Chair of the Department, while Ada Mae Newton was the Administrator, and only three staff members worked in the Physics Business Office. Beth's office was on the third floor of what is now known as the "old" Randall Laboratory, where some of the walls were painted olive green. The "new" Randall Lab, a 186,000-square-foot elaborate complex of teaching/research buildings did not exist.

Photo by Carol Rabuck



Demkowski

When Beth began in the Department, research experiments were typically smaller than twenty professors versus today, where some experiments have 2,000 collaborators around the world. Among her other fond memories:

- On special occasions, Senior Research Technician Helmut Schick used his laboratory as the pizza station. Helmut and fellow technicians made an oven for bending light pipes that was used for making 3-foot-square pizzas.
- Beth remembers that typing was a total nightmare! She used an A.B. Dick machine, which was one of the first word processors. Beth and her counterparts used huge floppy disks to save data which corrupted easily. To print anything, she had to telephone a research secretary on the next floor to make sure the printer wasn't being used so she could then send her printing job.
- Beth used the first email system sanctioned by our Department. Remember Decnet?
- Prior to FAX machines, Beth used an international Telex machine. This was similar to sending a telegram but you didn't have to go to a telegraph office.
- The experiment which Beth thinks was the most exciting was the Balloon Experiment. "You could actually see what was being made. The entire experiment was housed here at the Physics Department." She said it was a big deal for everyone. As soon as the Gondola driver wheeled out the balloon in its traveling case, everyone would gasp, "The egg is coming, the egg is coming!"

New Physics Staff

Hope Lake joins the Physics Department as a Financial Clerk III after being a stay-at-home mother, in addition to running her own child care business for several years. Previously, she worked for National City Bank as a Financial Representative. She received her Associate Degree in Early Education from Suomi College in Hancock, Michigan and is currently looking into a Bachelor of Arts Degree from Eastern University in Business Administration. In her free time, Hope and her children enjoy bike riding and she walks five miles a night. She also enjoys reading and scrapbooking.

Photo by Carol Rabuck



Lake

Photo by Carol Rabuck



Thebaud

Before arriving at the Physics Department, **Alex Thebaud** spent eight years with the University of Michigan Health System, during which time she was promoted from Page Clerk, to Nurse Clerk, and finally, Triage Clerk at the Emergency Room Department. She joined the Department of Pharmacy in 1997 as a receptionist and later a Secretary II. In August, 2004, she joined the Department of Physics as a Financial Clerk III. She graduated from Washtenaw Community College in 2002 in Applied Science and is now seeking a Bachelor of Arts degree in Business Accounting from Eastern Michigan University. She is fluent in speaking and writing French and Haitian Creole, and speaks some Spanish. She listens to all types of music and loves to dance: salsa, hip-hop, jazz, reggae, merengue, to name a few. She enjoys writing french poetry in her spare time and also beads, roller skates, bike rides and reads.

Student Awards

Physics undergraduate Jacob Bourjaily scooped the top prizes at the International Summer School on the 42nd International School for Subnuclear Physics: *How and Where to Go Beyond the Standard Model* in Erice, Sicily. His trip was sponsored by the Michigan Center for Theoretical Physics (MCTP). He was awarded three prizes—"Best Student", "Paul A. M. Dirac Scholar", and "Best Presentation of a Theoretical Subject." He presented the results of research carried out with MCTP member and Physics Professor Gordon Kane on supersymmetric dark matter cosmology that will form the basis of his senior honors thesis. These awards were particularly notable because he was the only undergraduate student at the School among all graduate students or postdoctoral fellows.

Jacob Bourjaily has also accepted the Marshall Scholarship to study Math and Physics at the University of Cambridge, United Kingdom. He is the first student from the University of Michigan to have been awarded this prestigious scholarship in seven years. The Marshall Scholarship is given to about forty students each year to study in the UK. He plans to return to the United States to obtain his Ph.D. in physics.

Physics Research Fellow Rhonda Dzakupasu is one of ten recipients of a 2004 United Negro College Fund (UNCF) Merck Postdoctoral Science Research Fellowship. Rhonda was chosen for her academic achievements and her potential in the field of biomedical research. Her advisor is Assistant Professor Michal Zochowski, and together they currently study spatiotemporal patterns of synchronization in coupled neural systems. Rhonda will use the grant for travel or laboratory supplies related to her studies. The fellowship also includes a grant for the Physics Department. The partnership between the UNCF and Merck & Co. was created in 1995 to expand America's pool of world-class African-American biomedical research scientists ready to meet the challenge of national economic competitiveness and social diversity.

Undergraduate Research (continued from page 1)

Department machine shop informal technical course in mechanical design and operation of machine tools. The research experience is complemented by a wide range of educational and social activities, helping the students to see their work in a wider perspective, and build a network of professional contacts for a future career in physics.

Photo by Joshua Miller



The Summer 2004 REU students visiting the Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois, about 45 miles west of Chicago.

A Variety of Research Options

One of the special benefits offered to physics concentrators at Michigan is the opportunity to participate in active research efforts in many sub fields of physics. Students may also participate in research by obtaining course credit or landing a paid assistantship. One path commonly followed by students is to carry out independent research for one or two semesters with a faculty mentor, while earning academic credit through the independent study Physics 415 project. Typically, the student works part-time on a research project during the academic year and full-time (for an hourly wage) during the summer. Whether the student earns academic credit or an hourly wage is arranged between the student and mentor. When the research project is sufficiently advanced, the student enrolls in the appropriate senior thesis course and writes a thesis under the supervision of the research mentor to summarize his/her research experience.

The William L. Williams Award for a senior thesis is a cash award established in memory of our own Physics Professor William L. Williams. It is presented for the best thesis submitted by a graduating senior, to recognize students who exhibit excellence in posing a question, conducting

independent investigation, and determining an answer. Recent recipients of the Williams Award include:

2004 Michael Borysow for work with his advisor Professor Wolfgang Lorenzon and the Michigan Supernova/Acceleration Probe (SNAP) project. He is now employed as a full-time research assistant in the U-M Physics Department.

2003 Brandon Kelly for work with the Sloan Digital Sky Survey and his advisor Professor Timothy McKay. He is currently a graduate student in Astronomy at the University of Arizona. Mr. Kelly's thesis work has led to two first-author scientific publications.

2002 James Degenhardt for his precision measurement techniques for the Michigan ATLAS Muon Detector construction site with advisor Professor Bing Zhou. He is now a physics graduate student at the University of Michigan.

Successful research projects often lead to authorship of journal publications and to presentations at conferences.

Each summer the Physics Department awards research participation salary grants to physics concentrators who are just beginning their thesis research. Students receiving these awards receive three months of salary support so they can spend their summer laying the foundation necessary for a significant research project. Application for these awards is made during the first weeks of the winter term preceding their senior year.

Some undergraduates in Physics also participate in research at other institutions. In our Department, students have conducted research at such places as the European Laboratory for Particle Physics (CERN), the world's largest particle physics laboratory, and through the Fermi National Accelerator Laboratory (Fermilab).

Physics Department Events

Nobel Prize Recipient Lectures at Physics Department

The annual Ta-You Wu Lecture in Physics, is named in honor of Michigan Physics alumnus and honorary Doctor of Science, Ta-You Wu, one of the central figures of the 20th century in the Chinese and Taiwanese physics communities.

Photo by Jens Zorn



Gross

This fall's Ta-You Wu lecturer was David J. Gross, recipient of the 2004 Nobel Prize in Physics, Frederick W. Gluck Professor of Theoretical Physics and Director, Kavli Institute for Theoretical Physics, University of California at Santa Barbara. His lecture, "Asymptotic Freedom and the Emergence of QCD (Or How I Won the Nobel Prize)," described the theoretical scene in the 1960s and the developments that led to the discovery of asymptotic freedom and to Quantum Chromodynamics (QCD).

Professor Gross' discovery, along with Frank Wilczek, of asymptotic freedom—the primary feature of non-Abelian gauge theories—was crucial to the formulation of Quantum Chromodynamics and its emergence as the accepted theory of the strong (nuclear) force. Asymptotic freedom is a phenomenon where the nuclear force weakens at short distances, which explains why experiments at very high energy can be understood as though nuclear particles were made of non-interacting quarks. The flip side of asymptotic freedom is that the force between quarks grows stronger as one tries to separate them. Almost all current work in experimental particle physics relies in one way or another on the theoretical bedrock of QCD. This work was awarded the 2004 Nobel Prize in Physics, which was shared by Professor Gross, Professor Frank Wilczek of the Massachusetts Institute of Technology, and University of Michigan Physics graduate, Professor H. David Politzer, of the California Institute of Technology.

Professor H. David Politzer was born in New York City, graduated Bronx High School of Science (1966), received his bachelor's degree from the University of Michigan (1969), and his Ph.D. from Harvard University (1974). In his first article, published while he was a graduate student (1973), he independently discovered the idea of asymptotic freedom around the same time as Professor Gross and Professor Wilczek at Princeton University. After graduating from Harvard, Professor Politzer moved to the California Institute of Technology, where he is currently professor of theoretical physics.

Faculty Retirements

Martin B. Einhorn, Professor of Physics in the College of Literature, Science, and the Arts, retired from active faculty status on August 31, 2004. He has moved to the distinguished position of Deputy Director of the national Kavli Institute for Theoretical Physics, University of California at Santa Barbara, a combined research and administrative appointment.

Professor Einhorn received his Bachelor of Science in 1965 from California Institute of Technology, and his Ph.D. from Princeton University in 1968. He joined the University of Michigan as Associate Research Scientist in 1976, became Associate Professor in 1979, and Professor in 1983.

Professor Einhorn's well-cited research spans a broad range of topics in relativistic quantum field theory, particularly ones relating theory to existing or potential experimental results. He contributed to developments in cosmology and phase transitions in the early universe, quantum gravity, the cosmological constant problem, and superstring theory. He has played a significant role

in government and university advisory positions, including being a member of the original panel that established the national Institute for Theoretical Physics twenty-five years ago. He was also a member of HEPAP (the national advisory panel to the Department of Energy); Chair of the scientific advisory board of the national Theoretical Advanced Study Institute; member of the Executive Committee of the Division of Particles and Fields of the American Physical Society; the Physics Department Executive Committee; and Chair of both the Research Policies Committee and the Financial Advisory Committee of the University of Michigan. He is a Fellow of the American Physical Society, and a Guggenheim Fellow for 2003-2004.

His colleagues describe him as possessing a broad and deep understanding of theoretical physics, as well as a distinct presence as a friendly and stimulating person. Students remember him as an uncompromising and well-liked teacher.

The Regents salute Martin B. Einhorn by naming him Professor Emeritus of Physics.

Photo by Jens Zorn



Einhorn

In Memoriam

Editor's Note: Adapted from an article by the Donahue Family and the Department of Atmospheric, Oceanic and Space Sciences

Thomas M. Donahue, one of the nation's leading space and planetary scientists and a pioneer of space exploration, died Saturday October 16, 2004, from complications following heart surgery. He was 83. Dr. Donahue, the Edward H. White II Distinguished University Professor of Planetary Science at the University of Michigan, shaped space exploration through his scientific achievements and policy positions.

His early work in atomic physics and atmospheric science led to experimental and theoretical studies of the upper atmosphere of the Earth and other planets of the solar system with instruments flown on sounding rockets and spacecraft.

Joining the University of Michigan in 1974, he began as Chairman of the Atmospheric and Oceanic Science (AOSS) Department. In 1989, he was appointed Professor of Physics in the Physics Department because of his academic background and growing liaison between the Physics Department and the Departments of Astronomy and AOSS. He was a frequent participant in the Physics Department's weekly "High Energy and Astrophysics" seminars. In 1986, he was named the Henry Russel Lecturer at the University of Michigan—the highest honor the University confers on a faculty member.

Elected to the National Academy of Sciences in 1983 and to the International Academy of Astronautics in 1986, Dr. Donahue was a Fellow of the American Geophysical Union and the American Association for the Advancement of

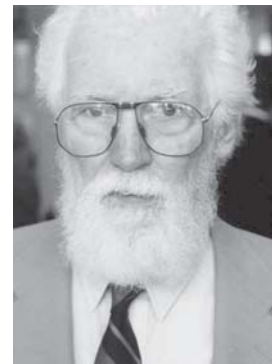
Science. The same year he was awarded the Arctowski Medal by the National Academy of Sciences and the John Adam Fleming Medal by the American Geophysical Union.

From 1982 to 1988, he was Chairman of the Space Science Board of the National Research Council of the National Academy of Science, where he was a strong advocate for unmanned space science missions within the federal space budget. He also served on numerous governmental, NRC, and National Academy of Science advisory boards and committees. He authored more than 200 research publications.

Dr. Donahue's participation in space exploration was influential over many decades and on diverse projects. He was an experimenter or interdisciplinary scientist on the orbiting Geophysical Observatory Missions, Apollo-17, Apollo-Soyuz, Voyager, Pioneer Venus Multiprobe and Orbiter (of which he served as the Science Steering Group chair), Galileo, Comet Rendezvous Asteroid Flyby, and Cassini. Based on observations by the Pioneer Venus entry probe, he concluded that Venus once had an ocean before a runaway greenhouse effect led it to its current state. Analyzing similar data from Martian meteorites, he again argued for a substantial Martian ocean, anticipating the current series of missions to Mars. In these and many other cases he laid the foundation for our current understanding of planetary atmospheres.

The Department of AOSS is establishing the Thomas M. Donahue Memorial Student Fund. This fund will further Ph.D. students in their quest to learn more about the universe in which we live.

Photo by Jens Zorn



Donahue

Send contributions to:
**Thomas M. Donahue
Memorial Student Fund
Dept. of AOSS
Room 2204 SRB
2455 Hayward Street
Ann Arbor, MI 48109-2143**

Alumni Corner

*Editor's Note: Excerpts from an interview with Michigan Physics alumnus **David G. Grier (Ph.D. '89)** currently a Professor of Experimental Condensed Matter Physics at New York University.*

What type of physics did you study at Michigan and what was your research involvement?

I arrived in the early days of the present boom in soft-matter physics. This studies how nature organizes even the simplest objects into complex hierarchically-structured systems. The field did not yet have a name when I started. I fell into my thesis project almost by accident. I had made a point of going to all the seminars in the Department so that I could get a feeling for the different fields. One of the first I attended was given by **Professor Eshel Ben-Jacob**, an Israeli theorist who was then on the faculty at Michigan, and who was one of the pioneers of soft-matter physics. He gave a talk on the patterns that many systems form when they're driven far from equilibrium that really impressed me.

Professor Eshel in collaboration with **Professor Len Sander** set me the task of growing and measuring fractals, a class of highly disordered patterns that appear throughout nature. They were hoping I would produce experimental examples of the diffusion-limited aggregates that Len had co-discovered with Professor Tom Witten. I set to work trying to grow fractal electrodeposits because that would take advantage of my interest in electronics and my undergraduate training in chemistry. However, I was impatient, and what should have been feathery dust-balls of metal actually turned out as beautifully ordered metallic snowflakes. This was a remarkable observation because systems driven far from equilibrium are supposed to become less well-ordered, not more. It soon became clear that we would want to study these strange metal deposits at all length scales, and Len recruited **Professor Roy Clarke** to guide me in

Photo courtesy David Grier



Grier

(continued on page 10)

Alumni Corner (continued from page 9)

the necessary crystallography. The result was a super interdisciplinary collaboration. I spent my days doing experiments and my nights doing the theory needed to explain all the surprises that the experiments revealed. The division was quite even, so I consider Len and Roy to have been my equal co-advisors. This marriage of theory and experiment has turned out to be the hallmark of soft-matter research, although at the time it was quite unusual. This project therefore, positioned me perfectly for my future career as a soft-matter physicist.

What happened after you graduated?

Largely on the strength of my unusual thesis research, I was able to land three excellent postdoctoral offers, one at Sandia National Labs, one at the University of Chicago, and the one that I took at AT&T Bell Laboratories. Folks at Bell Labs were looking for someone who knew how to do quantitative image analysis, and I was looking for something new and different. So, I went to Murray Hill as a postdoc for two years, studying phase transitions in the vortex lattice of High-Tc superconductors. Despite its low-temperature solid-state cachet, this actually turned out to be an archetypical soft condensed matter project, which helped to solidify my interest in driven dissipative many-body systems. It also brought me back to New York, where I met my wife.

Luckily for me, the people at Chicago had not lost interest in me, and Sid Nagel called me up to see if I'd be interested in interviewing for a job. I jumped at the opportunity because Chicago has one of the finest condensed matter groups in the world. I was on the faculty for twelve years, starting in January 1992. I was promoted to tenure in 1997, and was made a full professor in 2002.

As part of our quest to study macroionic interactions, we needed a method to control more than two objects at once, requiring multiple light beams, and ran into a practical limitation of the optical tweezer technique. We came upon the idea of splitting a single beam into many with computer-designed holograms. The result was a way to create arbitrary three-dimensional patterns consisting of thousands of traps, each of which can be moved independently under computer control. This is the holographic optical trapping technique, another of my group's major contributions.

Holographic optical trapping defines entirely new categories of applications in scientific and industrial research, drug discovery, medical diagnostics, and even manufacturing. Almost as soon as we'd demonstrated the technique, we realized that this might be very useful, and applied for a patent. This first patent provided the foundation for Arryx, Inc.

Where you involved with Arryx from its conception?

My graduate student, Eric R. Dufresne, and I are co-inventors of the holographic optical trapping technique, and cofounders of Arryx. Having secured a very broad patent for holographic materials processing, we were approached by Lewis Gruber, who offered his business expertise, broad experience in biotechnology, and financial resources to build a company around the idea. From its inception, Arryx has been dedicated to commercializing holographic optical trapping, the processes that it facilitates, and the novel materials, systems and devices derived from those processes. The company is based on Michigan Avenue in Chicago, in the heart of the business district. Unlike its neighbors, Arryx is a high-tech R&D firm, with extensive laboratory facilities. Its employees are mostly biologists, chemists, and physicists. One of my former graduate students, Joe Plewa, is Vice President for Research. Several other Chicago alums provide the company with scientific clout. Arryx's first product, the BioRyx 200 holographic optical trapping system, received an R&D 100 Award as one of the most technologically innovative products for 2002. This activity also won me a Scientific American 50 Award in 2003. I serve as Chair of Arryx's Scientific Advisory Board, consult with Arryx on technical issues, and collaborate with Arryx's scientists on some research projects.

I am an inventor holding seven patents on holographic optical trapping technology and applications, with another due to issue in a month or so, fifteen pending U.S. Patent applications, and several dozen foreign filings. These all grew out of the research group's activities, and most involve graduate-student co-inventors. Some of the pending patents include undergraduate co-inventors.

What types of research are you currently performing at New York University?

Having largely perfected our optical trapping technique, we're combining it with microfluidic sample control and branching out into several related directions. One involves the group's core mission of studying the emergence of many-body properties in macroionic systems. Another builds on insights drawn from earlier studies to resolve long-standing problems in molecular and cellular biology. The reconstituted group also has renewed contacts with our hard-condensed matter colleagues and we have several exciting collaborations under way.

My move to New York University is the first step in a major university-wide initiative. The Center for Soft Matter Research, of which I am the acting director, will consist of six experimental faculty, two theorists, and at least two full-time visiting faculty positions. The idea is to create an international interdisciplinary research center for the soft-matter community in the heart of New York City, with facilities for scientists and engineers to come from around the world to do their research in a highly interactive group. My group is occupying the first lab to be built, and large-scale construction on the rest of the facilities is just getting under way. The goal is to create experimental space with the minimum number of intervening walls consistent with safety.

*To view the interview in its entirety, please see the Physics Department website:
<http://www.physics.lsa.umich.edu/nea/alumni/kesten.asp>*

You Can Help!

The Department of Physics relies on its discretionary funds to support students by providing vital opportunities and resources, and to maintain special events, lectureships, and other ongoing activities. Alumni contributions comprise an extremely important part of these funds. If you would like to contribute to maintaining the quality of education and research for the physicists of tomorrow, please mail the form below.

NOTE: For 2004 charitable deductions and credits, the IRS has ruled that credit card gifts are deductible only in the year the bank processes the transaction. To be processed for tax year 2004, credit card gifts by mail must reach the University by December 15th; OR you may call (888) 518-7888 (toll free) or (734) 647-6179 (local), 8 A.M.- 4 P.M. EST, between December 15th and 31st, 2004. Please have this form at hand for your call. Your gift by check must be postmarked by December 31, 2004. Thank you!

UNIVERSITY OF MICHIGAN DEPARTMENT OF PHYSICS ALUMNI GIFT FUND

Enclosed is my gift of: \$500 \$250 \$100
 \$50 \$30 Other

Name(s): _____

Address: _____

Phone: _____

I have enclosed my (or my spouse's) employer matching gift form.
 My check is made payable to the **University of Michigan**.
 Charge my gift to MasterCard VISA AMEX Discover
Account Number _____
Signature _____
Expiration Date _____
E-mail _____

- Please send me information on making a bequest to the Department
- Please send me information on establishing an endowment within the Department of Physics

Please send to:
Carol Rabuck
Department of Physics
University of Michigan
2484B Randall Laboratory
500 East University Avenue
Ann Arbor, MI 48109-1120

*Thank you for your generous support
for the Physics Department.*

EID#	361517	AGABDA05LS18
------	--------	--------------

News of Michigan Physics is published biannually by the
**Department of Physics
Literature Science & Arts
University of Michigan**

Please send all correspondence and address changes attention:

Editor
Department of Physics
University of Michigan
2484B Randall Lab
500 East University Avenue
Ann Arbor, MI 48109-1120
or
physicsalums@umich.edu

Department Chair
Professor Myron Campbell

Editor
Carol Rabuck

Editorial Board Chair
Professor Dan Amidei

ALUMNI We would like to hear from you!

We're Interested In What You're Doing..

Please let us know by filling out the form below, and mail to:
Editor, News of Michigan Physics, University of Michigan,
2484B Randall Laboratory, Ann Arbor, MI 48109-1120 or
email physicsalums@umich.edu.

Name:

Degree/Major:

Advisor's Name/Research Field:

Graduation Year:

Name of Employer:

Job Title:

Current Address:

City/State/Zip:

Phone:

Email:

Comments:

Nondiscrimination Policy Statement
The University of Michigan is an equal opportunity/affirmative action employer.

**© 2004 Regents of the
University of Michigan**
David A. Brandon, Ann Arbor
Laurence B. Deitch, Bingham Farms
Olivia P. Maynard, Goodrich
Rebecca McGowan, Ann Arbor
Andrea Fischer Newman, Ann Arbor
Andrew C. Richner, Grosse Pointe Park
S. Martin Taylor, Grosse Pointe Farms
Katherine E. White, Ann Arbor
Mary Sue Coleman, ex officio

Randall Laboratory
500 East University Avenue
Ann Arbor, MI 48109-1120
Phone: (734) 764-4437
Fax: (734) 763-9694
Web: www.physics.lsa.umich.edu

UNIVERSITY OF MICHIGAN
PHYSICS

Non-Profit
Organization
U.S. Postage
PAID
Ann Arbor, MI
Permit #144