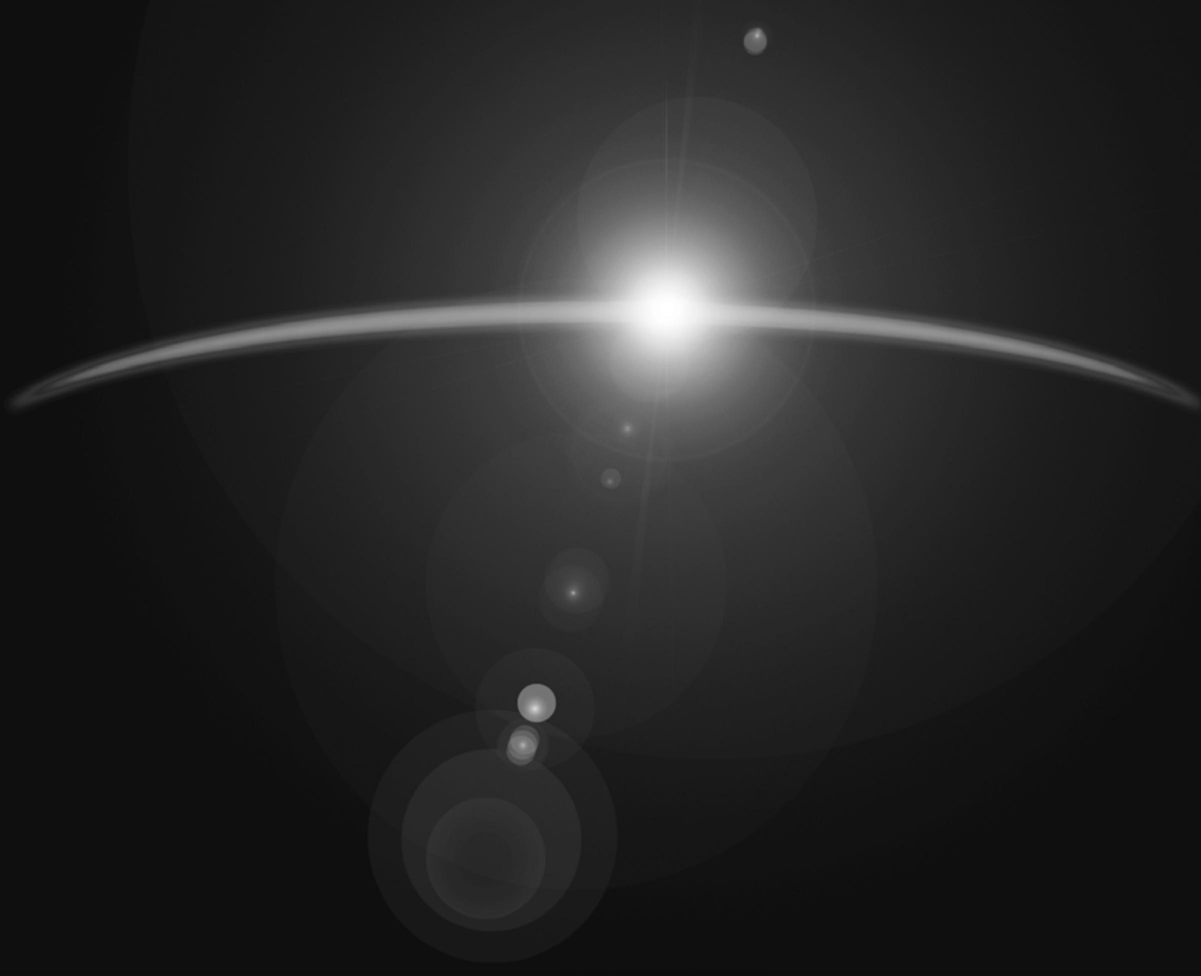
THE WISCONSIN PHYSICIST

VOL. 7, NO. 1 A NEWSLETTER FOR UNIVERSITY OF WISCONSIN PHYSICS ALUMNI WINTER 2000–2001

MOVING AHEAD INTO THE 21ST CENTURY...



UNIVERSITY OF WISCONSIN – MADISON

FEATURES

Jean Buehlman, Editor

FROM THE EDITOR

Greetings to alumni and friends,

It's already been seven years since the inception of *The Wisconsin Physicist*. Time does fly when you are having fun! As you may have noticed, this year's newsletter is moving from the theme of celebrating centennials and bicentennials to looking toward the future. What will be happening in physics in the twenty-first century?

Before we go there though, it was indeed very energizing to meet and visit with the many alumni who attended our "100 Years Since the First Physics Ph.D." celebration October 8 & 9, 1999. We had about 150 alumni in attendance. We were especially pleased to have Rocky Kolb, Fermi National Accelerator Lab; Daniel Gelatt, President of NMT Corporation; Matt Bernstein, Mayo Clinic; Steven Bomba, Johnson Controls; Jorge Lopez, Shell Technologies; Jeffrey McAninch, Lawrence Livermore National Lab; John Nimmo, U.S. Geological Survey; Frank Rose, Far Systems and Carol Wilkinson of Los Alamos National Lab as our invited speakers. While physics faculty provided their view of the science in academia, our invited speakers were able to expand the view on what is happening in physics in other realms. A big thank you to all who attended.

On with the show…as you will read in the outgoing Chair's message, it's been an exciting year and, of course, we are never without new challenges. There are new hires (including another new woman) in new areas of physics. There is an "unheard of" large size incoming graduate class (including ten new women) for Fall 2000. There are plans for moving out of Sterling Hall. There's a new look to our department literature (some of which we are sharing with you). Please carefully tear out the colored poster and POST it in a spot where prospective grads in your area might see it. In this way, you can make a real difference in our recruiting efforts.

We hope that you enjoy browsing through this 2000 issue. You'll notice many new faces, new ideas and new attitudes. Physics, like most things, is moving on…

Jean Meyer Buehlman, Editor

P.S. Be sure to read about WEST, a new national non-profit organization starting a pilot program at UW-Madison this fall. (See p. 31)

FORMER CHAIR'S REPORT

I have now completed my third and final year as Department Chair. Although there are several loose ends remaining, I am happy to turn the code books over to my colleague, Don Reeder.

This was another banner year for recruiting. No one knows how long it will last, but the Department roster has certainly undergone significant change in the past three years. The new staff appointments made last year are all now on board, including Associate Professor Brenda Dingus, who joins us from the University of Utah. Professor Dingus' specialty is high energy gamma ray astrophysics. She was honored at a White House ceremony this past April as the recipient of a Presidential Early Career Award for Scientists and Engineers. The award was presented by Neal Lane, the President's science advisor. She will play a key role in the new NASA gamma ray telescope, called GLAST. Pupa De Stasio continues her frenetic pace with spectromicroscopy research at the Synchrotron Radiation Center at Stoughton. A report on her work appears elsewhere in this Newsletter. Mark Eriksson and Mark Saffman are both up and running with their experimental research programs after less than a year's setup time. Albrecht Karle and Bob Morse have already been to Antarctica and back since we last corresponded. So all of the recent additions to the faculty are off to a great start. The academic staff appointment of Matt Briggs is a first for the Department. Matt's principal responsibility will be undergraduate teaching. With many changes going on in the undergraduate program, we anticipate that Matt will be a very busy man.

During the spring 2000 recruiting season, the Department performed international searches for faculty in experimental high energy and experimental nuclear physics. We also pursued targets of opportunity in theoretical physics. As of September, 2000, we have one acceptance and two offers pending. Sridhara Dasu joined the faculty in the fall of 2000 as assistant professor in experimental high energy physics. Professor Dasu's research interests include B physics studies at SLAC and work at the highest energy at the CERN LHC.

Last year the Department FTE count stood at 47, with seven new faculty and six departures over the past three years, for a net gain of one. Four people have assumed emeritus status: Bob March, Murray Thompson, Randy Durand, and Ugo Camerini.

The Department Review by a campus committee chaired by Jay Gallagher in Astronomy was submitted this spring to the deans. The committee recommended that the Department invite a group of physicists from outside the University to visit the campus as an outside review team. The outside review has taken place in November.

There has been a lot of progress this past year in the plans for the remodeling of the part of Chamberlin Hall now occupied by Pharmacy for use by that part of the Physics Department now housed in Sterling. Much credit for this progress goes to Mark Rzchowski. We now have a better understanding of the mapping from Sterling to Chamberlin, and it is clear that the Department will continue to have a space shortage. We have many new and expanding experimental programs. The Department has proposed a new addition to Chamberlin to be built in the Chamberlin-Sterling courtyard as a part of the Chancellor's initiative. The Department is seeking private funds for this building.

The Department had a very successful symposium on October 8 and 9, 1999, in Madison to renew acquaintance with alumni and friends and to mark the 100th anniversary of the first Ph.D. in Physics. The program was enjoyed both by the local staff and the visitors. Then on May 5, 2000 the Department had a banquet honoring the emeritus faculty and giving awards to the meritorious undergraduate and graduate students. This banquet was held at the new Fluno Center on Campus, which was built for the Business School. This was the first year of what we hope will become a tradition.

Next year's entering graduate class will be 49 students, after a vigorous recruiting effort. This is the largest class in the past several years, and we are all very pleased. We are not sure of the reasons for our success. Perhaps it was the organized visits for prospective students in groups, or the extra stipend bonuses, or the attraction of our program, or an increase in interest in physics nationally. Or all of the above. For whatever reason, this large entering class will give us a big boost in TA's, RA's, people registered for graduate courses, etc.

On the undergraduate program front, the Department was authorized to start a new introductory calculus based physics sequence 247/48/49 in the fall of 2000. This sequence is based on the idea of introducing modern physics ideas along with the standard curriculum, to make things more interesting. We are starting out with a class of 29, and designing the curriculum, labs, etc. Computerization of the laboratories continues to place a heavy work load on those involved. This process still has a few years to go.

I hope this gives you a flavor of what has been happening around here this last year. Serving as Department Chair has been time consuming, and, on the whole, rewarding, especially because of the large number of faculty hires. I look forward to returning to research in high energy physics, and to the upcoming Tevatron run at Fermilab. I wish the best of luck to all, and especially to my successor.

Lee G. Pondrom
Professor of Physics
Former Chair Physics Department

THOUGHTS OF A NEW CHAIRSHIP

In accepting the Chair beginning in Summer 2000, I am struck by the differences between now and my last term in the chair ('82–'84). Some things, of course, are the same, but others are remarkably changed. The mix will certainly provide spice and challenge in the next few years.

The Physics Department is in excellent shape, for which I thank my predecessor, Prof. Lee Pondrom. There are no immediate crises on the horizon, but there exists the necessity for fine tuning the programs and direction of the Department as it enters a new millennium.

Don Reeder

Although the employment situation seems to be easing a bit, this may be only the reflection of the unprecedented "good economic times" that we have enjoyed for the past years. Federal support of basic research in the physical sciences has not kept pace with inflation in contrast with the situation in the life sciences. Nationally, we must take advantage of the relative largess to establish a balanced basic research program on which our technical society is dependent. Stability and continuity of support are necessities for successful basic research, which is characterized as curiosity-driven, rather than goal-oriented.

The long anticipated demographic "bulge" is now upon us. There are now 18 emeritus faculty in the Department. Nonetheless, our ranks have not been depleted, indeed, we now have about 50 active members. We have been extraordinarily fortunate in recruiting a truly outstanding cadre of new faculty, representing expansion into new areas as well as continuity of current programs.

Thanks to the fine efforts of everyone; faculty, alumni, staff, and current graduate students, we have been successful in presenting the excellent program at UW to potential graduate students. The incoming class has both quality (6 fellowship winners) and quantity (49 entering students).

A major opportunity in the near future is the plan to consolidate the Department within Chamberlin Hall, for the most part abandoning Sterling Hall, which we have occupied for more than eight decades. The challenge is to incorporate successfully the evolving faculty interests and needs within a rather limited budget. The renovation of that portion of Chamberlin Hall to be vacated by the Pharmacy School will be quite extensive. We must construct new lecture halls which combine tried and true demonstrations with state-of-the-art visuals. The disruption of the program during construction must be minimized, planned and endured.

An external review of the Department by physicists from other institutions was planned for the fall. This is to supplement the review by campus faculty completed last spring. The goal is to provide guidance both to the Department and the College for improving the perception of the Department and its activities from the outside. State support of the University continues to be well below past levels. In order to snare our share of the dwindling resources, we must communicate the productivity, excitement and applicability of our research.

The status of the Physics Department depends on the collective effort of faculty, staff and students in the traditional areas of research, teaching and service. For the next few years it will be my privilege to help provide the direction for continued progress and success. But, the extent to which the Department attains its goals will, as always, ultimately rest with my ability to enlist the enthusiastic engagement of its members.

On Wisconsin,

Don D. Reeder

Don Reeder
Professor of Physics
Current Chair Physics Department

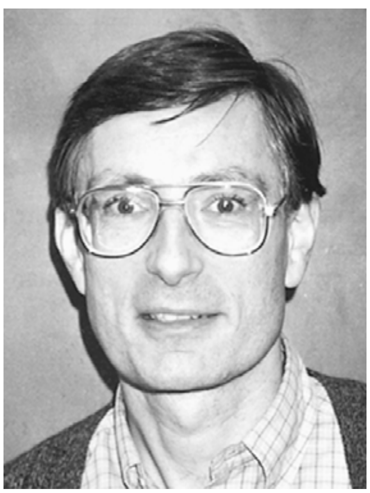
FACULTY RESEARCH AWARDS

Professor Himpsel receives named professorship

Congratulations to **Franz Himpsel** who became the Ednor M. Rowe Professor of Physics through a named WARF/University Houses Named Professorship. This Professorship will cover a five-year period (July 1, 2000–June 30, 2005).

Franz Himpsel joined the department in 1995. He received his Ph.D. at the University of Munich in 1976, followed by a post-doc at IBM Watson Labs. He became a staff member at IBM in 1980 and continued his work there until coming to U.W. Madison as professor and Associate Director of the U.W. Synchrotron Radiation Center. In 1997, he became Co-Director of the Synchrotron.

Since he is also an active user of the facility, Himpsel has been able to provide crucial scientific leadership from a unique perspective. Himpsel's work has emphasized surface physics studies utilizing synchrotron radiation, in particular, the electronic structure of semiconductor surfaces and magnetic nanostructures. He has played a significant role in developing core level spectroscopy and in mapping energy bands via angle-resolved photo emission and inverse photo emission. Currently, he is interested in finding self-assembly techniques for producing tailored materials such as arrays of nanowires.

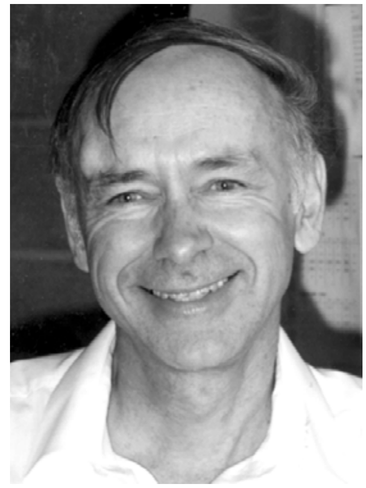


Franz Himpsel

Professor Himpsel has also received the Peter Mark Award of the American Vacuum Society, 1985. He is a Fellow in the American Physical Society and the American Vacuum Society and a member of the New York Academy of Science.

Barger wins 2000 Hilldale Award

Congratulations to **Vernon Barger**, whose research has steered the course of particle physics for three decades, upon winning the 2000 Hilldale Award in the Physical Sciences. Professor Barger is the founder and director of the Institute for Elementary Particle Physics Research and a Fellow of the American Physical Society.



Vernon Barger

Barger received his Ph.D. from Penn State University in 1963 and came to Wisconsin that year as a Research Associate. He became an Assistant Professor in 1965 and a full professor in 1968. He has co-authored four text books during his tenure at Madison:

Phenomenological Theories of High Energy Scatterings: An Experimental Evaluation (with D. Cline), 1969; *Classical Mechanics: A Modern Perspective* (with M. G. Olsson), 1973; *Classical Electricity and Magnetism: A Contemporary Perspective* (with M. G. Olsson), 1987; and *Collider Physics* (with R. J. N. Phillips), 1987.

Barger has also held a University Houses Professorship as J. H. Van Vleck Professor of Physics since 1983, a Hilldale Professorship from 1987–91, and a Vilas Professorship since 1991. The last Physics Department faculty member to receive the prestigious Hilldale award was Willy Haeberli in 1995.

Mark Eriksson awarded Packard Fellowship

Assistant Professor **Mark Eriksson** has been awarded a David and Lucille Packard Fellowship for Science and Engineering. Mark completed his undergraduate work at UW-Madison in 1992 and went on to complete a Ph.D. at Harvard in 1997 under Professor Robert Westervelt. During his postdoc, he worked at Bell Laboratories, Lucent Technologies. He joined the staff of the U.W. Madison in fall of 1999.

His Packard Fellowship will allow him to continue an ambitious program in nanoscale science and technology with the goal of "understanding, controlling, and exploiting the interaction of nanoscale systems with the atomic environment."

Mark Eriksson

Mark has also been active in working with Peter Timbie, the Undergraduate Coordinator and Thad Walker in creating the startup of a new undergraduate physics course series, Physics 247, 248 and 249. This course is directed specifically at introductory level physics or AMEP majors and will include the introduction of modern physics throughout the course series. (You can read more about this in the Undergraduate News section.) Mark has taught Physics 322, electromagnetic fields, in the spring semester.

Onellion receives research award

Professor Marshall Onellion has been awarded a Certificate of Commendation by Gov. Thompson for 10 years of public service by meeting with public high school students to teach them science and mathematics.

Walker becomes Vilas Associate

Congratulations to Professor **Thad Walker** who recently became a Vilas Associate. This recognition is made possible for tenured faculty by the Vilas Trustees. It provides for 2/9 summer salary for two summers, plus $5,000 in flexible research funding for two years.

Walker, a member of the atomic group, received his Ph.D. at Princeton in 1988. He became an assistant professor in 1990, an associate professor in 1993 and a full professor in 1999. His research interests include laser cooling and trapping of atoms: ultracold collisions, collective behavior, electron scattering, beta decay. He is also interested in spin-exchange optical pumping.

Walker and Zeppenfeld named members of the APS

Dieter Zeppenfeld and **Thad Walker** have been added to the list of fellows in the American Physical Society. Zeppenfeld, a member of the phenomenology group, received his Ph.D. in physics at the **Universität München** in 1984. He joined the staff in 1989 as an assistant professor, with a full professorship coming in 1994. His other honors include a Romnes Faculty Fellowship in 1995 and being a Scientific Associate at CERN in 1995.

Walker has also received several other honors in his career including the Romnes Fellowship (1996), the Packard Fellowship in Science and Engineering (1992), the National Science Foundation Young Investigator Award (1992) and the Sloan Fellowship (1991).

Balantekin becomes Sr. Fellow

Professor **Baha Balantekin** has been selected a Senior Fellow of the European Centre for Theoretical Physics (ECT) in Trento, Italy in recognition of his research activities at the interface of nuclear, particle physics and astrophysics. In 1997, Balantekin received the Humboldt Research Award for Senior U.S. Scientists, based on nominations from eminent German scholars.

Lagally elected

Max Lagally has been elected to the Deutsche Akademie der Naturforsche Leopoldina, the German equivalent of the Academy of Sciences.

Larbalestier receives prize

David Larbalestier was presented with the IEEE Council on Superconductivity Prize for Significant and Contributing Contributions to Superconductivity at the most recent Applied Superconductivity Conference in Virginia Beach, September 2000. The award recognizes the work of he and his collaborators during more than 20 years on understanding the critical current density of superconductor forms. The award carries a plaque and a prize of $5,000. The biennial Applied Superconductivity Conference is the premier applied meeting worldwide of this community and attracted 1750 participants this year.

FACULTY NEWS

Promotion

Congratulations to Professor **Andrey Chubukov** on his promotion to full professor. Chubukov joined the physics faculty in 1993 as an Assistant Professor, having received his Ph.D. from Moscow State University, USSR in 1985. He was promoted to Associate Professor in 1997. Chubukov is a condensed matter theorist who is working in the area of strongly correlated electron systems, with particular emphasis on high temperature superconductivity. He is widely recognized as a world leader in developing and applying diagrammatic methods to high-T_c systems. Since his promotion in 1997, he has published, or submitted for publication, 13 papers on superconductivity and magnetism. He has also given 12 invited talks in the U.S., Russia, France, Germany, Spain, Finland, England, Italy and Canada. Taking leave from his usual teaching of Physics 715 (Statistical Mechanics) and 311 (Mechanics), Chubukov will make use of a sabbatical leave during the 2000–01 academic year.

Andrey Chubukov

New Instructional Academic Staff

Matt Briggs, University of Utah, has become the second permanent Physics Faculty Associate involved in the instructional program. (The other being Susan Nossal as Director of the Peer Mentor Tutor Program.) Matt is co-teaching Physics 202 with Professor Paul Quin in the Fall 2000 semester and also works on laboratory and lab manual development for the 200 course series.

Two New Emeritus Faculty

Two very long-term physics faculty chose the end of the first semester (January 6, 2000) as their retirement dates. Both Loyal Durand (previous graduate program committee chair) and Ugo Camerini (previous undergraduate lab development guru) have hung up their teaching hats. Ugo often could be found teaching physics introductory level undergraduate courses, especially 103 and 104, while Loyal hung out in the 700 level graduate classes a lot. Both will truly be missed by students and staff alike.

Loyal Durand, known to his friends and colleagues as Randy, has made extraordinary contributions in teaching, research and service over his 34-year academic career in the Department of Physics at the University of Wisconsin-Madison. His professional achievements have been recognized by the University through the Chancellor's Teaching Award, a Fellowship in the University of Wisconsin Teaching Academy, and by the physics community by a Fellowship in the American Physical Society.

Randy Durand has the well-earned reputation among our students and faculty as being the best graduate-level teacher in the department. Graduate students have flocked to the required 700-level theory courses taught by him. His teaching is characterized by clear lectures, interesting in-class examples, challenging and realistic homework, fair exams, careful feedback and accessibility. He directed the Ph.D. thesis research of 18 students and all are still active in physics or closely related fields.

Loyal (Randy) Durand

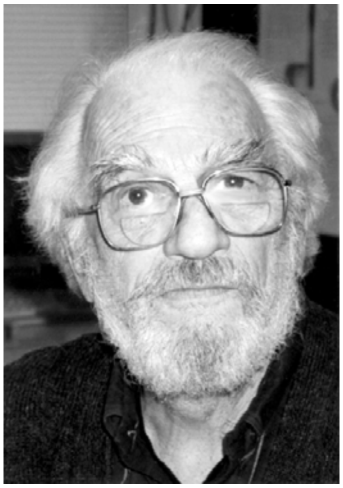
Randy Durand is internationally recognized for his research in elementary particle theory. His 100 published research articles in refereed journals reflect important advances in the frontier areas of particle physics. His work typically has involved deep mathematical insights in quantum field theory. His work in the 1960's and 1970's focused on theoretical models for hadron scattering processes. He derived a significant analytic relation in high energy scattering amplitudes between Regge pole exchange and direct channel resonances and proposed a diffraction model that provides the lasting description for high energy *pp* scattering. In the 1980's he made seminal contributions to the theoretical description of heavy quark-antiquark systems. In the 1990's he analyzed consistency conditions from perturbative unitarity of scattering of amplitudes in gauge theories.

Randy co-chaired the 1980 International High Energy Physics conference, with over 1300 participants. The conference was very well organized and a great success. Randy chaired the Physics Department during the two difficult years (1969–71) when there were demonstrations, tear gas and the bombing of Sterling Hall. He served on the Physical Society Divisional Committee for three different terms, including as chair, and has also effectively and willingly served on other faculty governance committees.

Randy Durand was President and is now an Honorary Trustee of the Aspen Center for Physics, the largest center for theoretical physics in the world during its annual period of operation. He was influential in its development from the inception in 1962 and he remains a very active member. Among his professional activities, Randy held either regular or visiting staff positions at, or was on advisory committees for, four major national research laboratories: Brookhaven, Argonne, Fermilab, and Los Alamos.

The Department of Physics highly values the many important contributions that Professor Durand has made to our department, the University and our field during his productive career.

The professional career of Professor **Ugo Camerini** spans more than half a century and follows closely the history of particle physics. After receiving his education in mathematics and physics from the University of Sao Paulo, Brazil, Ugo joined Powell at Bristol in 1949 and was present at the birth of particle physics — the discovery of the pion. He participated in the discovery of the 2-prong charged "K" meson later found to be but another form of the neutral "strange" particle of Rochester and Butler and the "tau" meson. Returning to Brazil as a UNESCO technical expert, he accepted a position on the faculty at Centro Brasileiro do Pesquitas Fisicas in Rio de Janero. In 1957 he joined Jack Fry at the UW-Madison in a lifelong productive collaboration. In a series of innovative and significant experiments they elucidated the characteristics of the K_0 system: the $\Delta S = \Delta Q$ selection rule, the K_L-K_S mass difference and, very cleverly, the sign of the mass difference. Ugo also collaborated in the study of the photo production of the ψ meson and in the discovery of open charm. In the lepton sector, he was a pioneer in the study of the ν interactions and collaborated in an early observation of the τ lepton.


Ugo Camerini

Always a superb experimenter, Ugo first used visual techniques in his research — emulsions and later bubble chambers — and then designed innovative optical and mechanical apparatus. Camerini and Fry built the novel optical system used to view the MURA hydrogen bubble chamber and also proposed a large heavy liquid bubble chamber, but only the competitor GARGAMELLE was built in Europe. Ugo has had a continuing interest in cosmic rays, at first exposing emulsions (while skiing), then at Mt Evans, Colorado with Good, searching for extra-solar γ rays at Haleakala, Hawaii, and finally collaborating on the DUMAND experiment to study ν's using deep sea water.

Not only has Ugo guided more than a score of graduate students to their doctorates with zest and enthusiasm, he has also served the department as an inspired teacher of undergraduate courses. For his innovation in the development of Physics 109 — Physics in the Arts — he was given a Teaching Award in 1984. He was the originator not only of most of the light and color experiments for this course, but also made major contributions to striking lecture demonstrations. Never timid, and aware that demonstrations would be visible from the back of the lecture room, his demonstration of standing waves in a pipe uses a 3 meter long Lucite tube.

In recent years, he not only taught Physics 103/104, where he kept students awake with his lively lectures, but also made much needed contributions to upgrading of the introductory laboratories. In particular he has been a stalwart in the ongoing effort to modernize the introductory laboratories and to introduce computers. As chairperson and member of the Introductory Lab Committee and the Lecture Room Committee, he helped secure money for laboratory modernization and for large screen video equipment. Those of us who walk across campus with Ugo know of the many friendly greetings he gets from present and former students. His always accessible office and his special tutoring sessions on Saturday morning were appreciated and will be remembered. His friendly and relaxed ways did much to counteract the impersonality of our large University.

Space and time permit only a sampling of his achievements. He truly has had a memorable and productive career, has been a true friend of the department and its faculty and has contributed significantly to the reputation of the UW Department of Physics.

Sabbaticals for 2000–01:

Professor **Andrey Chubukov** has been granted sabbatical leave for the 2000–01 academic year, while Professor Clint Sprott has been given leave for Spring 2001.

Professors **Richard Prepost**, **Stewart Prager** and **Yibin Pan** are on on research leave for the Fall, 2000 semester.

NEW FACULTY

Welcome to new faculty

Three new physics faculty are "shoring up the ranks" as we look at the roster this fall: **Bob Morse**, **Brenda Dingus** and **Sridhara Dasu**.

Brenda Dingus

Welcome to UW to **Brenda Dingus**, an astrophysicist from the University of Utah, who became an Associate Professor of Physics beginning in Spring 2000. Dingus received her Ph.D. in experimental cosmic ray physics from the University of Maryland in 1988. She spent several years as a research scientist at NASA before joining the faculty of Utah in 1996. She has had broad experience both in ground and satellite based detectors. She will broaden the activities in the Physics Department in high energy astrophysics, and is expected to greatly strengthen our program. Her research is centered on a ground based gamma ray observatory now operating near Los Alamos, NM, dubbed MILAGRO. She's also working on NASA's GLAST satellite, an orbiting gamma-ray observatory to be launched in 2005. She was recently selected to serve on the GLAST science working group to represent the interests of ground based gamma-ray observers.

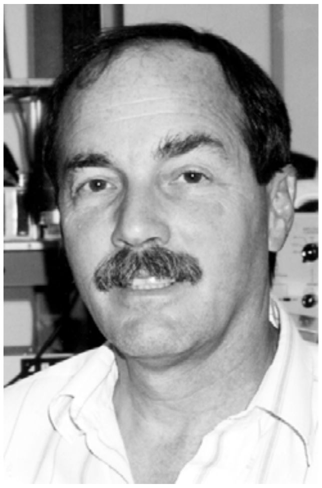
Brenda Dingus

Dingus was part of the university's interdisciplinary hiring initiative shared by Physics and Astronomy. Since her hire, she has been awarded a Presidential Early Career Award for Scientists and Engineers (PECASE). The PECASE is considered the highest honor bestowed by the U.S. government on young scientists. Winners each receive $500,000 over five years to support research and education. U.W. Madison and MIT were the only schools this year to win two PECASE awards. Dingus traveled to Washington, D.C. in April to attend the White House award ceremony.

Dingus began her U.W. Madison teaching career as co-instructor of Physics 103 this fall with Bob Morse.

Bob Morse

Robert M. Morse has joined the physics faculty as a professor in the area of high-energy astrophysics. Bob has been at UW Madison since 1977 and a Senior Scientist since 1984. Prior to coming to UW, he was at the University of Colorado and SLAC, teaming with Nobel Laureate Mel Schwarz on an extensive study of the rare decay-modes of Kaons. On coming to Madison Bob joined Professor Prepost's MAC detector team at SLAC. He then worked with Professors Cline and Camerini to build one of the first proton-decay detectors in a mine in Utah. Later he joined Professors Camerini and Fry to build a high-energy gamma-ray telescope on Mt. Haleakala in Hawaii. In 1989, Morse became the PI of a NSF project to construct a prototype gamma-ray telescope at the South Pole.



Bob Morse

The AMANDA neutrino astronomy effort at the South Pole began in 1991 and grew out of the gamma-ray effort. Morse collaborated with Professor Halzen to propose a neutrino telescope, detecting high-energy neutrinos using the polar ice. Morse had first proposed using ice to detect muons from cosmic rays to the NSF in 1986. It is through his AMANDA efforts that Morse has achieved distinction at the NSF as a PI, and he has been the AMANDA PI from UW since its beginning. Bob also helped bring the NSF's Antarctic Ice Drilling and Coring Program to the UW, and through his efforts the UW Physical Sciences Lab has become a world-leader in deep ice-drilling technology.

In 1997 Bob won the UW Chancellor's Award for Excellence in Research and was named in 1992 by the students as one of the best 100 teachers at the UW for his performances in teaching introductory physics to the engineering students. Bob is co-teaching Physics 103 this fall with new faculty member Professor Brenda Dingus.

Sridhara Dasu

Sridhara Dasu was born in India, and received his Ph.D. from the University of Rochester in 1988 for his study of the structure of proton. After four years as a post doc at SLAC, he joined the University of Wisconsin high energy physics group. He has worked with Professors Wesley Smith, Don Reeder and Richard Prepost at UW. He continued to participate in the study of the structure of proton by collaborating on the ZEUS experiment at DESY lab in Hamburg. His current physics interest is in exploring the energy frontier using very high energy proton collisions using CMS detector at CERN laboratory in Geneva, and in study of matter/anti-matter asymmetries using lower energy particle decays using BaBar detector at SLAC. He brings to the department extensive experience in all areas of high energy physics experiments encompassing design, construction and commissioning of detector, trigger, data acquisition and computer systems. Assistant Professor Dasu began his faculty teaching career in the fall 2000 semester as instructor of Physics 321 (Electric Circuits and Electronics).

Sridhara Dasu

FACULTY RESEARCH

Wu's team narrows search for Higgs boson

by Terry Devitt
Wisconsin Week, September 27, 2000

With time running out for Europe's largest particle accelerator, a team of Wisconsin physicists may be tantalizingly close to being among the first to see the Higgs boson, the subatomic particle that is responsible for endowing all matter with mass.

At a meeting Sept. 5, a collaboration of scientists representing ALEPH, one of four large experiments at the European Laboratory for Particle Physics' (CERN) Large Electron Positron (LEP) collider, presented evidence of what may be the first observation of the Higgs boson, a particle so crucial to the current understanding of Nature that it is sometimes referred to as the "God particle."

"The discovery of the Higgs boson would mark a profound point in the history of science," says Sau Lan Wu, Enrico Fermi Professor of Physics at UW-Madison and the head of the UW-Madison's High Energy Physics group working on the ALEPH detector.

"The Higgs boson is perhaps the most important and unique elementary particle," Wu explains. "There is literally no other particle like it, and without it our understanding of the behavior of matter and energy at the most fundamental levels breaks down."

Wu's group is at the forefront of the endeavor with the ALEPH experiment. She and members of her group are among those who observed a number of Higgs boson candidates with a mass of roughly 114 GeV (or 122 times heavier than a proton).

"If these candidates are proved to be signs of the Higgs boson, we finally have a complete picture of the behavior of matter and energy at the most fundamental levels currently experimentally accessible to us," Wu says.

The Higgs boson is named after Peter Higgs, a Scottish theorist who suggested its existence in the 1960's.

To explore the world of subatomic particles, scientists must orchestrate collisions between ordinary particles such as protons or electrons by accelerating them to great speeds and detecting the product of these collisions. The work is done in a large particle accelerator, LEP at CERN, located in a 17-mile underground tunnel near Geneva, Switzerland.

Complicating the hunt for the Higgs boson, however, is the planned closing of the LEP accelerator Oct. 1 to make way for a new accelerator known as the Large Hadron Collider. But with strong hints of the Higgs boson emerging from ALEPH and possibly a hint from one other detector DELPHI, CERN officials have extended the life of LEP by a month, giving scientists an opportunity to collect more data in the hope of firming up observations of Higgs candidates.

At the center of the current excitement at CERN are three collisions — among many thousands — seen by the ALEPH group. The three events bear all the characteristic signs of the appearance of the Higgs boson, Wu says.

Wu's group has been searching for the elusive particle for several years by combing mountains of data collected during collisions in the ALEPH detector. Production of the Higgs boson is extremely rare and there are other, more mundane processes that might mimic its production.

While not conclusive, the new evidence is compelling.

"The statistical interpretation is exceedingly complex," Wu says, and picking those events out against background noise can be a labor of Hercules.

"However, in our case, the interesting Higgs candidates are clustered around a mass of 114 GeV, roughly 122 times the mass of a proton. In this region, we expect few background events, but the possibility of an upward statistical fluctuation from these background events cannot yet be ruled out."

In this, the final year of LEP operations, the collision energy of LEP was pushed to the highest level yet achieved, thanks to the excellent work of the accelerator physicists at CERN, bringing new opportunities for discovery, Wu says.

"An immediate turn-around time was required for analyzing the ALEPH data and extracting results during this critical year," says Wisconsin researcher Stephen Armstrong. To accomplish this, an automated search system known as "BEHOLD!" was developed by Armstrong and graduate student Jason Nielsen. This acted as an early warning system to alert ALEPH physicists that the Higgs boson may have been detected.

"Although the results are exciting and compelling, more data are required for an unambiguous declaration of discovery," adds Wisconsin researcher Peter McNamara.

It is possible that by the end of the year, a combination of data from the four LEP experiments may be able to confirm if the Higgs boson has at last been found.

Wu is no stranger to groundbreaking discoveries. As a young postdoctoral researcher, she worked in the group that first discovered the charm quark, another basic subatomic particle, in 1974. As an assistant professor at Wisconsin, Wu was the leading figure in the discovery of another fundamental particle in 1979, the gluon, responsible for the strong or "color" force which binds together the quarks to form protons and neutrons.

She shared the 1995 European Physical Society Prize for the gluon discovery. Wu also holds a Vilas Professorship with the UW-Madison and is a fellow of the American Academy of Arts and Sciences.

Testing a new therapy for brain cancer

by Gelsomina pupa De Stasio

Modern medical research can often benefit from collaborations between physicists and medical doctors. Magnetic resonance imaging, computerized axial tomography and laser surgery are only a few offshoots of such teamwork, demonstrating that an interdisciplinary view of medicine has become essential. Today's outstanding medical problems are cardiovascular diseases, dementias and cancer, and all of them are being explored by a diversity of scientists. A relevant example is a new therapy for malignant brain cancers.

The results presented here are a clear example of interdisciplinary work at UW. They could not be achieved by physicists or medical doctors separately. Only the synergy of these two disciplines made them possible, and will hopefully one day lead to clinical trials of a novel therapy for glioblastoma, the most malignant brain cancer, often non operable, in most cases lethal. Gadolinium Neutron Capture Therapy (GdNCT) is a non-invasive experimental therapy for malignant gliomas never tested on human or animal cases. It is based on a binary approach. In the first step, the patient is intravenously injected with a tumor-seeking compound containing the ^{157}Gd isotope that has a capture cross section for thermal neutrons many times greater than other elements present in tissue. In the second step, the patient's skull is exposed to thermal neutrons, which induce a localized, biologically destructive nuclear reaction where Gd is localized. Gadolinium-157 (^{157}Gd) appears to be a good potential neutron capture agent for several reasons:

1. ^{157}Gd is the most effective isotope in terms of neutron capture, having the largest thermal neutron cross section of all the stable isotopes at 254,000 barn. By comparison, ^{10}B has 3,840 barn, ^{16}O has 0.00019 barn, ^{12}C has 0.0035 barn, ^{1}H has 0.333 barn, and ^{14}N has 1.83 barn.

2. Gadolinium compounds are known to accumulate in brain tumors and not in the surrounding healthy tissue. They are in fact used as tumor contrast-enhancing agents for magnetic reso-

nance imaging (MRI), a result of the large magnetic moment of the Gd^{3+} ion.

3. While the Gd^{3+} ion is itself toxic, its usefulness in MRI stimulated the search for compounds such as the Gd-DTPA complex, which is stable in the blood stream and non toxic. The pharmacokinetics, biodistribution and tolerance of Gd compounds used for MRI are well documented.

The gadolinium neutron capture reaction, $^{157}Gd(n, g)\ ^{158}Gd$, provokes complicated nuclear decay transitions that generate prompt g emission up to 7.8 MeV, accompanied by the emission of internal conversion electrons, mostly Auger electrons in the energy range 41 keV and below. Both g rays and Auger electrons are low LET radiation, with contrasting ranges and biological effects in tissue. Gamma rays travel through the whole thickness of the skull, and are weakly absorbed by both healthy and tumor tissues. Hence these capture products would deliver dose widely, independent of the precise location of a GdNCT agent in the tumor cells.

By contrast, mass and charge carrying Auger electrons, are highly ionizing over a short range. The longest radiation length is on the order of tens of nanometers for the most energetic electrons. Most favorably for Gd-NCT, Auger electrons may induce double strand damage if Gd is in the proximity of DNA, so the dose enhancement due to the electrons emitted in the GdNCT reaction would clearly be most substantial if they originate from a site within the cell nucleus, i.e. if Gd accumulated in tumor cell nuclei. Previous studies demonstrate that GdNCT can be used to kill tumor cells, but do not differentiate the relative efficacies of the g rays and Auger electrons. It was often assumed that Gd did not penetrate the plasma membrane, but no experiment had been performed, to the best of our knowledge, to tackle the issue of Gd penetration in tumor cells.

We addressed this question with the most direct approach: we exposed human glioblastoma cells to Gd, and then observed Gd accumulated intracellularly and intranuclearly. We used x-ray spectromicroscopy, a well established technique

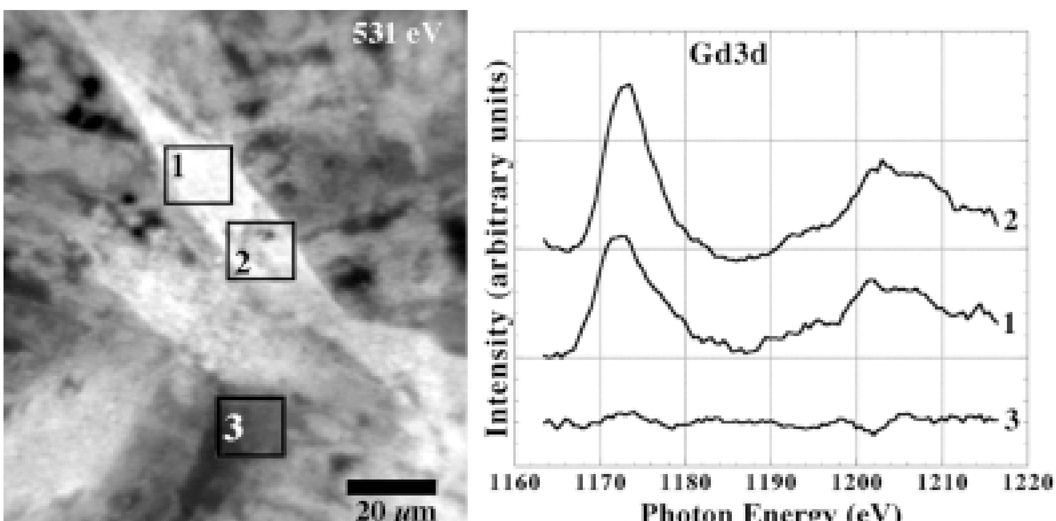


Figure 1

MEPHISTO image (on the left) showing the characteristic elongated shape of glial cells growing on a flat substrate. The gadolinium spectra on the right were acquired from the three microscopic box-regions in the image. Gd is present in regions 1 and 2, absent from the gold substrate area of region 3.

We acquire several hundreds images like the one in Fig. 1, and from cell cultures that had been exposed to Gd for different periods of time, ranging from 0-72h. We demonstrated that Gd is preferentially accumulated in cell nuclei, and its concentration increases with exposure time. We also observed the Gd micro-distribution in human glioblastoma tissue, extracted from a patient injected with Gd before surgery. We found that at least in some areas Gd is localized in cell nuclei, and not elsewhere in the cancer tissue.

in materials science which is still rather novel for the microchemical analysis of physiological and trace elements in bio-specimens. The spectromicroscope we used is MEPHISTO, designed, built and installed at the UW-Synchrotron Radiation Center, in Stoughton. We directly observed the intracellular distribution of gadolinium, via x-ray absorption spectroscopy at the Gd 3d edge. We demonstrated that Gd penetrates both the outer and nuclear membranes, and additionally showed preferential accumulation in the cell nuclei. The cells we used were extracted from a human glioblastoma case, cultured in vitro, exposed to Gd, carefully washed to remove non-uptaken Gd and then ashed.

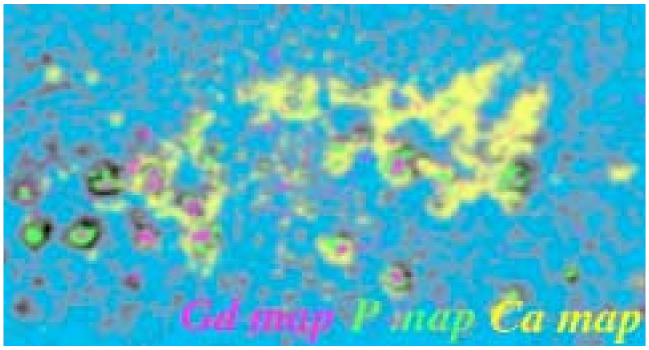


Figure 2

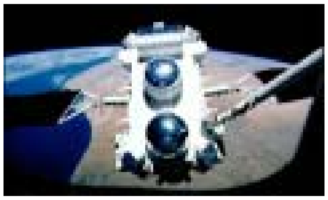
Figure 2 shows the Gd micro-distribution, superimposed to a direct image of the tissue section (blue), and the distribution maps of calcium (yellow) and phosphorus (green). P occurs at higher concentration, Ca at lower concentration.

Probing nature's particle accelerators

by Brenda Dingus

Gamma-ray observations have opened a new window on the Universe. Nature's most powerful particle accelerators have been shown to emit most of their power in very few, but very high energy photons. These accelerators exist in extreme environments and push our understanding of basic physics. For example, a black hole at the center of an active galaxy powers a relativistic jet of particles producing 100 times more energy than all the stars combined in a bright galaxy. Or a neutron star of mass similar to the Sun's but only 10 km in size spins around in a fraction of a second emitting pulses of gamma rays each rotation. Or a gamma-ray burst, which emits the rest mass energy of the Sun in a few seconds, yet the astrophysical object capable of this powerful explosion is unknown.

The opening of this new window was made possible with the launch of the Compton Gamma Ray Observatory (CGRO) in April 1991. The photograph below shows CGRO as viewed from the space shuttle while being deployed. EGRET, the high-energy gamma-ray detector on CGRO, detected nearly 300 sources emitting gamma rays of > 100 MeV. Prior to EGRET, fewer than a dozen such sources were known. Now new classes of sources have been identified. However, the largest class contains sources that have not been identified with objects known at other wavelengths. Clearly there is much more to learn. Unfortunately CGRO was recently decommissioned. CGRO's aging components caused NASA to destroy the satellite via a controlled reentry into the Earth's atmosphere in order that the 900 mile long debris field would not harm any people. However, the demise of CGRO does not mean the window will slam shut. New and improved observatories are planned.



Compton Gamma Ray Observatory being deployed, as seen from the space shuttle.

Brenda Dingus, a new professor in the University of Wisconsin physics department, was a research scientist at NASA Goddard Space Flight Center analyzing data from EGRET and is now involved with two new observatories for gamma-ray astrophysics. Milagro is a ground based gamma-ray observatory that operates in the mountains of New Mexico, and GLAST, an improved version of EGRET, will be launched on a satellite. At energies below a few tens of GeV, the Earth's atmosphere blocks gamma rays, so a detector on board a satellite is required. At higher energies, the shower of energetic particles created when the gamma ray interacts in the atmosphere is detectable from the ground. A ground-based detector is also required because the flux of gamma rays decreases with energy as well as the mass required to stop a higher energy gamma ray increases. Such a large detector is prohibitively expensive to launch into orbit.

GLAST uses improved technologies developed for particle physics detectors, with NASA, DOE and international institutions collaborating to build it. The tracking part of the detector consists of silicon strip detectors interleaved with lead foils. The lead is required to increase the probability of a gamma-ray pair production, yet the lead is detrimental to the angular resolution because of the increased multiple scattering of the electron and positron. Because power and weight must be minimized, there is a trade off between the increase in detection efficiency and the angular resolution. The major contributor to the weight, however, is the calorimeter to measure the electron and positron energies. The detector must also screen out the many charged particles that out number gamma rays by a factor of nearly 100,000 to one. A plastic scintillator surrounds the tracker to identify charged particles and pattern reconstruction algorithms will be used on board in order to reduce the data that must be telemetered to ground. The launch of GLAST is scheduled for 2005. University of Wisconsin alumni also work on GLAST, such as Prof. Robert Johnson of UC Santa Cruz and Dr. Steve Ritz of NASA Goddard Space Flight Center.

GLAST will have nearly a factor of 50 improvement in sensitivity over EGRET. EGRET detected nearly 300 sources (Hartman et al. 1999), and GLAST is predicted to detect several thousand sources. Much will also be learned from an in-depth study of a smaller number of sources — those objects that are bright enough to be monitored frequently and detectable in short time intervals. GLAST in its scanning mode will be able to monitor the whole sky each day with the sensitivity to observe EGRET's weakest source detections.

Meanwhile, great advances have been made in detecting gamma rays of energy greater than a few 100 GeV from the ground. The Earth's atmosphere is the part of the detector that converts the gamma rays into a shower of particles, which then radiate Cherenkov light. The Cherenkov light extends over a diameter of ~100 meters on the ground, so a single 10 meter diameter mirror, with a camera of photomultiplier tubes to detect the pulse of light, can have a large effective area for gamma-ray detection. The much more prevalent background of cosmic rays limited the sensitivity of this technique until researchers from the Whipple Gamma Ray Observatory used extensive Monte Carlo simulations and smaller pixelization of the camera image to distinguish the Cherenkov image of cosmic rays from that of gamma rays. Several such Cherenkov observatories operate around the world, and ~10 astrophysical sources have been detected. Major new multi-mirror observatories, such as VERITAS located near Tucson, Arizona, are planned which will have even greater sensitivity.

While atmospheric Cherenkov detectors have good sensitivity, they have a low duty cycle of 5-10% due to the requirement of clear, moonless, nighttime observing. Also, the camera has a field of view of a few degrees, so surveying the sky is difficult. EGRET with its field of view of ~1sr discovered most gamma-ray sources are variable, so a large field of view is essential to catching unexpected transients especially if they only last a few seconds like gamma-ray bursts. Therefore, in order to monitor the gamma-ray sky from the ground, a new type of detector is also needed.

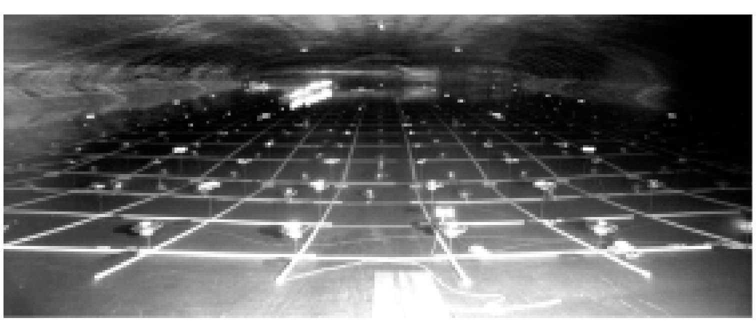
Milagro is such a gamma-ray observatory with a large field of view and continuous operation that has just been built in the Jemez Mountains near Los Alamos, NM at an elevation of 2,650 meters. Milagro was built and is operated by a collaboration of eight universities (University of Wisconsin–

The Milagro pond above the cover.

Madison, University of Maryland, University of California–Irvine, University of California–Santa Cruz, University of California–Riverside, University of New Hampshine, New York University, and George Mason University) and the Los Alamos National Laboratory. Another UW alum, Dr. Gus Sinnis of the Los Alamos National Laboratory, works on this project.

Milagro uses the large pond of water 80 m x 60 m x 8 m shown in the photographs to detect the particles that reach the ground from the extensive air showers initiated by cosmic rays and gamma rays interacting in the Earth's atmosphere. The high elevation of the observatory is important to detect more particles, as is the large area of the detector with a high efficiency of detecting the shower particles. The shower is a thin pancake of particles and secondary gamma rays moving at nearly the speed of light. The plane of the pancake is perpendicular to the direction of the primary particle. The pond has a light-tight cover, and contains 723 photomultiplier tubes (PMTs) that are placed on a 3 m x 3 m grid in 2 layers at 1.5 m and 7 m below the surface

The relativistic particles in the extensive shower radiate Cherenkov light in the water so that several tens of PMTs detect light within a few 100 nsec time interval. From the relative timing of the photomultiplier tube signals, the direction of the particle or gamma ray initiating the shower can be determined to of order 1 degree, depending on the number of PMTs hit. The angular resolution helps reject the isotropic background of cosmic ray initiated shower, but pattern recognition and detector enhancements are being studied to improve the rejection. For example, a layer of PMTs at the bottom of the pond detects the penetrating muons, which are more prevalent in cosmic ray showers.



The Milagro pond below the cover.

Milagro began operations in December 1999. Over 1000 showers per second are recorded and ~100 Gbytes of data per day is written to tape. The basic technique was tested with a smaller version of Milagro, called Milagrito, which operated for 15 months. Much was learned about calibration and reconstruction from Milagrito, as well as the active galactic nuclei Mrk 501 (Atkins et al. Ap J Lett. 525 L25 1999) was detected and evidence of TeV emission was observed in a gamma-ray burst (Atkins et al. Ap J Lett 533 L119 2000). Milagro will be more than 5 times more sensitive than Milagrito, as well as have better energy resolution.

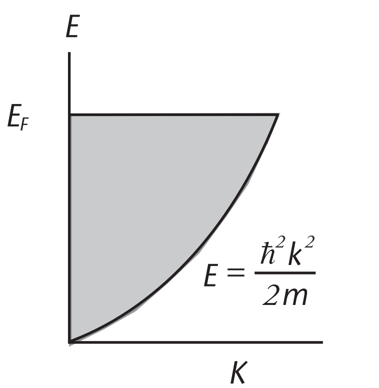
The new observatories described here and others, guarantee that the future of gamma-ray astrophysics will be exciting. Observations from these future detectors will tell us more about Nature's particle accelerators and more about particle physics as well. This new field of investigation is an example of the benefits of bringing together the talents of high energy physicists, cosmic ray physicists, and astronomers.

Dimensionality and physics

by Marshall Onellion

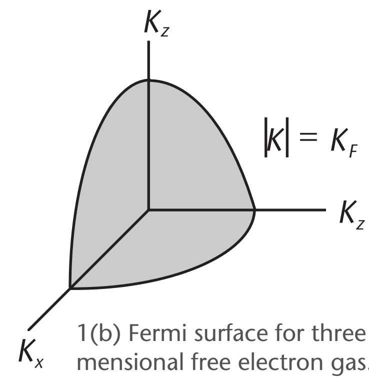
Many of us remember the Flatland cartoons, and imagine life on a plane as in a line. Recent technological developments have allowed several UW physics faculty to investigate such behavior in real physical systems. Profs. Bruch, Chubukov, Eriksson, Himpsel, Joynt, Lagally, Onellion and Rzchowski study different aspects of metal and insulator (or semiconductor) systems in which carrier (electron or hole) transport is much better in one or two directions than the others. In this article, I describe one particular type of system: quasi-one-dimensional conductors.

I begin with our friendly reference system, the ideal three dimensional free electron gas. As Figure 1(a) illustrates, at low temperatures (near 0K) electronic states are occupied up to some special energy called the Fermi energy. In a well-ordered, periodic, material the linear momentum and wave vector (= $2\pi p/h$) are well defined quantum numbers. With a "gas" there is no potential energy term, so the energy is simply the kinetic energy $E = p^2/2m$. We can then illustrate the occupied energy states by Fig. 1(b), and find that the highest occupied energy level corresponds to a three dimensional surface in k-space. This surface is called the Fermi surface; it is simply an equi-energy surface in k-space. Because electrons are fermions, and obey Fermi-Dirac statistics, the electrons are not all in the lowest energy state. Instead, two electrons, one of each spin angular momentum orientation, are in each energy level. This leads to having a Fermi energy and Fermi surface as the electrons fill up energy levels from lowest to highest; the highest occupied energy level is the Fermi energy. The value of the Fermi energy is determined by the number of carriers per volume, the carrier density. The energy between the bottom of the allowed energy levels and the Fermi energy, called the "bandwidth," is thus also determined solely by the carrier density.



1(a) Electron energy values (E) versus wavevector (K) at T ≅ 0K. Energy values up to the Fermi energy (E_F) are occupied.

Let us compare and contrast 3-dimensional and 1-dimensional Fermi gases. In one dimension, the same equation for kinetic energy applies: $E = p^2/2m$. However, now the carriers can only move in one direction! This means that actually $E = p_x^2/2m$, where (x) is the direction of motion along the 1-dimensional chains. Now the carriers again fill up energy levels from lowest to highest, but only changes between one energy level and another. Consequently, the highest occupied energy level corresponds to a particular value of $|p_x|$, and the Fermi surface consists of only two points: $\pm\, p_{xf}$. 1-dimensional conductors thus exhibit a particularly simple Fermi surface: two points in k-space. As with 3-dimensional systems, the values of the Fermi energy and of the bandwidth are determined solely by the carrier density.

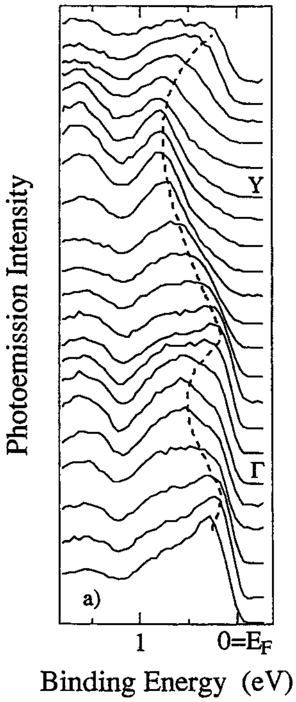


1(b) Fermi surface for three dimensional free electron gas. Wavevectors up to the Fermi wavevector (K_F) are occupied.

There have been many studies of quasi-one-dimensional conductors.[1] In comparing real materials and the above ideal system, note the important characteristics:

- energy levels only depend on k_x;
- the Fermi surface consists of two points at $\pm\, k_{xf}$;
- the Fermi energy and bandwidth are determined solely by the carrier concentration.

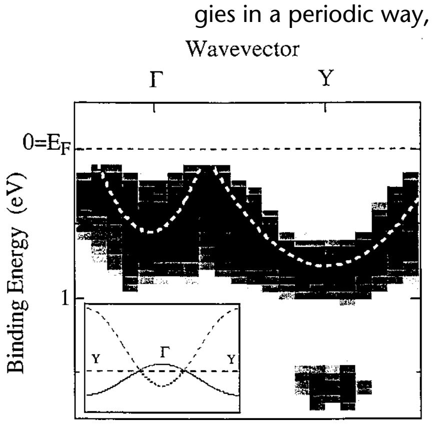
In comparing to real materials, two additional points become important. Most quasi-one-dimensional materials undergo a metal-insulator phase transition, in which the material conducts (along one direction) like a metal for some temperature range and like an insulator for a different temperature range. Also, the lattice (nuclei) of real materials establish a periodic electrostatic potential. This periodicity causes the electronic energy levels to vary with the same periodicity.



2(a) Series of photoemission spectra versus wavevector (K_X). G corresponds to $K_X = 0$, Y to Brillouin zone boundary.

The reason is physical: in a well-ordered material, each unit looks like any other, so a change of distance (L) leads to the same electrostatic potential. In k-space, which is the Fourier transform of the real-space lattice, this produces a periodicity of ($2p/L$) in the energy levels.

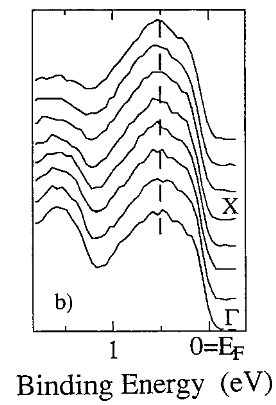
Angle-resolved photoemission is well suited to measure the change of energy levels with wavevector, the Fermi energy, and the bandwidth. Figure Two illustrates one recent study of an organic quasi-one-dimensional conductor TTF-TCNQ (tetrathiafulvalene-tetracyanoquinodimethane). This material has a rich phase diagram and has been widely studied.[2] Among its fascinating properties, TTF-TCNQ has a soliton, a solitary wave, excitation.[3] TTF-TCNQ also exhibits a metal-insulator phase transition at app. 35K; it acts like a good 1-dimensional metal above app. 35K. Fig. 2(a) illustrates a series of photoemission spectra taken at different wave vectors corresponding to the conducting chain direction. Notice that the peak- which corresponds to a particular band of energy levels, changes with wavevector. This is as expected: the energy changes with wavevector. Also, the peak moves to higher and lower energies in a periodic way, as illustrated in the intensity profile of Fig. 2(b). The periodicity is as expected for the three-dimensional crystal structure, indicating that the surface of TTF-TCNQ exhibits the same lattice structure as the bulk.



2(b) Intensity profile versus wavevector (K_X) and binding energy. Inset: Band stucture calculated by tight binding method.

However, in Fig. 2(c), I illustrate a series of photoemission spectra taken in a direction perpendicular to the conducting chains. Note that the peak does not change energy with wavevector. This is also as expected; the energy is only suppose to depend on k_x, not k_y or k_z. So far, this material acts close to the ideal quasi-one-dimensional conductor.

Figure 3 illustrates an expanded view of two photoemission spectra at the expected Fermi wavevector. Since TTF-TCNQ undergoes a metal-insulator phase transition, we expect to measure a gap opening in the allowed energy states of the electrons. We indeed do measure such a gap, and the size of the gap is consistent with the size estimated from resistivity and optical measurements. Did you notice there is something odd about Figs. 2(b) and 3? The highest occupied energy level is, by definition, the chemical potential. We measured the chemical potential directly by depositing a silver film on top of the sample and obtaining the Fermi-Dirac distribution illustrated in Fig. 3. So we expect the peak- the energy band- to be at the chemical potential when the wavevector is the Fermi wavevector. On the contrary, the data exhibit nothing of the sort. While the periodicity is as expected, the peak never reaches the chemical potential. Instead, the signal near the chemical potential is merely incoherent intensity, with a power law decay as we approach the chemical potential.



2(c) Series of photoemission spectra versus wavevector (K_Y) along non-dispersing wavevector axis.

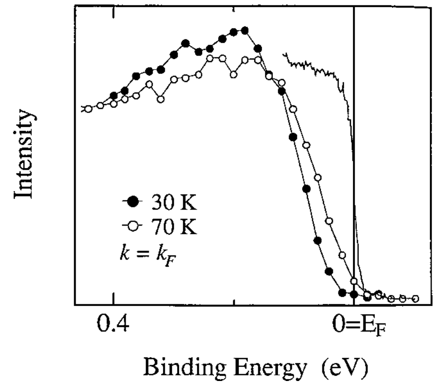
Many years back, two theoretical physicists Drs. Luttinger [4] and Tomogawa,[5] predicted some of these properties. They asked the question: can a single electron be the elementary excitation in one dimension? Their answer, surprisingly, was no! Their calculations predicted that in one dimensional systems, there were two elementary excitations: a "holon" that carries the charge of the electron and a "spinon" that carries the spin. Their calculation was based on an electron scattering along a one-dimensional wire. In one dimension, an electron can either be scattered forward, or backward. They neglected back-scattering, and, considering only forward scattering, arrived at these fascinating predictions.

This prediction was very exciting: imagine qualitatively new elementary excitations as you change the dimensionality of a conductor! Many investigations have and continue to be launched in the hope of proving whether such "spin-charge separation" actually occurs.[6] In this context, my work indicates that matters are both more complicated and even more interesting.

The data of Fig. 3 can be used to test the Luttinger-Tomogawa model. The power law decay of the signal is due to scattering. The exponent of the power law leads to a length scale-what is the average distance an electron travels between scattering events? Data such as Fig. 3(b) indicate a rather long-range interaction between the electron and the rest of the system. This is bad news for the Luttinger-Tomogawa model, which presumes short-range interactions dominate.

Fig. 4 illustrates another, and perhaps the most puzzling, aspect of the TTF-TCNQ data. In Fig. 4, I illustrate a series of photoemission spectra taken at different temperatures, all at the Fermi wavevector. Note that the peak becomes weaker and moves further away from the chemical potential. Also, the leading edge shifts away from the chemical potential.

The data of Fig. 4 are quite puzzling. In many systems having a phase transition in their phase diagram, it is common to have fluctuations. Fluctuations can be thought of as part of the system changing from one phase to another for a short time, then changing back to the "correct" phase for that location in the phase diagram. When such fluctuations occur, they are expected to be strongest near the phase transition line, and to die out as you move away from the phase transition. Increasing the temperature for TTF-TCNQ moves away from the metal-insulator phase transition. We would expect the system to get closer to the ideal quasi-one-dimensional metal. Instead, the material acts as though the system is becoming more unstable, not less, as the temperature increases.



3. Angle resolved photoemission spectra at wavevector $K_X = K_F$ for the metallic state (open circles) and the insulating state (closed circles). The solid line is a silver film reference spectrum that establish the Fermi energy.

The data of Fig. 4 do not fit into any model. Such data illustrate both the motivation and frustration of lower dimensional studies. Because the mathematics to analyze any model is quite difficult, experimentalists are reduced to comparing their data to simplified models. This is frustrating, since the data in this article indicate a rich phase diagram with several unexpected phenomena. At the same time, these lower dimensional systems are certainly not merely 1- or 2-dimensional analogs of copper (or any good 3-dimensional metal): qualitatively new physics is at work. My colleagues and I, along with many other scientists world-wide, are continuing to probe the complex and fascinating world of lower dimensional conductors.

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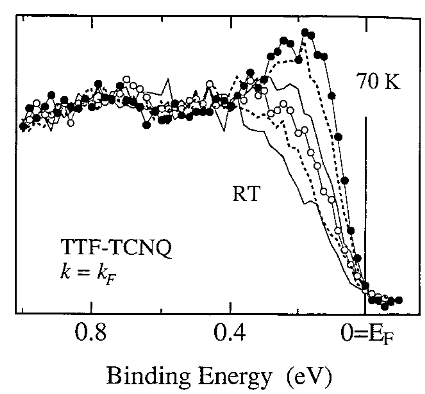
[2] *F. Zwick et.al., Phys. Rev. Lett. 81 (1998) 2974*

[3] *Solitary waves have been observed for centuries in some canals. The first report in the European literature seems to be J. Scott Russell, "Report on Waves," Rep. 14th Meet. Brit. Assoc. Adv. Sci., York, 1844, pp. 311–90.*

[4] *For a general discussion: F.D.M. Haldane, J. Phys. C 14 (1981) 2585*

[5] *For a review: J. Voit, Rep. Prog. Phys. 58 (1995) 977.*

[6] *For a recent review, see P.W. Anderson in "Physics Today."*



4. A series of angle-resolved photoemission spectra at wavevector $K_X = K_F$ versus temperature in the metallic state, from 70 K to room temperature (RT).

Madison dynamo project seeks to recreate Earth's magnetic field in the laboratory

by Terry Devitt

From *Wisconsin Week,* October 20, 1999

For more than 100 years, scientists have been trying to tease out the secrets of the natural, magnetic field-generating dynamos that exist in the Earth and virtually all other celestial objects from stars to galaxies.

But the phenomenon, which occurs deep within the Earth at its outer core of molten iron, or at vast distances from our planet, has proved inaccessible, a mystery shielded by miles of rock or distances often measured in light years.

Now, however, scientists may soon get the opportunity to study the phenomenon firsthand. The finishing touches are being applied to a university experiment that will attempt to recreate — in a 1-meter-wide stainless steel sphere — the same conditions that give rise to the self-perpetuating magnetic fields seen in nature.

"This is something that hasn't been done before," says **Cary Forest**, a physics assistant professor.

Forest leads one of several groups from around the world racing to be the first to mimic a well-known, but poorly understood, feature seen in the Earth and other rotating objects such as stars, galaxies and planets.

Physics professor Cary Forest shows off a large stainless steel sphere used for the Madison Dynamo Experiment, which is expected to demonstrate how molten iron combines with the planet's rotational energy to generate the self-perpetuating magnetic field responsible for effects that range from spinning compass needles to shielding our planet from dangerous cosmic rays.

"You can't measure it in the Earth. You can only look at it from far away," says Forest.

At the heart of the Madison Dynamo Experiment is perhaps the world's most unusual blender, a large stainless steel sphere fitted with two opposing propellers. By filling the sphere with 200 gallons of molten sodium and spinning the propellers in opposite directions, Forest hopes to recreate the same kinds of flows that exist at the Earth's outer core. There, molten iron combines with the planet's rotational energy to generate the self-perpetuating magnetic field responsible for effects that range from spinning compass needles to shielding our planet from dangerous cosmic rays.

"The most successful outcome would be that we spin it and a magnetic field spontaneously grows," Forest says.

Such an outcome would permit scientists access to the fine details of a natural system that cannot be directly observed. In recent years, elaborate high-speed computer models have been developed to simulate the flow of the molten fluids at the Earth's core, but to date there is virtually no experimental system to observe or manipulate.

"There are unknown issues, questions that can only be answered experimentally," Forest says. "Just observing a magnetic field won't tell us much. It's the details that are important, and with this experiment we can turn the knobs and see what happens."

For example, the Earth has an observable magnetic field, a dipole, that flows into the South Pole and out of the North Pole. But inside the Earth, some scientists believe there is a yet-to-be discovered toroidal or donut-shaped magnetic field that goes from east to west. Seeing a similar phenomenon in the laboratory, according to Forest, would help confirm this picture of what is thought to be happening at the center of the Earth.

These intricate, hidden details of naturally occurring dynamos, says Forest, have relevance to a raft of fields including geophysics, solar physics, plasma physics and astrophysics.

"This will be a working model that has relevance to all of those things," he says of the experiment.

According to Forest, physicists would like to answer the fundamental question of how these magnetic fields are generated in the first place.

In principle, nature's electromagnetic dynamos consist of a source of free energy that drives a motion. For example, at the outer core of the Earth, the flow of molten iron creates an electric field which, in turn, generates the planet's magnetic field.

"In the Earth, the source of free energy is heat from the core and the rotational energy of the planet," Forest says. The turbulent motion that's generated within the molten iron at the core of the Earth — and the one that scientists hope to recreate with propellers in their stainless steel sphere — is one that "self excites" or produces a spontaneous magnetic field, Forest says.

In nature, as in the laboratory, another magnetic field is required to jump-start an electric current and transform it into a self-perpetuating magnetic field. The Earth's magnetic field was helped along early in the history of our planet, scientists think, by a preexisting magnetic field in the solar system. In the Madison Dynamo Experiment, electric fields generated within the swirling molten sodium will get a kick-start from the Earth's small magnetic field.

Forest says the stainless steel sphere at the heart of the experiment will have no wires to direct current flow, and there will be no insulators or pipes within the sphere to control the flow of molten liquids.

"In principle, we're going to learn something about a very basic system," he says. "We can measure everything we need to and test theory to its extremes."

Photos by Jeff Miller

The sphere is fitted with two opposing propellers. By filling the sphere with 200 gallons of molten sodium and spinning the propellers in opposite directions, Forest hopes to recreate the same kinds of flows that exist at the Earth's outer core.

Physics team studies atomic life at "absolute zero"

by Brian Mattmiller

From *Wisconsin Week*, August 25, 1999
(Editor's note: This is the first of a series of stories about the everyday — yet extraordinary — process of discovery at UW-Madison.)

Thad Walker

With a lab full of lasers to corral and chill atoms, physicist **Thad Walker** is plunging into the frigid domain of "absolute zero." It's not just cold there. It's weird.

At 460 below zero, give or take a millionth of a degree, things start to behave freakishly. Atoms, normally darting around at 1,000 mph, begin to move as if suspended in molasses. Their once-chaotic movement becomes almost choreographed in smooth little waves.

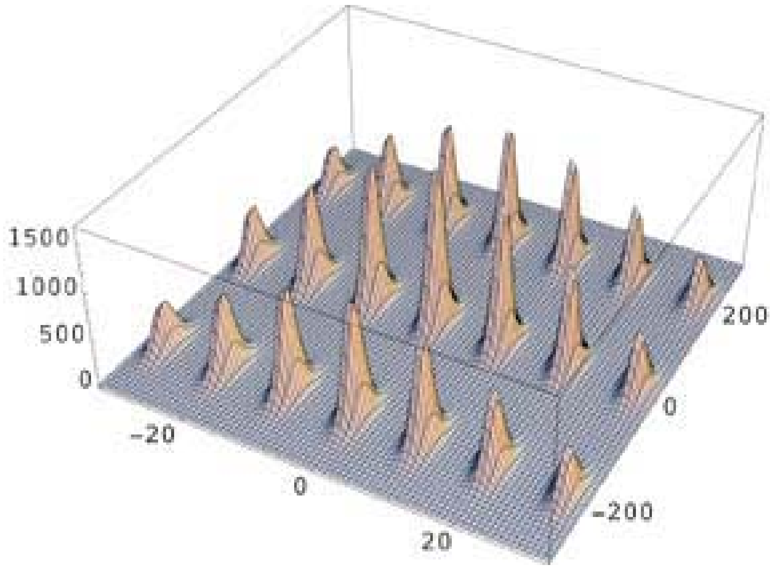
This is the chilly climate in which physics professor Walker and his team of "atom trainers" work to ultimately control the behavior of atoms. From a behavior-modification perspective, this is the physics equivalent of transforming a heavy-metal mosh pit into a military parade.

As a science, atom trapping and cooling was thought to be an impossible dream 15 years ago. Today, there are hundreds of laboratories capable of exploring super-cooled atoms, and it's one of the most full-bore explorations in physics.

A few labs have even reached the ultimate in cold, a new state of matter called a Bose-Einstein Condensate. It's the point where all movement ceases, and single atoms seem to morph together into a uniform, beautifully arced wave.

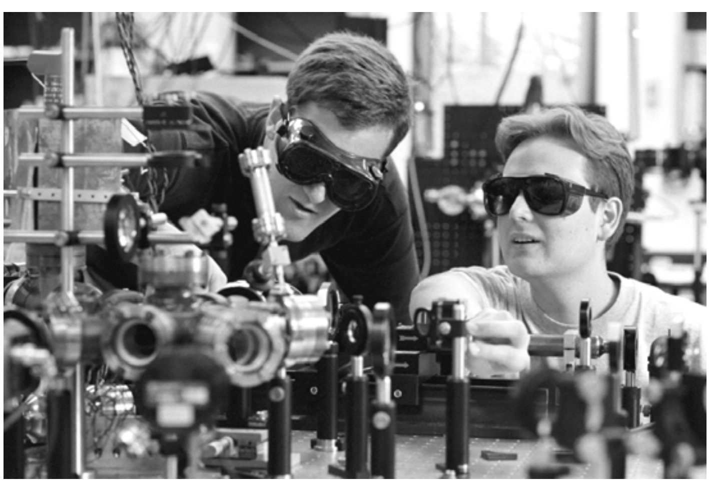
Walker is one of the early pioneers in this work. In the late 1980s, he built only the second atom trap in existence while at the University of Colorado. Scientists from Stanford and Paris who did similar work went on to win a Nobel Prize in 1997.

"One thing I really try to do with the research is emphasize it's curiosity-driven," Walker says. "We don't know where it's going."



"This computer graphic illustrates a theory behind Professor Thad Walker's new atom trap, which uses a hologram to trap atoms inside a cylinder of light. Each cone in this light field would hold an individual atom precisely in place, like an atomic egg carton." Image courtesy Thad Walker

There are, however, some wild-eyed technology predictions. The ability to control atomic movement could produce extremely precise atomic clocks, small enough to fit in a glove box. Such a clock could revolutionize navigation systems, and make global positioning systems, for example, accurate to within a blade of grass. They could also be used to create a laser that sends out a uniform beam of atoms, which could etch integrated circuits with staggering detail.



"Physicist Thad Walker, left, and senior Nathan Harrison, right, adjust infrared laser equipment used to trap and cool atoms to near absolute zero. By using a special infrared lens, one can see a tiny green ball of light, smaller than a marble, that constitutes the trapped atoms scattering laser light. It can take more than a year to set up a functional atom trap." Photo: Jeff Miller

But gadgets are not the driving force for Walker. His atom traps, which can take years to correctly calibrate, are after fundamental questions.

"I have an opportunity to study matter under circumstances that it's never been studied in before," he says.

Inside Walker's lab, all outside light is extinguished with foil coverings on the windows. The dominant feature is a large steel-plated table rigged with peg-holes. Hundreds of optical tools are screwed into the table to intercept beams of laser light. The beams get focused through lenses and scopes, deflected by mirrors and parted by beam-splitters. Ultimately, a series of five to six precisely manicured beams are all trained on a tiny center point inside a vacuum chamber. By using a special infrared lens, one can see the tiny green ball of light, smaller than a marble, that constitutes the trapped atoms scattering laser light.

Thus, the trap is set. But the cooling is trickier. The laser light emits photons that constantly pound against atoms moving toward the laser. It's like throwing ping-pong balls at a billiard ball, causing it to gradually lose momentum. The slower an object moves, the colder it becomes. Stopping atoms dead in their tracks constitutes zero degrees Kelvin, or minus 459.6 below zero. These experiments all achieve temperatures in the range of one thousandth to one billionth of a degree from absolute zero.

"If you can precisely control these laser beams, you can con the atom into doing what you want," he says. Visually this process is a challenge, since infrared light is not visible to the naked eye. But Walker uses tiny surveillance cameras to keep the hazy ball of light glowing on a TV monitor.

Walker is perfecting a stripped-down, portable atom trap that he can set up for lectures and public talks. When he first used it a year ago in a lecture hall, the ball of light popped on the screen and the crowd cheered in approval. The sound waves promptly threw his machine into chaos, and the beam was lost. Once he got the crowd quieted down, the ball of light reappeared.

Today, Walker continues to refine the tools for this work. He's also developed a specialized research area into how these atoms interact with light and interact with each other. By using lasers to cool atoms, they are also bathing atoms in light. The atoms are constantly absorbing and shedding photons from the laser light, which produces a force between atoms a thousand times higher than normal. Walker's goal is to minimize the effects of light on the atoms, and to produce atom traps that do not scatter light.

And he's added a new tool to the arsenal to achieve that goal. He uses a hologram to split a single beam five ways, trapping atoms inside the cylinder of light. In theory it will do amazing things, like corral individual atoms into "atomic egg cartons," holding individual atoms inside a dimpled light field that comprises the interior of the cylinder. For the first time, he will be able to increase the density of his trapped atoms by more than a factor of one thousand, at a temperature a few millionths of a degree above absolute zero. No other place in the world is using such a device. "If what happens is what we think will happen, it will be fantastic," he says. "If it doesn't work, it will likely be because of some new phenomena we don't yet know about, which will also be great." "Where this is all headed, I don't know," Walker adds. "But 30 years ago, people were saying the laser was an invention without an application."

"It's kind of my job to be pie in the sky."

Lab brings complex science hardware to life

by Brian Mattmiller

At Stoughton's Physical Sciences Laboratory, a glimmering stainless steel pod resembling a miniature bank vault gets a final inspection. Computer readouts fine-tune the machine for its ultimate task Pinpointing the structure of materials, one atom at a time.

Farshid Feyzi, associate director of the facility, puts some perspective on this impossibly precise machine. He says it's the equivalent of having a sharpshooter take aim from Madison and hit a target the size of a dinner plate — in Los Angeles.

These are the kinds of parameters staff at PSL manage as one of the nation's leading toolmakers for Big Science. This particular device — called a double crystal monochromator — is headed for use at Argonne National Labs. It's one of the many federal laboratories for which PSL has built machines in its 33-year history.

PSL staff built a collider detector for northern Illinois' Fermi Lab, which was used to help identify the top quark, one of the landmark physics discoveries of the 1990s. Staff also built gamma ray telescopes stationed in Hawaii and ice drills for the cosmic neutrino experiment in Antarctica.

But PSL's biggest influence is local, as a provider of one-of-a-kind research tools for UW-Madison scientists. PSL handiwork can be found in dozens of labs around campus, from humming donut-shaped confinement rings for fusion experiments to DNA sequencing machines.

PSL's work floor looks like any machine shop, with milling machines, lathes and drill presses grinding away on aluminum, copper and steel. But PSL tools have transformed research projects on campus from paper theories to functional experiments.

"Many times faculty come in with a basic idea — 'wouldn't it be great to do something like this,'" Feyzi says. "Sometimes it's out of the blue or a fresh idea in their field. We can help them with the concept, design and construction of a device that will fit their research needs."

One prominent current project at PSL is a tomotherapy device, a potentially revolutionary new way to deliver radiation treatments for cancer. Tomotherapy offers the promise of delivering hundreds of precisely tailored beams in exactly the dosage to kill cancer, but protect healthy tissue.

The machine's complexity is in the details. A finely machined tungsten box, about the size of a toaster oven, has 64 flat tungsten leaves each controlled by a piston. The leaves are choreographed to shift back and forth in the radiation's path, sculpting an exact dosage as the beam completes a pass around the patient.

Even though all drafting work today is done through computer-aided design, PSL has a complete archive of all its hand-drawn blueprints over 33 years of projects.

"It certainly makes us feel good to be participating in some of these landmark projects," says Dave Huber, PSL director. "We can take loose specifications and translate them into a functioning machine."

Radiation promotes better health

Commentary by John Cameron
in *The Gainesville Sun Newspaper,* 2/28/00, p. 8A

A recent editorial in the Gainesville Sun lamented the lack of a scientific solution to the nuclear waste problem. The scientific solution was found years ago but has never been publicized. The small amount of radiation to the public from nuclear waste will improve their health. However, there is no obvious solution to the political problem of "not in my back yard." There is no health risk in storing nuclear power waste in dry cask storage as is done at the Northern States Power nuclear plant in Minnesota. The radiation to the public in a year is less than you get in one jet flight. The recent statement of health damage to early nuclear workers by Secretary Richardson of the Department of Energy (DOE) was not based on facts. He gave no data and quoted no studies. He did not mention a $10 million unpublished DOE study of nuclear shipyard workers — probably the best study of radiation workers ever done. It showed that radiation was beneficial to the health of nuclear shipyard workers. Radiation not only reduced the incidence of cancer but also reduced death from other causes. The study is described in DOE report DE-AC02-79 EV10095, 1991: "Health effects of low-level radiation in shipyard workers" by Professor G. M. Matanoski of the Johns Hopkins School of Public Health in Baltimore MD. The health of about 30,000 nuclear workers with the largest lifetime radiation doses was compared to the health of 33,000 non-nuclear workers with the same ages and jobs. I was a member of the Technical Advisory Panel (TAP) which met regularly to review the progress of the study. The chair of TAP was the distinguished radiation scientist, Professor Arthur Upton. The study was completed in 1987. TAP members approved the final report in early 1988. However, the final report was not submitted until late in 1991. No reason was given for the delay. The good news in the report was never publicized to the public or to the scientific community.

Nuclear shipyard workers had a significantly lower cancer death rate than non-nuclear workers and much better general health. The death rate from all causes of the nuclear workers was an amazing 24% (16 standard deviations) lower than the death rate from all causes of the non-nuclear workers. This improved health was probably due to stimulation of the immune system by the increased radiation.

Health improvement from increased radiation has been known since 1974. Dr. Norman Frigerio at the Argonne National Laboratory near Chicago (a DOE facility) published a study showing that states with high natural background radiation — comparable to the increased dose to a nuclear worker — had a 15% lower cancer death rate than the average for all states. Scientific evidence for improved health from the high natural radiation was also shown in a recent study. (See Natural Background Radiation and Cancer Death in Rocky Mountain and Gulf Coast States by John Jagger in Health Physics, Oct. 1998 pages 428-430.) The cancer death rates in three mountain states with high natural radiation were compared to the cancer death rates in three Gulf States with only one-third the natural radiation. The cancer death rate was about 25% lower in the mountain states. This study supports the data from the nuclear shipyard worker study.

I suggest that the increased cancer death rate in the Gulf States is due to radiation deficiency. The DOE should sponsor a study of health benefits from increased radiation. It would be easy to increase the background radiation by placing sacks of uranium ore under the bed. The control group would have sacks of ordinary sand. The radiation level of the exposed group would be well below the level known to cause cancer. I would be happy to volunteer for the study. I believe that in another generation radioactive waste will be incorporated into building materials in the Gulf States to increase the background radiation. This would be similar to the added vitamin D in many foods and added iodine in our salt.

John R. Cameron
e-mail: jrcamero@facstaff.wisc.edu

GRADUATE NEWS

Graduate awards

Katherine Rawlins

Another first! The date of May 5, 2000 marked the first ever Spring Physics Majors Banquet and Awards Ceremony in the physics department. The setting was the exquisite new Fluno Center for Business Executive's training on University Avenue. With Lee Pondrom as Master of Ceremonies, and Professor Al Groshaw of Duke University as Keynote Speaker, award winners and retirees were toasted.

In the graduate arena, the following awards were presented:

The 2000 Elizabeth Hirschfelder Scholarship Awards for Physics Women to further their careers in science were awarded to **Katherine Rawlins** and **Olivia Castellini**. Katherine Rawlins is an advanced grad studying Astrophysics with Professor Albrecht Karle. She came to Wisconsin after receiving her B.S. in 1996 from Yale University.

Olivia Castellini

Olivia Castellini works with Mark Eriksson, in the Condensed Matter area. She received her B.S. in 1999 from Depauw University, Greencastle, Indiana. Both young women made use of their scholarship funding during the 2000 summer to support their research goals.

Tony Gerig

Tony Gerig was the winner of the 2000 Dillinger Award for Teaching Excellence. Tony received his B.S. degree in Taylor University, Upland, Indiana. He has served as a teaching assistant in the Engineering LINK initiative which placed groups of Engineering students together in sections of Math, Physics and Chemistry. His students reported that he was an outstanding, empathic teacher.

The Emanuel R. Piore Award for distinguished achievement in the study of physics (top scores on the Qualifier) went to two international students this year: Zhigang Xie & Hye-Sung Lee.

Zhigang Xie comes from P.R. China and began to be interested in Physics when he was in high school. In 1991, he enrolled in Tsinghau University which is ranked #1 in P.R.C. He graduated with two B.S. degrees (Physics and ECE) in 1996. After graduation he focused his interest on condensed matter physics and continued his study and research at Tsinghau University as a graduate student. In the fall of 1999, he received his M.S. degree, came to UW and became a Ph.D. candidate. He works in Professor Lagally's group.

Hye-Sung Lee came to Madison in the summer of 1999 as part of the International Teaching Assistant Early Training Program. He received a B.S. in 1996 and a M.S. in 1998 from the Korea Advanced Institute of Science and Technology, Seoul, Korea. He is currently working with Professor Barger in the area of phenomenology.

Hye-Sung Lee

GRADUATE PROGRAM REPORT

Intensified graduate student recruiting efforts prove successful

The Admissions and Fellowships Committee, under the chairmanship of Jim Lawler, took many steps to heighten graduate student recruiting efforts for the class of 2000. The outcome was extremely successful. A total of 132 offers were made (87 domestic, 45 international). Acceptances number 49. Most importantly, we will be enrolling 6 of our top 20 applicants. This is a record for the Department. Thirty-two of the incoming students are domestic, and seventeen are international.

There were a total of 256 applications for admission (up 18% from last year) to the Physics graduate program. Of these, 96 were domestic and 160 were international. Offers were made to 102 males and 30 females, with 39 males and 10 females accepting.

Instituting many changes at the same time makes it difficult to ascertain which of those changes were most important. Included in this year's recruitment initiatives were group visits, greater involvement of current graduate students, an increased financial supplement to all TA offers with a marked boost to our top 20 applicants, many summer RA offers to prospective students, and publication of a new professionally done 4-color graduate program brochure and poster. Professor Mark Eriksson enthusiastically took the lead and acted as Editor in Chief during the production of the brochure and deserves much credit for doing an outstanding job. Additionally, Professor Robert Joynt (on sabbatical in Taiwan) conducted personal interviews with 34 Chinese students as part of the application process.

We organized two collective "Visit Weekends" for prospective graduate students, which were very well-received. Visit participants expressed a great deal of enthusiasm for these events and urged us to continue this approach. Evaluations revealed that meeting faculty and spending time with current graduate students were the most beneficial parts of their visit. On the day students spent in the department, short presentations by selected faculty from each major research area in the Department were scheduled in the mornings. Lab tours and visits with individual faculty were scheduled in the afternoons. We served a continental breakfast before the morning talks, catered a lunch with existing graduate students, and hosted a reception with faculty in the evening. Current students told us that "lots of food" was important. Other weekend events included airport pickup by current graduate students, a tour of SRC and the campus, and social activities involving both the visitors and current graduate students. Prospective students unable to participate in the group events were given the option of an individual visit to campus. Seventeen of the group visitors and four individual visitors accepted our offer.

TA stipend levels at UW-Madison are lower than almost any other school we would consider to be a peer university. In recent years, we have provided a $2,000 Van Vleck Fellowship (a supplement to each teaching assistant offer from Department resources). This year, the Van Vleck Fellowship was increased to $3,000. The Physical Sciences Division has the option of trading in our WARF Fellowships for cash, which we did for the first time this year. We offered a TA plus an additional $7,000 to each of the top 20 applicants approved for WARF Fellowships, and six of these students accepted our offer.

Several faculty members offered new students research assistantships for the summer of 2000. Thirteen accepted these appointments and are working on research projects at the Madison campus (7), Fermilab (1), New Mexico (1), and DESY (4) in Germany.

The success of our recruitment efforts this year was a joint venture. The cooperation and enthusiasm of the Physics Department's current graduate students, faculty, staff, and the Admissions and Fellowships Committee was essential. For your convenience, a copy of our new poster is the centerfold of this newsletter. Feel free to post it wherever you believe it would be appropriate and visible. We are anticipating equally productive results in the coming years and invite you, as alumni, to encourage prospective graduate students to consider pursuing their graduate studies at the UW-Madison.

New Physics Ph.D.s

Summer 1999

Boyle, James
"Lake/Ocean Surface Heat Flux Measurement from the Aqueous Thermal Boundary Layer" (Terry/Anderson)

Goyette, Amanda
"Gas Phase Studies of Diamond Deposition" (Lawler)
Postdoc, NIST, Gaithersburg, MD

Greening, Thomas
"Search for the standard model Higgs Boson in topologies with a charged dilepton pair" (Wu)
Postdoc, CERN, Geneva, Switzerland

Kadlecek, Stephen
"Spin Relaxation in Alkali Vapors" (Walker)
Research Associate, UW-Madison Physics Department, Madison WI

Mitchell, Gregory
"A Precision Measurement of the Spin Structure Function g_1 (x, Q^2) for the Proton and Deuteron" (Prepost)
Postdoc, SLAC, Stanford, CA

Nesnidal, Renee
"Ultracold Collision Measurements in Low Intensity Magneto-optical Traps" (Walker)
Focused Research, Madison, WI

Rainwater, David
"Intermediate Mass Higgs Boson Searches in Weak Boson Fusion" (Zeppenfeld)
Research Associate, Fermilab, Batavia IL

Rufinus, Jeffrey
"Calculated Electronic Structure of (GAAS)/Ge Superlattices" (Rzchowski/Crook)
Lecturer, UW-Whitewater, Whitewater, WI

Fall 1999

Chilton, Jeffrey
"Studies of Electron Excitation of Rare Gas Atoms by a New Application of Fourier Transform Spectroscopy" (Lin)
Research Analyst, Center for Naval Analyses, Alexandria, VA

Fontana, Paul
"Edge Ion Flow Dynamics in a Reversed Field Pinch" (Prager)
Lecturer in Physics and Supervisor of Laboratories, Lawrence University, Appleton WI

Ha, Phuoc Dai
"Baryon Magnetic Moments and Baryon Masses in QCD" (Durand, L.)
Graduate Student in electrical and computer engineering and Physics Teaching Assistant, UW-Madison

Hayes, Owen III
"Measurement of the lambda-B Baryon lifetime in Z Decays" (Wu)
IT Consultant, Booz-Allen and Hamilton, Chicago IL

Jaczko, Gregory
"An effective theory of mesons and baryons" (Durand, L.)
AIP Congressional Fellowship, Washington DC

Lanier, Nicholas
"Electron Density Fluctuations and Transport in the Reversed Field Pinch" (Prager)
Postdoc, Los Alamos National Laboratory, Los Alamos, NM

Li, Adam
"Strain Effect on the Initial Stage of Heteroepitaxial Growth" (Lagally)
Postdoc, UCLA Electrical Engineering Dept., Los Angeles, CA

Mattingly, Sean
"Virtual Photon Structure at ZEUS" (Smith)
Research Associate, Fermilab, Batavia, IL

Peters, Dana
"Fast contrast-enhanced imaging with projection reconstruction" (DeLuca/Mistretta)
Postdoc Fellow, National Heart, Lung, and Blood Institute, Bethesda, MD

Wilson, Gregory
"NMR Relaxation Measurements of ^{129}Xe in Tissues and Blood: Toward Imaging of Laser- Polarized ^{129}Xe in Tissues" (DeLuca)
Postdoc Fellow, VAMC, Seattle, WA

Wodarczyk, Michael
"Measurement of the F_2 Structure Function of the Proton at HERA from 1996 and 1997 ZEUS Data" (Smith)
Yield Engineer, Intel Corp., Hillsboro, OR

Spring 2000

Fetter, Jonathan
"Resonant Active-Sterile Neutrino Conversion and r-process Nucleosynthesis in Supernovae" (Balantekin)

Radeztsky, Scott
"Dalitz Analysis of the Decay Ds $\rightarrow 3\pi$" (Halzen)
Research Associate, Fermilab, Batavia, IL

Steele, Joseph
"Inclusive Cross-Section of J/ψ Particles in the Forward Direction in $\bar{p}p$ Collisions at the square root of s=1.8 TeV" (Pondrom)
Postdoc, Physics Department, UW-Madison

Masters' degree recipients

Summer 1999

Kirakosian, Armen
Plumb, Andrew
Qian, Kun

Fall 1999

Papaioannou, Anastasios
Walters, Michael

Spring 2000

Apodaca, Emmanuel
Frazer, Bradley
Peck, John
Rugheimer, Paul
Smith, Christopher

UNDERGRADUATE NEWS & AWARDS

Yes — Physics Undergraduate Majors are alive and well here! As a matter a fact, fall 2000 marks the first time offering of the beginning of our new introductory course series for majors in Physics, Astronomy or AMEP: 247, 248, 249 — A Modern Introduction to Physics. This new sequence parallels the traditional UW-Madison courses Physics 207–208–241 or 201–202–244. While all three course sequences are good preparations for physics related degrees, students who are considering a major in a physics intensive field will be well served by the new sequence.

Physics 247 is the first new course in physics which is recommended over other introductory courses for physics and closely related majors. Why this change for majors? The physics department is seeking more rapid exposure to modern physics for potential Physics, Physics/Astronomy , and AMEP majors. In 247, modern concepts including special and general relativity are presented in the first semester. By the end of the first year, students will be familiar with enough quantum mechanics to discuss laser cooling of atoms and the fractional quantum Hall effect — both topics of recent Nobel Prizes in Physics — along with many other topics of current interest. Enrollment is limited to 30 students.

Hilldale undergraduate/ faculty research awards

Laurie Riley & Zachary Prager will be working with Professor Jim Lawler. Sara Knaack will be working with Professor Marshall Onellion. Jeffrey Snyder & Stephen Demski will conduct research with Professor Willy Haeberli, while Lucas Finco will work with Assistant Professor Mark Eriksson.

The L. R. Ingersoll Awards for distinguished achievement in undergraduate physics for Spring and Fall were awarded on May 5, 2000 at the Physics Majors Banquet and Awards Ceremony at the Fluno Center. Awardees included:

Spring 2000

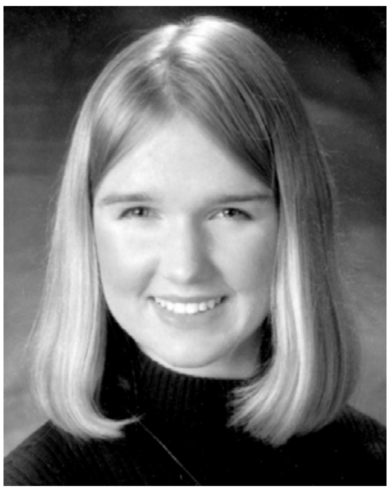
Andrew Vanderheyden (103–104)
Robert Kozlowski (201–202)
Bryan Landre (207–208)

Fall 1999

Nathan Rasmussen (103–104)
Gregory Michna (201–202)
Brian Yablon (207–208)

In addition, the 2000 **Albert Augustus Radtke Scholarship** for distinguished achievement in the study of undergraduate physics was awarded to **Nicholas Brezvar a**nd **Matt McGinley.**

The 2000 **Fay Ajzenberg-Selove Award** for outstanding undergraduate woman majoring in Physics, Astrophysics or Astronomy was awarded to an Astronomy Physics major, **Moire Prescott**. Moire was born in Minneapolis, but grew up here in Madison. Like many children, she dreamed of becoming either the president or an astronaut, but never had any idea where she was truly headed until high school. She found enjoyment in just about every subject she took, but she felt certain that for her career path she needed something special, something that would nearly blow her mind.



Moire Prescott

During her junior year at James Madison Memorial High School, she took an astronomy class taught by Art Camosy and was hooked. However, she was inspired to go beyond her amazement at it all and learn what was really going on. Astronomy and Astrophysics seemed even more appealing because they encompass so many other sciences — chemistry, geology, meteorology, and perhaps even biology.

Since then, astronomy and physics have been her main academic interests — it has been a challenging but invigorating ride! During her two years of undergraduate work, she has gotten her first taste of quantum mechanics, done research work with Assistant Professor Eric Wilcots in the Astronomy department and become increasingly aware of how much she loves teaching others about what she learns.

PEER MENTORING

Striving to Help all Students Succeed in Physics: The Physics Peer Mentor Tutor Program

The Physics Peer Mentor Tutor (PPMT) program significantly expanded during the 1999–2000 academic year, with an approximately 50% increase in student interest and enrollment. This is a highly structured program linking upper level undergraduate students as tutor/mentors in small study groups with students potentially at-risk for having trouble with or feeling isolated in their introductory physics course. The Physics PMT program was started in the Chemistry Learning Center and continues to be run in collaboration with a similar Chemistry PMT program. With recently obtained support from the College of Letters and Sciences, in supplement to that from Undergraduate At-Risk Initiatives Funds, the Physics PMT program has made a transition from a pilot program to one institutionalized within the Physics Department.

Goals of the Peer Mentor Tutor program are to provide a supportive academic environment for potentially at-risk students, while also creating a leadership role and teaching experience for undergraduate tutor/mentors. Another aim is to provide additional opportunities for the undergraduate tutors to interact with faculty members through meetings with course instructors. The Physics Peer Mentor Tutor program strives to complement and to contribute to the efforts of other campus retention programs and the University system's Plan 2008 program aimed at creating a supportive and welcoming environment for diverse groups of students.

Students enrolled in the Physics PMT program include those lacking in academic preparation, indicated by academic probation status, a low GPA, or poor math preparation. We strive to create an environment in which students can admit without shame if they are having trouble with the math in the course and have found that many of these students can quickly learn the math skills they need. Others in the program are students often feeling isolated at the University such as returning adults, first generation college students, and students of color. The small size and consistent membership of the tutoring groups facilitate students meeting one another and finding study partners. In addition, during the previous year, we noticed that students who joined the PMT program after doing poorly on their first exam often had not had a physics course in high school. Thus, this year we asked the teaching assistants to refer names to us of students who had no prior physics experience. Enrollment during the fall semester was about 60 Physics 103 students in the physics PMT program (out of a course enrollment of ~525) and during the spring semester was about 40 Physics 104 students (out of a course enrollment of ~475).

The Peer Mentor Tutors were junior and senior level undergraduate students who are chosen for their knowledge of physics and for their abilities to relate well to fellow students. The tutors had a diverse group of majors including physics, astronomy, engineering, and science education. During the fall 1999 semester, we had eight Physics PMTs. Two made a successful transition to working as Teaching Assistants in the Physics Department during the spring semester.

Students enrolled in the Peer Mentor Tutor program initially fill out a survey to aid in assessing the students' needs. They are placed in a group with a PMT and their progress is monitored throughout the semester. Each Peer Mentor Tutor meets twice a week with the same group of students. A major focus of these meetings is to involve the students in doing problems so as to enhance their confidence and to identify areas of confusion. The Peer Mentor Tutors also meet twice weekly as a group. One is a course-specific meeting used to overview the material being covered in the course, as well as strategies for teaching the material and problem solving techniques. The second is a meeting to discuss pedagogical, teaching, mentoring, and cultural issues.

Overall, student evaluation comments were positive regarding the role their Peer Mentor Tutor played in helping them to learn physics. Nearly all students who attended for an average of an hour per week over the course of the semester received a C or better in the course.

The PMT program provides both a rigorous teacher training program for the undergraduate tutors and a supportive learning environment for at-risk students. Future plans include expanding the support services of the Physics PMT program to provide small study group support for the off-semester Physics 103/104 course.

Dr. Susan Nossal is the coordinator of the Physics Peer Mentor Tutor program. She also works as an assistant scientist on research relating to atmospheric physics and spectroscopy.
nossal@wisp5.physics.wisc.edu / 608-262-9107

UNIVERSITY PHYSICAL SOCIETY

UPS: What have we been up to?

Hey all you crazy cats! Another fantastically exciting year here at the University of Wisconsin-Madison Physics Department has concluded. The University Physical Society (a.k.a. UPS, or the Physics Club) experienced an active year with participation in many events. This year, we were lucky enough to go to Chicago and get a tour of Fermilab. We got the chance to actually view the D0 detector from about a mile away. After our tour of Fermilab, we proceeded to shop in Chicago.

UPS also sponsored many social events this year. A good time was had by all at our first annual UPS racquetball tournament. Many showed up to participate, learn, and have fun whacking around racquet balls. We also had our bi-annual ice cream and pizza socials.

There have been a couple of new additions to the club room this year. We now have a small Linux server in 2321 Sterling for our members to use. We have also compiled a small library of fiction and non-fiction books for the club room.

As always, our doors are open to anyone interested in Physics. We continue to offer free physics tutoring at the times posted on our door during the semester. During the school year, club members meet with the colloquium speaker — every Friday at 3:30 P.M. — to discuss the issues and concerns our undergraduates have about physics and the physics community. Our discussions with the colloquium speakers typically provide us with insights not only on the colloquium's topic, but in other areas as well.

More recent info can be found at http://www.sit.wisc.edu/~ups. To finish, we leave you with a list of our new officers, and a piece of advice:

"Bureaucracy is a challenge to be conquered with a righteous attitude, a tolerance for stupidity, and a bulldozer when necessary."

Feel free to contact the new UPS officers:

Mark Chapman
machapma@students.wisc.edu (Pres.)

Hal Canary
hwcanary@students.wisc.edu

Caitlin Doran
crdoran@students.wisc.edu

Lucas Finco
lmfinco@students.wisc.edu

Jill Meyer
jmmeyer4@students.wisc.edu

Becca Pifer
rjpifer@students.wisc.edu

Suzy Reichel
suzy@ftmax.com

CAMPUS VIEW

New chancellor search ends — John Wiley to lead UW-Madison

John D. Wiley, provost and vice chancellor for academic affairs, UW Madison has been chosen as chancellor of the University of WisconsinMadison. The appointment will be effective Jan. 1. The UW System the Board of Regents announced Wiley's appointment following a closed meeting on Nov. 10, in Madison. Wiley will succeed David Ward, who has served as chancellor since 1993.

Wiley received his bachelor's degree in physics from Indiana University in 1964. From there, he immediately attended graduate school at the UW-Madison as an NSF Fellow. He received a master's degree in physics in 1965 and a Ph.D. in physics in 1968.

The other chancellor finalists were Nancy E. Cantor, provost and executive vice president for academic affairs at the University of Michigan, and Susan Westerberg Prager, provost and chief academic officer, Dartmouth College, Hanover, N.H.

Dean of students named

***Wisconsin Week*, May 17, 2000**

Alicia Fedelina Chavez of Miami University in Oxford, Ohio, has been named dean of students. Chavez, an assistant professor in Miami University's department of education leadership, replaces Mary Rouse, now an assistant vice chancellor in charge of strengthening and expanding programs that connect classroom and service learning. Chavez is a native of Taos, New Mexico, with a Hispanic and Native American background. Chavez has a long history of working in higher education. She brings to us extensive experience in student affairs, business affairs, diversity issues and academic research, both in student affairs practices and higher education.

Sanders to chair ASEC

Wilt Sanders, scientist in Physics and Atmospheric & Oceanic Sciences, has been named as new Chair of the Academic Staff Executive Committee. This committee, made up of nine elected academic staff members acts in parallel to the University Committee in matters of academic staff shared governance issues at the campus level. Jean Buehlman, Physics, was elected to this governing board beginning July 1, 2000. Esther Olson, SRC, has served on the ASEC board for several years and is well known for her representation of ASPRO, the academic staff lobbying arm.

WEST has arrived

A new national organization, Women Entrepreneurs in Science and Technology, has been created by three Wisconsin Physics and Astronomy women alumna; Jiahong Juda (Ph.D. 1992, Space Physics), Paula Wamsley (Ph.D. 1994, Solid State Physics) and Barbara Whitney (Ph.D. 1989, Astronomy). The goal of this new organization is to lower the barriers for scientists to participate in entrepreneurship/intrapreneurship opportunities and to enable them to use an entrepreneurial approach in career development.

WEST has come to U.W. Madison to begin a pilot program which would make career planning an active part of the informal academic life of physics and astronomy graduate students. In addition they are considering starting an off campus professional pilot program in Boston.

(Editor's note: Plan to hear a lot more about WEST in the future! The opportunity they are bringing to the department is indeed an exceptional one.)

STAFF NEWS

Kristine Soukup joined the department as the new payroll and benefits coordinator in the Department Office on October 25, 1999. She is replacing **Carla Schmidt**.

Kay Shatrawka, secretary of the Plasma Office retired in May. Her current replacement is **Linda Jones** who transferred from Human Ecology.

Sue Hessen joined the Department as secretary in the Atomic/Solid State Office.

Jesse Prochaska, financial specialist, recently left the department for a "trainee" position with the State of Wisconsin.

Rick Williams, electronics shop supervisor, returned to the Astronomy Department.

FUND RAISING

THANK YOU TO ALL WONDERFUL SUPPORTERS

The Department has received a $50,000 gift from the Liebenberg family for use towards scholarships for juniors and seniors. Many thank you's! Your generosity will enable the Physics Department to award one or more fellowships for undergraduate summer research in the Department. Candidates can be Physics, AMEP, or Astronomy-Physics majors. The selection will be based on proposals from the students and their academic records. Selection will be made by the Coordinator of Undergraduate Programs and the Chair of the Undergraduate Awards Committee.

And a big "THANK YOU" to all 92 donors who provided our Department of Physics General Fund with a total of $18,004 during the period of July 1, 1999 through June 30, 2000. We greatly appreciate your generosity! Your donations have resulted in our ability to recruit 50 outstanding graduate students from around the world to join our department in the Fall 2000 semester. We also wish to thank those of you who made use of industry matching programs — doubling many donations.

And, last but certainly not least, an ongoing thank you to Jeff and Lily Chen and to the estate of Ray and Anne Herb for the funding of Wisconsin Distinguished Graduate Fellowships. These fellowships are funded at $500,000 and then matched by funds from the Graduate School. The interest from these funds provide full fellowships for new graduate students.

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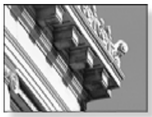

ALUMNI CORNER

Mark Diestler, B.S., 1983 is currently an engineer/technician at Brimroe Corporation of America in Baltimore, MD. They manufacture acousto-optics, lasers, fibers. He volunteered to be in the physics alumni data base. His best advice to graduate students: Be aware of departmental politics (maybe not at UW, but elsewhere) and don't stretch yourself too thin. Thanks, Mark!

Theodore J. Allen, B.S. in AMEP, 1982 (Ph.D. CIT), has accepted a tenure track job at Hobart & William Smith Colleges. That's his second tenure track offer in two years. He says they'll be one of the only liberal arts colleges in the country with a high energy physics bias, as two of three members are HEP theorists.

Ralph Muehleisen, B.S., 1990 (Ph.D. elsewhere) is currently an Assistant Professor of Civil, Environmental and Architectural Engineering at the University of Colorado. He resides in Boulder.

Sally Laurent-Muehleisen, B.S., 1989 (Ph.D. elsewhere) is currently a Postdoc in the Physics Department at the University of California, Davis but is living in Colorado and telecommuting from home.

John Jacobsen, Ph.D., 1996 got his Ph.D. on the AMANDA project with Professor Halzen. After a postdoc and two trips to the South Pole, Jacobsen is now working half time as a physicist/ software engineer in the neutrino astrophysics group at Lawrence Berkeley National Lab, and works the rest of the time on his art work. Since going half time, he has exhibited several times around the San Francisco Bay Area, and also continues to display his paintings on the Web at www.johnj.com. Although his current situation is a good one, he is nostalgic for Madison, his home town.

John H. Rickert, B.S., Astronomy/Physics & Math, 1984 is an Associate Professor of Mathematics, Rose-Hulman Institute of Technology, Terre Haute, Indiana. He received his Ph.D. in Math in 1990 at the University of Michigan. In 1999 he received a Polya award from the MAA recognizing expository articles published in the College Mathematics Journal for an article co-authored with a Rose-Hulman colleague.

Christopher J. Stolz, B.S. in AMEP, 1986 wrote to Jim Lawler that he was in a graduate optics class in 1985 taught by Dr. Miller and Prof. Lawler when he was an associate professor. Chris works in the Laser Materials and Technology Group for the Inertial Confinement Fusion program at Lawrence Livermore National Lab. He directs optical fabrication and coating vendors in developing advanced manufacturing processes for producing optics that tolerate high laser fluences for the National Ignition Facility. He just wanted Professor Lawler to know how important his optics class turned out to be in his career path.

Robert Leach, Ph.D., 1972, from Minneapolis, Minnesota has joined the Physics database. He can be reached at rleach@minn.net.

Matt Devlin, M.S., 1989 is now a staff member at Los Alamos National Lab, working on nuclear physics and the structure at the Los Alamos Neutron Science Center.

Robert Eugene Warren, Ph.D., 1947 passed away on June 20, 1999. He was in the nuclear physics area. In World War II, he commanded the radio company of a signal armored battalion, then served in the Radio Countermeasures Detachment of 12th U.S. Army Group in Europe. Recalled to the Army during the Korean War, he served with the Electronic Warfare Center in New Jersey and the Atomic Energy Commission in Washington, D.C. In 1959, he was assigned to NASA, where he was involved in the development of communication satellites: Echo, Telstar, Relay and Syncom. Retiring from the Army in 1966, he worked for industry and led a group of systems analysts at General Westmoreland's headquarters in Saigon.

Jim Sorenson, M.S., 1964 wrote to suggest we include some information about things that happened 25 and 50 years ago. He thinks readers would enjoy it! (I'll see what I can find!)

Jim is an Emeritus Professor of Medical Physics.

Arthur Hundhausen, Ph.D., 1965 a senior scientist emeritus at the High Altitude Observatory of the National Center for Atmospheric Research, has received the National Academy of Sciences 1999 Arctowski Medal. The award supports research in solar physics and solar-terrestrial relationships. Hundhausen lives in Boulder, Colorado.

Ron Kelley, Ph.D., 1994 wrote to us when he found our web page. He asks to be included in the alumni data base. He works in the Advanced Product Technology Center of Motorola at Plantation, Florida.

Jay Davis, Ph.D., 1969 is the Director of the Defense Threat Reduction Agency in Arlington, Virginia. He says, "I never imagined while at Madison having a career that would include facility and organization building, arms control technologies and inspectors, and immersion in the geosciences and biosciences. The Wisconsin training in team spirit and work and in a confident approach to problems turned out to be more singular than I would have imagined. My debt to UW is great, as is my appreciation for its lessons. He advises graduate students to take any two courses in business and psychology. Learn the vocabulary if nothing else. You'll be astonished how often this will help and how powerful it will be when you need it! He also says he's still enjoying memories of the Centennial celebration (fall 1999).

Cahit Erkal, Ph.D., 1986 is employed at the University of Tennessee at Martin, Tennessee. His advice to grad students: diversify your course work, find a research area that will be popular/funded in the future. He's joining the alumni network.

UW-Madison physics alum named as IBM fellow

Dr. Carl Anderson, a 48 year old native of Columbia, Missouri, was one of three recipients of IBM's 2000 top technical honor — the IBM Fellow. Anderson received his Ph.D. from the University of Wisconsin, Madison in 1979 under Professor Wilmer Anderson.

Anderson's work at IBM focuses on processors, or the hardware that supplies computer intelligence. Working out of a lab in Austin, Texas (the IBM Enterprise Systems Group), Anderson has developed processor technologies that are behind many of IBM's machines, including mainframe and mid-range computers, as well as supercomputers.

Working as IBM's leading high-frequency microprocessor designer for over the past eight years, he has spearheaded a new approach to designing high-performance server microprocessors, resulting in both increased performance and dramatically reduced development costs. His most notable recent achievements included leading the design of the "Alliance" family of server microprocessors — which enabled the System/390 G5 product to have a significant performance advantage over the competition when it was introduced in 1998 — and the Power4 Gigaprocessor, which will give future IBM AS/400, RS/6000 and SP computer systems blazing clock speeds of greater than 1,000 megahertz. His management philosophy of concurrently optimizing the circuit design, chip integration, silicon technology and design tools — while also training and mentoring design teams — has led to very high chip performance as well as a much shorter development cycle.

The IBM Fellows program was founded in 1962 by Thomas J. Watson, Jr., as a way to promote creativity among the company's "most exceptional" technical professionals. The program goes back to Thomas J. Watson Jr., a former IBM chief executive. Legend has it that he was visiting a company lab when he spotted an interesting project by a researcher. Watson learned that the scientist was working on the project at home because he did not have time at work. So the Fellows program was begun to free the company's best minds from daily chores. The first appointments were made in 1963. Requirements are stringent, and only the most significant technical achievements are recognized. In addition to a history of accomplishments, candidates must show strong potential to make continued contributions to the business and to the industry. IBM Fellows are given broad latitude to identify and pursue projects in their area of expertise to advance IBM's technological leadership.

Since the program's launch, 158 IBM Fellows have been appointed; 49 are still active employees. Included among the IBM Fellows are five Nobel Laureates. Four of the IBM fellows are also in the National Inventors Hall of Fame.

TALK TO US

Address correction and alumni news

Please use this form if you are writing to us hard copy. We are more than happy to hear your news and publish it in next year's issue of *The Wisconsin Physicist*. This is also the way to update your address. Send this hard copy to:

Jean Buehlman
Department of Physics
University of Wisconsin-Madison
1150 University Avenue
Madison, WI 53706

or E-mail to: *buehlman@facstaff.wisc.edu*

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Name: ____________________

UW-Madison Degree(s) and Year(s): ____________________

Employment: ____________________

Home Address: ____________________

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City, State and Zip ____________________

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Work Address: ____________________

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City, State and Zip ____________________

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My E-mail address is: ____________________

____

- I would be willing to be a part of an informal informational Physics network in my area for Physics graduates.
  ❐ yes ❐ no
- Do you have access to the World Wide Web?
  ❐ yes ❐ no
- Have you found us on the World Wide Web at: http://www.physics.wisc.edu/ ? ❐ yes ❐ no
- I would be interested in being included in a UW-Physics alumni database available on WWW.
  ❐ yes ❐ no
- Contact me about linking my WWW home page to the Physics Dept. homepage. ❐ yes ❐ no

Feel free to include the following information in the next issue of "Alumni News:"

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Tell us more

Survey question:

Would it be useful for physics graduate students to learn some formal business skills as part of their education?

If so, what skills?

____

Important Web Addresses:

For admissions materials, general UW information: ***www.wisc.edu***

For information on Physics Majors, Graduate Program: ***www.physics.wisc.edu***

THE WISCONSIN PHYSICIST
University of Wisconsin-Madison
Department of Physics
Vol. 7, No. 1, Fall 2000-2001

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