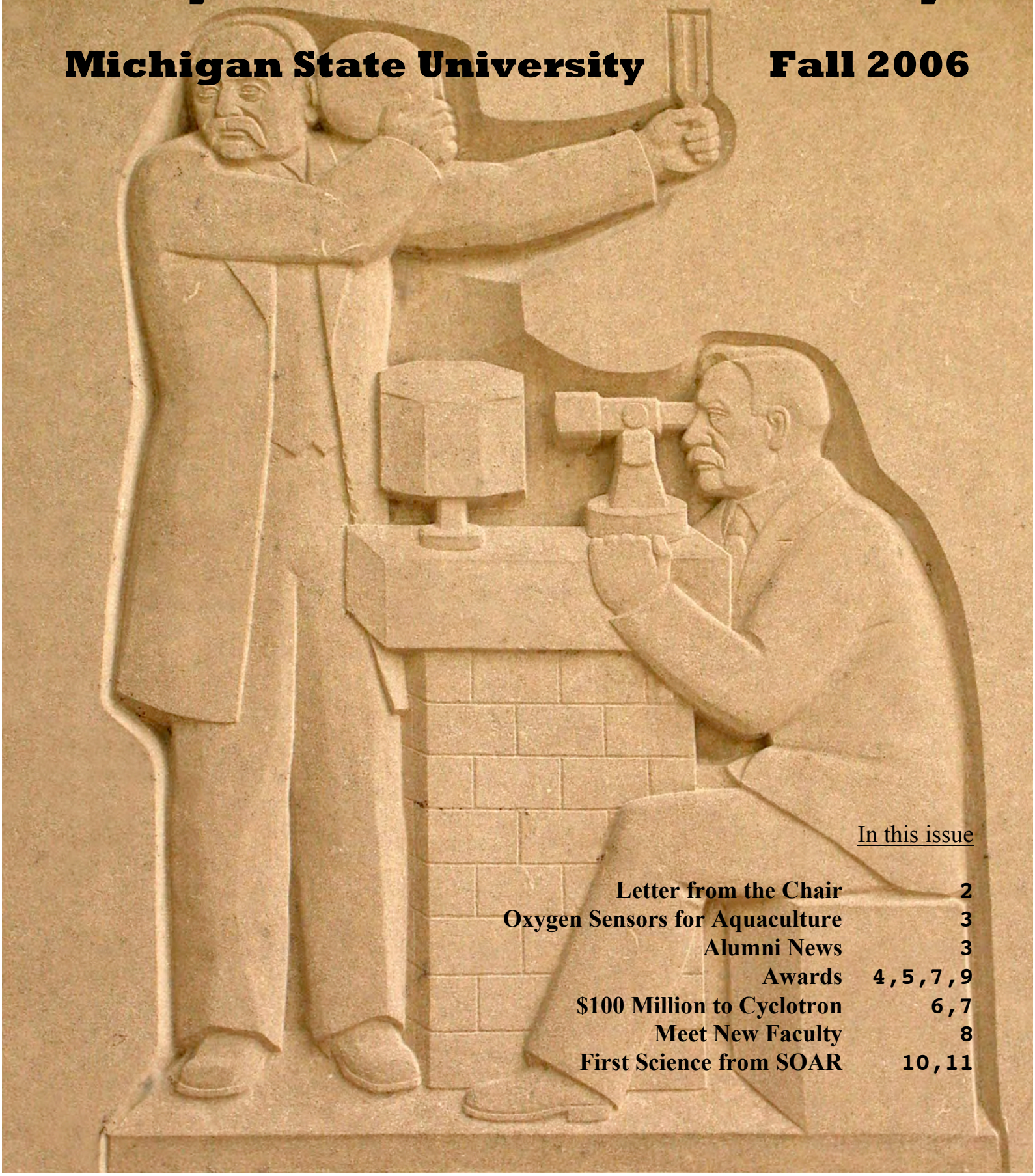
Physics and Astronomy

Michigan State University Fall 2006



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Newsletter
MSU Physics and Astronomy Department

Volume 8
Fall 2006

A Letter from the Chair

Dear Friends of the Department of Physics and Astronomy,

During the past year we have added three new members to our faculty. Reinhard Schwienhorst, a German citizen, was hired into our experimental particle physics group and is expected to play a major leadership role as we slowly move our main research emphasis in experimental particle physics from the Tevatron at Fermilab to the LHC at CERN, which is scheduled to start operating late next year. Alexandra Gade is also a German citizen and works in experimental nuclear physics at the NSCL. The third faculty hire is Michael Moore (no, not the filmmaker ☺). Michael is a theorist in atomic physics.

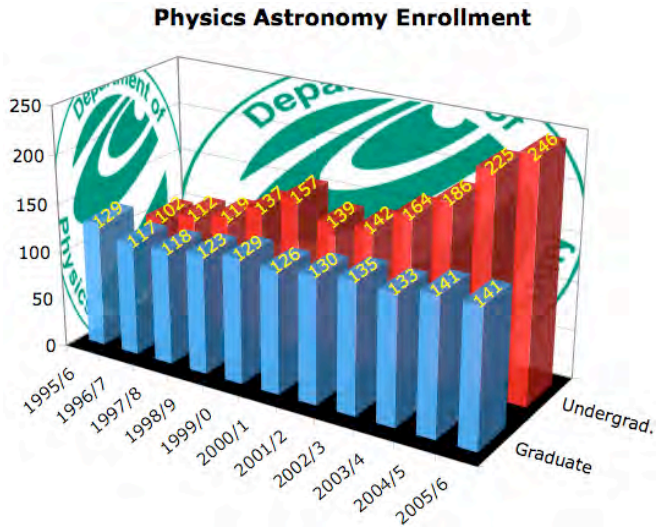
We also lost two of our distinguished particle physicists to retirement. Wu-Ki Tung, the long-time leader of our CTEQ effort, has moved to Seattle to spend more time with his grandchildren. Harry Weerts, one of the leaders of our experimental particle physics group, also retired, but then accepted a new position as the head of particle physics at Argonne National Laboratory.

For many years the Department of Physics and Astronomy has been one of the most productive generators of student credit hours in the entire university. The combined annual enrollment in all physics/astronomy classes has almost reached 10,000. We emphasize excellence in teaching; Megan Donahue and Mark Voit, have won college teaching awards this past year.

Our graduate program has been one of the largest in the country for quite some time, and the more than 140 graduate students that are presently enrolled are the maximum number that we can support with the resources of our department. Most gratifying is the strong growth that we have experienced in the number of undergraduate physics and astronomy majors. During the last decade this number has increased by almost 150%! (see the figure in the right column).

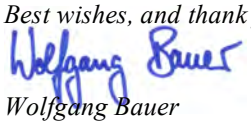
Dr. Wolfgang Bauer, Chairperson
Dr. Daniel R. Stump, Undergraduate Program Director
Dr. S.D. Mahanti, Graduate Program Director
Dr. Jack Baldwin, Associate Chair, Astronomy

There are numerous national and international faculty awards to report on. These are also indicators for the outstanding reputation that our department enjoys. Examples include Thomas Glasmacher, who won the Sackler Award, and Gary Westfall, who received an Alexander von Humboldt Senior Distinguished Scientist Award. Three of our faculty members were elected Fellow of the American Physical Society, Simon Billinge, Georg Bollen, and Phil Duxbury. Tim Beers, Simon Billinge, and Jack Bass all have won Distinguished Faculty Awards this year.



The federal funding to support our faculty's research continues to grow, despite the very constrained federal funding climate. The $100 Million five-year NSF award for the operation of the cyclotron lab stands out, of course. But there are numerous other examples of strong funding in all of our interest groups. One example: Prof. Ruby Ghosh received funding from the "Michigan 21st Century Jobs Fund" to commercialize a real-time optical oxygen sensor for fisheries applications, showing that even the most basic physics research sometimes can have amazing practical applications.

Best wishes, and thank you for your support



Wolfgang Bauer
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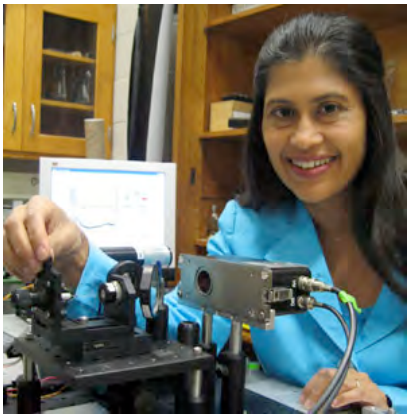
Ruby Ghosh Leads Team to Commercialize Oxygen Sensors for Aquaculture Industry



Ruby Ghosh was awarded $914,000 by the Michigan 21st Century Jobs Fund to lead an interdisciplinary team to develop oxygen sensors for the aquaculture industry. The purpose of the fund is to foster innovative ideas that have the potential to create high-tech jobs in Michigan. The competition was fierce, as only 12% of the proposals were funded. (See www.michigan.org/medc/ttc/21stCentury/)

In addition to Ruby (left), who is the project manager, the effort will involve Harry Westers and Chris Weeks of Aquaculture Bioengineering Corporation of Jackson MI who design aquaculture facilities. Harry Westers served 25 years as chief of hatcheries for the state of Michigan. TauTheta Instruments, who specialize in production of optically based fluorescence sensors, would open an office in the MSU Corporate Research Park. Greg Baker from Chemistry and Per Askeland from the Composite Materials & Structures Center are also participating in the proposal. Prototypes of the devices will be built and tested in Ruby's lab. Ruby and Greg Baker already have two patents on the oxygen sensing films.

Aquaculture is the fastest growing sector of the world-wide agriculture industry. As the fish are raised in a high-density environment (see photo below), maintaining a consistent level of oxygen 24/7 is essential to avoid catastrophic events. Michigan is the perfect testing ground for the sensor – if they can withstand Michigan's climate, the sensors can operate anywhere.

The team will develop a real time fiber optic DO sensor system that is superior to current monitoring equipment in terms of accuracy, reliability and cost. The sensor is based on the $^3O_2$ quenching of the red emission from hexanuclear molybdenum chloride clusters immobilized in a porous sol-gel matrix.

(See http://www.pa.msu.edu/people/ghosh/).

Oxygen levels must be carefully monitored in the dense environment common in hatcheries, such as this photo taken from the Oden State Hatchery outside Petoskey, Michigan.

MSU Physics and Astronomy Department

NEWS --- NEWS --- NEWS *Alumni* -- NEWS

We have received some news and visits from alumni, and encourage more of you to do so. **Bao-An Li** (Ph.D. '91) has accepted a position as Chair of the Department of Physics at Texas A&M at Commerce. **Bill Hurja** (BS '65) visited the Department in May (see picture on the right). **Philip Zecher** (PhD '96) has recently joined, EQA Partners, LP, a Connecticut based hedge fund manager, as Partner and Chief Risk Officer. He will also serve as the director of EQA Partners' Research Institute and external advisory board. **Ron Sager** (BS '69) has accepted an invitation to join the College of Natural Science Dean's Board of Advisers. Please send email to chair@pa.msu.edu to report alumni news.

Physics Teaching

When Professor Jim Linnemann decided to revamp the introductory lab exercise for his calculus-based introductory physics class, he was looking for an existing data set, which would allow students to learn the graphing and spreadsheet tools and statistical concepts used in the rest of the course. He found that data set he was looking for in his car's glove box: the mileage log he'd kept since he bought his 2002 gas-electric hybrid car. Students learn spreadsheet techniques by calculating miles per gallon from the raw data. They plot the mpg as a function of time to see the summer/winter variations, and learn least-squares techniques by fitting that data with polynomials or cosine functions. They meet the concept of systematic error by comparing the dashboard readout of mpg with the values calculated from the odometer readings and gallons pumped, and trying to understand how tire inflation, highway vs. city driving, odometer calibration, or the accuracy of the gas pump metering might affect the difference. Student feedback has been positive. "It's fun to teach both physics analysis techniques and show them the potential for transportation with a smaller environmental footprint," Linnemann said. "But my favorite student comment was one who said I should get more realistic data: they couldn't believe a real car regularly averaged more than 40 miles per gallon."

Gary Westfall Receives Humboldt Prize

The German Alexander von Humboldt Foundation announced in October that Prof. Gary Westfall will receive the prestigious "Forschungspreis", the senior distinguished scientist award. This is Gary's second major award in the last few years as he was named University Distinguished Professor in 2004. The prize is valued at up to 75,000 euro and will enable Gary to spend a research year at the University of Frankfurt, where he will collaborate on experimental high-energy heavy ion collisions with Joachim Stroth.

The Forschungspreis is awarded annually to a maximum of 100 scientists of all disciplines world-wide. Gary is the 7th MSU physicist and 13th MSU faculty member overall in the history of Humboldt Foundation, which was established in 1953, to receive this award. The past MSU-PA receipients of the award are Tom Kaplan in 1981, Walter Benenson in 1989, Alex Brown in 1991, Konrad Gelbke in 1993, Wolfgang Bauer in 2000, and David Tomanek in 2006. In addition, Brage Golding received this prestigious award before joining the MSU faculty.

Professors Bass, Beers, Billinge, Donahue, and Voit win CNS faculty awards

A record five PA faculty members received awards at the annual College of Natural Science awards ceremony. Megan Donahue (center) and Mark Voit(left) won the CNS Teacher-Scholar award. Tim Beers (second from left) and Simon Billinge (second from right) won the CNS Distinguished Faculty award, and Jack Bass (right) won the Meritorious Faculty award.

CNS Teacher Scholar Awards

Megan Donahue is co-author of the country's most widely used introductory astronomy textbooks, and won a departmental teaching award last year for her work in the ISP course "Visions of the Universe" where she brought infrared clicker technology into the classrooms in the BPS Building. In addition, Megan effectively communicates her research results to the general public, and recently authored a cover article in the country's most prestigious popular astronomy magazine and was nominated for an AIP Science Writing Award.

Megan is a leader in measuring distant galaxy clusters, and was a key player in the discovery of some of the major new evidence showing that the total mass content of the universe is not enough to halt its expansion. This led to the conclusion that most of the universe consists of dark energy. Her stature is attested by her membership on numerous national scientific committees.

Mark Voit has been an enthusiastic and highly popular teacher at the introductory astronomy level and was awarded the 2005 Lorena V. Blinn Endowed Teaching Award from the College of Natural Science. He is co-author of one of the country's most-popular introductory astronomy textbooks. In his previous position at the Hubble Space Telescope Science Institute, Mark gained broad experience in public outreach activities that have prepared him well for the transition into a career at MSU. His knack for explaining complicated physics issues in a very clear manner makes him the sort of theorist every observational astronomer likes to have nearby.

Mark's research has led to important discoveries about the mass-energy content of the Universe and the nature of the evolution of galaxies and galaxy clusters. He has authored a number of high-impact papers including a widely-read and quoted review paper.

CNS Distinguished Faculty Awards

Tim Beers is the world-wide leader in the search for the oldest and most chemically primitive stars in the galaxy and the universe. His efforts have led to the identification of more than 2,000 stars with metal abundances less than one percent of the solar value. These stars are providing astronomers and physicists with their best records of the chemical composition of the universe from the time of their formation some 13.5 billion years ago and of the origin and evolution of the chemical elements. Tim is a co-discoverer of the two most primitive "still shining" stars known and was named 2003 Michigan Scientist of the Year by Impression 5 Science Center. He is also a co-investigator in the $10 million Joint Institute for Nuclear Astrophysics Physics Frontier Center and spearheads its involvement in the Sloan Digital Sky Survey.

Tim has proven to be a highly effective instructor at both the graduate and undergraduate levels. He has helped develop a planetarium-based laboratory of the Integrative Studies Program. He is a popular public speaker and has used his talent to communicate the excitement of scientific discovery to audiences from the K-12 system, local business groups and MSU alumni. He is a long-time contributor to the Michigan Science Olympiad and the Math, Science and Technology summer program for young and gifted middle school children.

Simon J.L. Billinge's research involves using sophisticated X-ray and neutron diffraction techniques to study local structure property relationships in a large class of complex solid-state systems. He has made seminal contributions in the area of high temperature superconductors and colossal magneto resistance - two of the most important areas of interest in condensed matter physics during the last 15 years. In the past several years, Simon is a world leader in the "nanostructure problem" and has applied total scattering methods combined with computer simulations to solve fundamental problems in both nano- and bio-technology. Simon was awarded the Sloan Research Fellowship by Alfred P. Sloan Foundation for his promise as an outstanding research contributions and and now serves on a number of national and international committees, and organized several workshops and conferences.

As a teacher, Simon's enthusiasm, easy-going demeanor, and love for teaching are visible to every student. He was awarded the Thomas H. Osgood Undergraduate Teaching Award for his excellence in teaching and has mentored innumerable research associates and graduate students. He has also been extremely active in introducing the concept of nanotechnology in the K-12 community.

From right to left: Dean Leroi, Jack Bass, CNSAA President Peggy Bull, and Wolfgang Bauer

Meritorious Faculty Award

Jack Bass received his B.S. from the California Institute of Technology and his Ph.D. from the University of Illinois, Champaign-Urbana. He joined the MSU Department of Physics as an assistant professor in 1964. He is an internationally recognized expert in the study of electron transport in metals. More recently, his research has emphasized transport in multilayered metallic systems containing ferromagnets which are of direct relevance to future directions in magnetic-memory storage in computers. He has published more than 175 papers in refereed journals and has had continuous grant support from external sources since 1966. The importance of his research is not just recognized by his peers and federal funding agencies, but also by high-tech industry. A fellow of the American Physical Society and serves as chairman of the APS' Topical Group on Magnetism and It's Applications and as chairman of the Instrument Advisory Team of Spallation Neutron Source at the Oak Ridge National Lab.

Jack has supervised 17 Ph.D. awardees and has taught a range of undergraduate and graduate courses where he became known as a tough yet fair teacher. As the Chairperson of the PA Department from 1983 to 1988, he hired 19 faculty members and left his mark on the entire university. He received the MSU Distinguished Faculty Award in 1994.

Three PA Professors Named APS Fellows

Georg Bollen, Phil Duxbury and Simon Billinge were named Fellows of the American Physical Society. Georg was cited for his unique designs of traps for radioactive nuclei, which have allowed high precision mass measurements of particles which decay on the millisecond scale. Among many areas of expertise, Phil is especially well known for developing numerical methods for investigating the onset of long-range structure in phase transitions and, more recently, in biological applications of physics techniques. Simon's research is described in the earlier write-up describing his Distinguished Faculty Award.

Development:

While in the San Diego area, Wolfgang Bauer welcomed Richard and Patricia Wagner to the Kedzie Society in recognition of their endowment bequest package intended to sponsor a concerted program for innovative interdisciplinary research beyond the usual realms of physics, and also an endowment to foster career-track interest in experimental physics for undergraduate women.

NSCL OPERATIONS FUNDED FOR FIVE YEARS AND $100 MILLION

From left to right: MSU Trustee Melanie Foster, Congressmen Vernon Ehlers and Mike Rogers, MSU President Lou Anna K. Simon, NSF Director Arden Bement, NSCL Director Konrad Gelbke, US Senator Carl Levin, MSU Vice President for Research and Graduate Studies Ian Gray. (Photo credit: NSCL)

The National Science Foundation (NSF) has awarded the National Superconducting Cyclotron Laboratory at MSU more than $100 million to fund operations through 2011, highlighting the lab's status as a world-leading nuclear science facility. The funding guarantees the future for lab which has nearly 300 local employees and a history of applied entrepreneurial projects.

Arden Bement, director of NSF, U.S. Represenatives Mike Rogers and Vernon Ehlers, and Senator Carl Levin visited MSU in November to celebrate the grant renewal. "Renewal of our five-year operating grant is good news for our user community, which includes some 700 researchers from 100 institutions in 35 countries," said Konrad Gelbke, cyclotron lab director and University Distinguished Professor. "The laboratory remains an important node in the international physics network, and we look forward to further expanding our cutting-edge research program and helping to shape the future direction of nuclear science."

"Scientists and engineers of NSCL, with their partners, are transforming knowledge about the properties of atomic nuclei into remarkable innovations," said Bement. "In the process, they are providing valuable hands-on research experiences for students that train them to become the next generation of skilled researchers, able to operate in a world in which partnerships in innovation are highly valued."

Established in 1963, the cyclotron laboratory is the nation's largest nuclear science facility on a university campus. The laboratory faculty and users train about 10 percent of the nation's nuclear science doctoral students, even though the facility's budget represents just 5 percent of the annual U.S. spending on this kind of research. Currently, the laboratory operates the world's most advanced rare isotope research facility, the Coupled Cyclotron Facility where ultrafast beams of stable isotopes are broken up and separated into beams of rare isotopes which are then studied for their reactions and structure. These reactions, some of which take place in stars and exploding stellar environments such as novae and supernovae, continue to produce many of the atoms that make up human beings and indeed most of the observable world.The staff also is developing plans for a next generation laboratory - the working name for the planned facility is the Isotope Science Facility - on the MSU campus.

Graduate student Jill Pinter discusses her research on magnetic moment measurements with NSF Director Arden Bement during an afternoon poster session.The NSCL helps educate 10 percent of the nation's nuclear nuclear science Ph.D., and NSCL students complete their doctorates 1.5 years faster than the national average for nuclear science Ph.D. students. (Photo credit: NSCL)

"We take pride in being recognized as a national and international leader in rare isotope physics," said President Lou Anna K. Simon. "The work of NSCL has long been an essential part of MSU's science portfolio, one that attracts top researchers and scientists from around the world to Michigan State and can yield innovations that spawn new businesses to benefit both Michigan and the world."

"We will continue to support a broad program of applied, technology-focused projects, some of which will have commercial potential and create knowledge economy jobs," said Gelbke. "But we remain most energized by our core mission: exploring the unknown in basic nuclear science and the origins of elements in the cosmos."

The funding decision, made after a detailed review of the laboratory by a panel of NSF-appointed experts, enables the NSCL to build on its recent momentum. In March, U.S. News & World Report ranked MSU's graduate program in nuclear physics second nationally behind MIT, based on a survey of academic department heads and directors of graduate studies at peer institutions.

Thomas Glasmacher Honored with Sackler Prize

Thomas Glasmacher is one of two physical scientists selected from an international pool of researchers to receive the prize this year, earning recognition for the development of new, and ultra-sensitive techniques to study nuclear structure.

Each year the Raymond and Beverly Sackler Prize in the Physical Sciences recognizes young scientists, those 40 years old and under, conducting original research that has made a significant contribution to their field. The prize is administered by Tel Aviv University, and each recipient receives $20,000. “The Sackler Prize is distinctive in part because it is given to people who are young – and they are the future,” said Naftali Auerbach, professor of theoretical nuclear physics at Tel Aviv University.

Thomas received his doctorate from Florida State University where he was a Fulbright Scholar, then joined the cyclotron laboratory as a research associate in 1992 and became a faculty member in 1995. He has since been recognized as an APS Fellow, an MSU Lilly Endowment Teaching Fellow and a NSF Faculty Early Career Development Award recipient.

It is a great honor to be recognized in this worldwide competition,” said Thomas. “Today, experimental nuclear physics is a collaborative between aspiring and established scientists. This recognition, however, should really go to the high-performance team of undergraduate students, graduate students and postdocs who implement these successful experiments.” Thomas has directed more than 30 undergraduate students on various projects at the laboratory.

Simon Billinge will go to the Big DANSE

MSU Physics professor, Simon Billinge, will lead the diffraction sub-group of the DANSE (Distributed Data Analysis for Neutron Scattering Experiments) project to develop the next generation of computer programs to study complex materials using neutron scattering. The software developments will leverage results coming from the powerful new Spallation Neutron Source (SNS) under construction at Oak Ridge National Laboratory in Tennessee.

Materials researchers such as Prof. Billinge will take samples, prepared in their laboratories, to the SNS to characterize them using the intense neutron beams. The unprecedented power and size of this new source mean that interesting samples with complex structures can be studied that were beyond the capabilities of current generation sources. The source will produce many gigabytes of data each day of operation. Current data analysis software is inadequate to meet these new challenges, and the DANSE collaboration was formed to address this need. NSF has

recognized the scientific vision and expertise of the DANSE team, a multiple institution effort including Caltech, Iowa State, U. Maryland and U. Tennessee as well as MSU, by awarding $12M over 5 years. The software developments will marry modern advanced computing and software engineering methods with basic science goals in physics, chemistry and biology related to neutron scattering and will result in novel scientific results in areas as diverse as energy storage and conversion, earth science, electronics, structural materials and medicine.

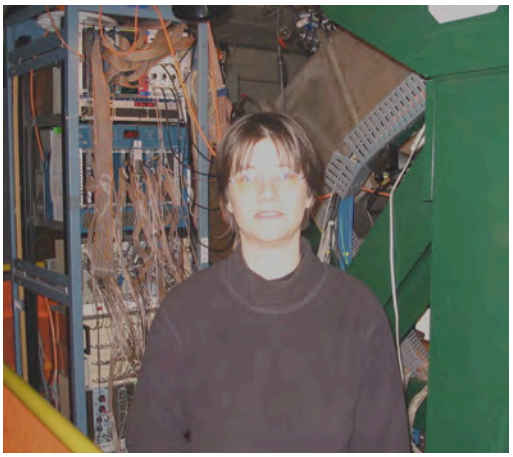
PA Welcomes Three New Faculty

Michael Moore

Michael joined the faculty this Fall as an AMO theorist specializing in quantum optics, quantum degenerate gases, and quantum information. He began his research career as an undergraduate at the University of Delaware, studying quantum chaos in ion traps. In graduate studies, he switched to the emerging field of trapping and cooling neutral atoms, earning his Ph.D. at the University of Arizona, where he concentrated his studies on the concept of the atom-laser, and the interaction between coherent laser light and Bose-Einstein condensates. This work earned a finalist selection in the DAMOP thesis prize competition. After graduation, he stayed at Arizona briefly, pioneering the study of nonlinear optical effects in systems of fermionic ultracold atoms. He then worked as a postdoc at the Institute for Theoretical Atomic and Molecular Physics (ITAMP) at the Harvard-Smithsonian Center for Astrophysics, switching focus to atom-molecule conversion in quantum degenerate systems, and the role of confined geometries on atom-atom interactions. The latter work being applied to experiments using recently developed magnetic waveguides for transport of ultracold atomic matter-waves. In 2003 Michael joined the faculty at Ohio and began studying new approaches to quantum information processing using single-atom qubits coupled only by light. Current research interests additionally include quantum-limited precision measurement, matter-wave amplification and super-radiance, and modeling atom-molecule conversion in quantum degenerate systems.

Reinhard Schwienhorst

Reinhard joined the faculty as an experimental high energy physicist in August. He started his career as an atomic physicist, getting his Diplom in theoretical atomic physics in Münster, Germany, then shifting to high-energy experiment where he earned his Ph.D. at the University of Minnesota working on the DONUT experiment that discovered the elusive tau neutrino. After receiving his Ph.D., Reinhard again shifted his focus, this time to collider physics working at the DØ experiment at Fermilab as a MSU postdoc. He worked on an elaborate trigger system, which selects the few interesting events out of the large sea of all proton-antiproton collisions (~1,000,000/s). Later, Reinhard led a team looking for a rare production mode of the top quark, which so far has only been observed through strong interaction channels, which always leads to top-antitop pairs. But the top quark also has weak interactions, and Reinhard hopes to learn more about both the top quark and the electroweak interaction itself by studying this channel. Electroweak production is much lower than that from the strong interaction, making this one of the most challenging analyses at the Tevatron. Reinhard also plans similar analyses for the ATLAS detector at the LHC, which should be noticeably easier due to increased production rates. Reinhard never forgot his roots in theoretical physics, and jumped at an opportunity to work with MSU theorist C.-P. Yuan. Their collaboration to explore rare interactions of the top quark has already produced two papers.



Alexandra Gade

Alexandra began her joint NSCL/PA joint appointment in the Spring, after spending two years as an NSCL faculty appointment. After earning both her Diplom and Ph.D. from the University of Cologne in Germany, she came to MSU to work as a post-doc with Thomas Glasmacher. Alexandra's research centers on using nuclear reactions to unlock the intricacies of the structure of exotic nuclei. In particular she uses the segmented Germanium array SeGA and the S800 spectrograph at the NSCL for experiments with rare-isotope beams.

For instance, in a recent experiment using a radioactive Titanium-54 beam from NSCL's coupled cyclotron facility, Alexandra studied the structure of the even more exotic nucleus Calcium-52 produced by the knockout of two protons from the titanium beam upon collision with a reaction target. In the very neutron-rich calcium isotope with mass 52 (20 protons and 32 neutrons) a variety of surprising nuclear-structure phenomena were observed that seem to be driven by the large proton-neutron imbalance. In addition to her collaborations with experimental groups, she works closely with Alex Brown of the NSCL theory group who is attempting to understand Alexandra's results from a theoretical perspective.

RETIREMENTS

Harry Weerts

In August of 2005 after a long and distinguished career in High Energy Physics at MSU, Harry Weerts decided to take early retirement and accept the position of Associate Director for High Energy Physics at Argonne National Laboratory.

Harry came to MSU in 1983 after getting his degree in Aachen and spending three years as a postdoc at Fermilab, where worked on neutrino scattering until the DØ experiment was launched at Fermilab's Tevatron shortly after his arrival in 1983. He played a major role in the construction of the liquid argon calorimeter as well as leading early work on QCD physics. He was elected in 1996 to two consecutive terms as co-leader of the DØ experiment which by then had grown to more than 500 authors from around the globe. In his years at MSU Harry served on numerous important committees, including HEPAP and the Fermilab Program Advisory Committee. He served as chair of the APS Panofsky Prize Committee, of the APS Division of Particles and Fields, and of the nominating committee for the Executive Committee. He is currently an editor for Physics Letters. Harry received a number of significant awards including election to Fellowship at the APS in 1997 and a Distinguished Faculty Award from the College of Natural Science in 2000. In the last few years he has broadened his physics outlook to include electron-positron scattering and also became involved in the International Linear Collider project where he co-chaired a detector study group.

Harry will be missed for his intellectual contributions, his wise counsel and most of all his good humor.

Wu-Ki Tung

Wu-Ki came to MSU in the year 1992 after having already established himself as one of the worlds' premier particle phenomenologists and having served as Department Chair at the University of Illinois at Chicago. Among numerous honors, Wu-Ki had was elected as a fellow to the American Physical Society in 1987. Guided by his vision for the High-Energy Physics Group as a whole, he transformed the theory group by attracting more graduate students and postdocs to work more closely with our (both experimentalist and theorist) colleagues. Many of our former Ph.D. students and postdocs are now themselves faculty members. The HEP group at MSU is now best known for its CTEQ effort, which was initiated by Wu-Ki and flourished by the involvement of other colleagues (mainly, Jon Pumplin and Dan Stump) in the group. The chemistry of the group could never be better when Wu-Ki was around.

Now, Wu-Ki is retiring at University of Washington (UW), Seattle, so that he can live closer to his greater family. He still goes to his UW office everyday to interact with the colleagues there while continuing his active research projects with many of us here at MSU. The retirement for him is to gain more time into research in order to enhance the CTEQ effort made by our group at MSU. It is foreseeable that he will work as hard as he were here till the end of his current NSF grant period (in 2009) and beyond. One of Wu-Ki's most lasting contributions is the collegial working atmosphere within the HEP group. For this, as well as the physics, he will be dearly missed.

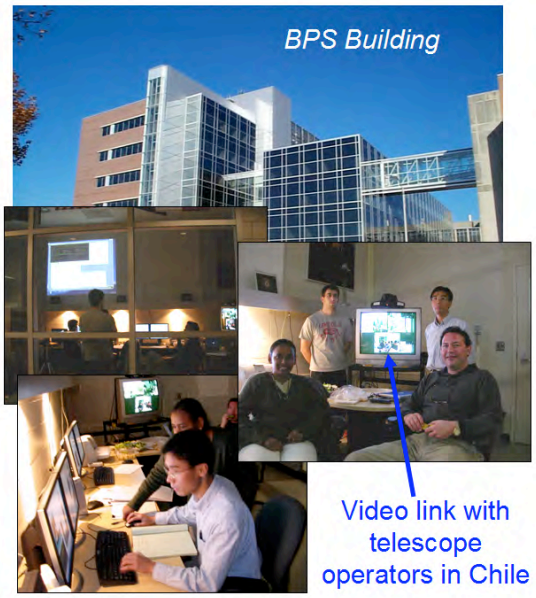
Departmental Awards

Each year the Department of Physics and Astronomy makes awards to outstanding students. For the year 2006 the recipients were as follows: the VerWest award (for junior majors) to Victoria Moeller and James Shanks; the Foiles award (for seniors) to Patrick Harrington; the Osgood Award (for seniors) to Joshua Pergande and Alexander Stuart; the Haynes Award (for students completing the Ph. D. degree) to Dmitri Rivkine and Roshan Foadi.

The Hantel Fellowships, made possible by a donation from Lawrence and Elizabeth Hantel, are awarded to students who are working on research projects with faculty. The recipients this year are Michele Berry, Kurtis Geerlings, Michael Saelim, Michael Schecter, and Richard Worhatch.

The department also presents awards to one non-tenured and one tenured faculty member, to recognize excellence in teaching. The Osgood Memorial Awards for Faculty Excellence in Teaching for 2006 were given to Remco Zegers and Jack Baldwin.

First Science Results from the SOAR Telescope

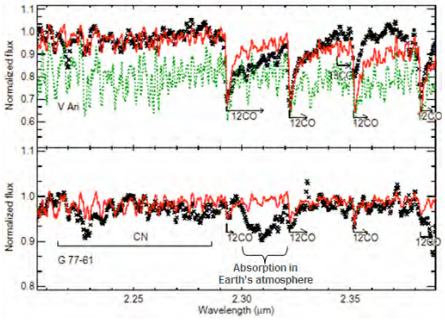


Professor Beers and his team observing with the SOAR Telescope from the BPS Building. *Although the telescope is located on a remote mountaintop in Chile, its instruments can be controlled in real time from the MSU campus. The data arrive at MSU within 20 seconds of being taken in South America.*

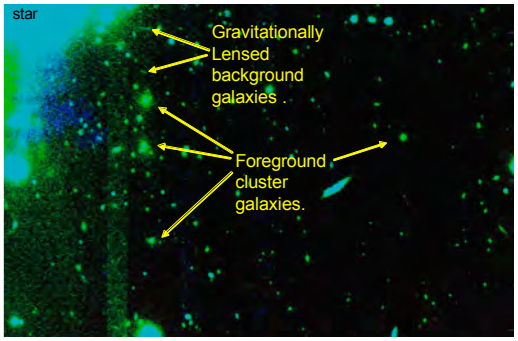
The use of our new SOAR telescope is gradually shifting from commissioning activities to science observations. We currently are using 50% of the nights for scientific investigations. For MSU astronomers, this translates into 1-2 nights each month spent carrying out a wide range of science observations from the SOAR Remote Observing Room off the atrium of the BPS building. Here we give thumbnail descriptions of a few of the early results from that work.

The Oldest Stars in Our Galaxy. MSU's first science paper based on SOAR Telescope data will appear in the March 2007 issue of the *Astronomical Journal*. The research team was led by MSU astronomy professor Timothy Beers, and includes MSU research associate Thirupathi Sivarani and graduate students Brian Marsteller and YoungSun Lee, as well as co-authors from Brazil and France. The paper describes a new method for accurately measuring the chemical abundances of nitrogen and carbon, relative to hydrogen, in the atmospheres (or outer layers) of the stars within our own Milky Way Galaxy that have the lowest-known abundance of iron. The context of this research is that, although the hydrogen and helium that constitute the vast bulk of atomic matter within the universe were formed during the first few minutes after the initial "big bang", all of the heavier chemical elements were subsequently built up through nuclear reactions associated with stars. Many, many generations of stars have formed from interstellar gas, increased the heavy-element content of material in their central regions, and then spewed some fraction of that enriched material back out into the interstellar gas ready for the next round of star formation. The history of galaxies like our own thus is one of the gradual conversion of a gas made solely of hydrogen and helium into material which includes elements such as carbon, nitrogen, oxygen and iron which are vital for forming solid planets and life.

How can we trace the earliest steps in this process? Tim Beers is one of the world's leading experts at using huge surveys to find the few stars in our Galaxy that have the very lowest abundance of iron, a good indicator of the overall fraction of heavy elements. The chemical abundances in a star's outer atmosphere generally are representative of the composition of the material from which the star originally formed, rather than of the material that has since been processed down in the star's hot interior. Since the heavy element abundances started out at zero and gradually increased, the stars with the lowest iron abundances in their outer atmospheres must be the long-lived examples of stars from almost the first generation, formed from interstellar gas that had not yet undergone very much chemical enrichment. The next step is to study these same stars to see to what extent the abundances of other heavy elements, most importantly carbon, nitrogen and oxygen, had been increased at that early date in the Galaxy's history. That is the subject of the new SOAR-based paper. A preprint is available at xxx.lanl.gov/abs/astro-ph/0611827.



SOAR Telescope infrared spectra *(black crosses) of two extremely metal-poor stars, and the best-fitting synthetic spectra from computer simulations of stellar atmospheres (red lines). The dashed green line shows the effect of a modest change in the carbon and nitrogen abundances used to compute the synthetic spectrum. Such fits allow very accurate determinations of the relative abundances of key chemical elements in the outer layers of stars such as these.*

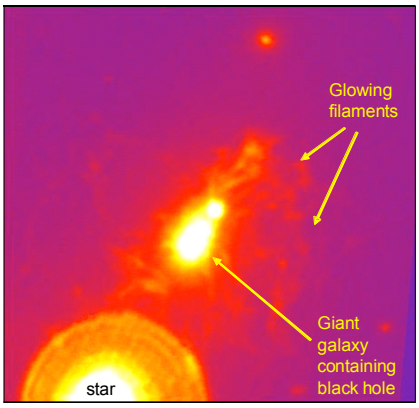


A giant galaxy cluster. *Although only a few have been pointed out in this SOAR Telescope image, most of the yellow objects are member galaxies of a galaxy cluster that extends far off the field of view.*

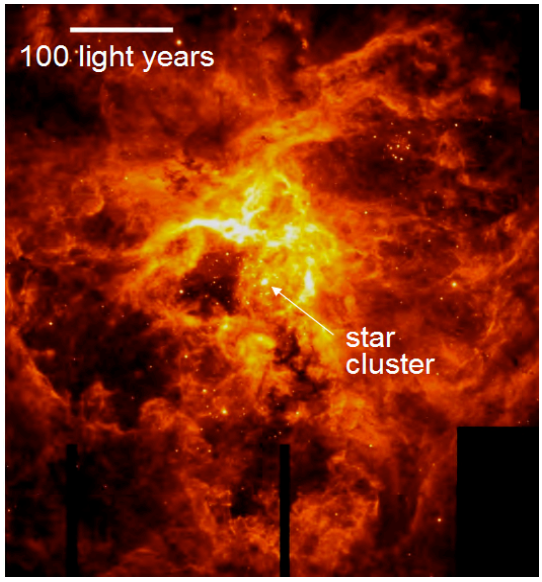
The Link between Quasars and the Evolution of Galaxy Clusters. The universe, and its complement of galaxies and galaxy clusters, has undergone strong structural evolution during its 13.7 billion year history. MSU professors Megan Donahue and Mark Voit, research associate Ming Sun and graduate student Kenneth Cavagnolo also have submitted to the *Astronomical Journal* a paper based on SOAR Telescope observations, this time of the interaction between Active Galaxies (low-level versions of quasars, powered by gas falling into a massive black hole) and the intergalactic gas in giant clusters of galaxies. Galaxy clusters provide the best unbiased sample of the true matter content of the universe, and have been found to be made up of 85% dark matter, 13% hot (millions of degrees) baryonic gas between the galaxies, and only 2% cool baryonic material (gas and stars) within galaxies. The dominant dark matter does not emit or absorb light, so must be studied indirectly through its gravitational interaction either directly with light or with the baryonic matter (which interacts with light and therefore can be seen). Given the surprisingly

small fraction of baryonic matter that is contained in even the sum of the many thousands of galaxies in these clusters, it is crucial to understand the behavior of the intergalactic gas in order to understand the overall structure and evolution of the cluster. This in turn tells us about the structure and evolution of the universe on even larger scales.

New work is showing that the intergalactic gas is continually being heated and stirred up by the energetic radiation coming from quasars and other forms of active galactic nuclei. One place where quasars form is in the particularly massive galaxies that are found at the centers of the clusters. Prof. Donahue's team has studied a particularly good example of such an object whose strong ultraviolet radiation is ionizing the surrounding intergalactic gas. Their paper combines observations using SOAR with those from the Hubble and Chandra space telescopes to study the details of this interaction.

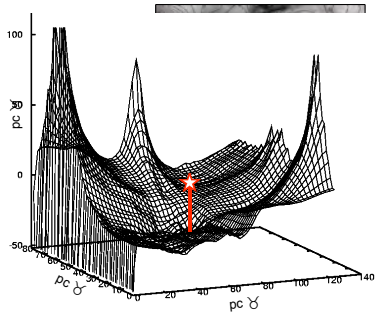


Filaments of intergalactic gas *are illuminated by the light from a mini-quasar at the center of a massive galaxy at the center of a giant cluster.*



30 Doradus*, in the light of the hydrogen Hα emission line. The emission comes from the ionized outer skin of the molecular gas from which the central cluster of stars has formed. The bright arcs are thought to be edge-on walls of glowing gas. This SOAR mosaic image, by REU summer student Lisa May Walker, can be downloaded from* www.pa.msu.edu/soarmsu.

Nearby Giant Star Forming Regions. Professor Jack Baldwin and graduate student Eric Pellegrini are using SOAR to study nearby regions where stars currently are forming, as examples of the similar processes that can be seen with much less detail in the very most distant observable galaxies. They are obtaining images and spectra of the huge 30 Doradus nebula. It lies a mere 160,000 light years away from us in the Large Magellanic Cloud, a satellite galaxy in orbit around the Milky Way. The goal is to understand the ways in which the light and particle winds from newly-formed stars interacts with the gas clouds from which the stars formed.



3D Reconstruction *of the ionized surface in 30 Doradus, based on the SOAR Hα image shown at the left. The scale is in units 1 pc = 3.26 light years. The red star indicates the position of the central star cluster. We are looking down from the top.*

The Future. SOAR is MSU's Laboratory for Astronomy.

The telescope carries a wide variety of instruments which can be used to study the full range of phenomena visible in the cosmos. Our initial agreement is to operate SOAR for the next 18 years, so it will be used by future generations of faculty and students for projects of which we have not yet dreamed. During 2007, MSU will deliver the $2M Spartan Infrared Camera, which currently is undergoing final checkout in the Astronomical Instrumentation Laboratory in the BPS building. This will open new frontiers for SOAR users. MSU is one of four partners in the construction and operation of SOAR (the others are Conselho Nacional de Pesquisas Científicas e Tecnológicas CNPq-Brazil, The University of North Carolina at Chapel Hill, and the National Optical Astronomy Observatory). Each of these partners also is working on additional instruments for SOAR, so our capability to carry out exciting forefront research will constantly grow. MSU astronomers expect to be using SOAR on 40 nights each year (our share for 100% science usage) by early 2008. Our observing schedule can be found at www.pa.msu.edu/soarmsu. MSU's use of the SOAR Telescope is coordinated through the Center for the Study of Cosmic Evolution, in the Physics and Astronomy Department. For information on how to help support our participation in SOAR, see www.pa.msu.edu/donate/.

Astronomical Horizons

This popular series of free public lectures surveys the latest developments in astronomy. The lectures are held at Abrams Planetarium, Thursday evenings at 7:30pm.

Fall 2006

SEP 21 WHAT HAPPENED TO PLUTO? *Prof. Jack Baldwin*

OCT 19 EARTH CROSSING ASTEROIDS: THINGS THAT GO BUMP IN THE NIGHT *Prof. Horace Smith*

NOV 16 THE ROLE OF SUPERWINDS AND SUPERMASSIVE BLACK HOLES IN GALAXY FORMATION *Prof. Megan Donahue*

Spring 2007

JAN 18 THE ANTHROPIC PRINCIPLE AND THE MULTIVERSE *Prof. Mark Voit*

FEB 15 GLOBULAR CLUSTERS: WHAT HAPPENS WHEN MILLIONS OF STARS FORM IN A VERY SMALL SPACE *Prof. Steve Zepf*

MAR 22 INFRARED ASTRONOMY WITH SOAR: RESULTS FROM THE SPARTAN IMAGER *Prof. Ed Loh*

APR 19 THE ORIGIN OF THE ELEMENTS OF LIFE: CARBON, NITROGEN, AND OXYGEN IN THE UNIVERSE *Prof. Tim Beers*

MAY 17 STELLAR DEATH AND ELEMENTAL TRANSFIGURATION *Prof. Ed Brown*

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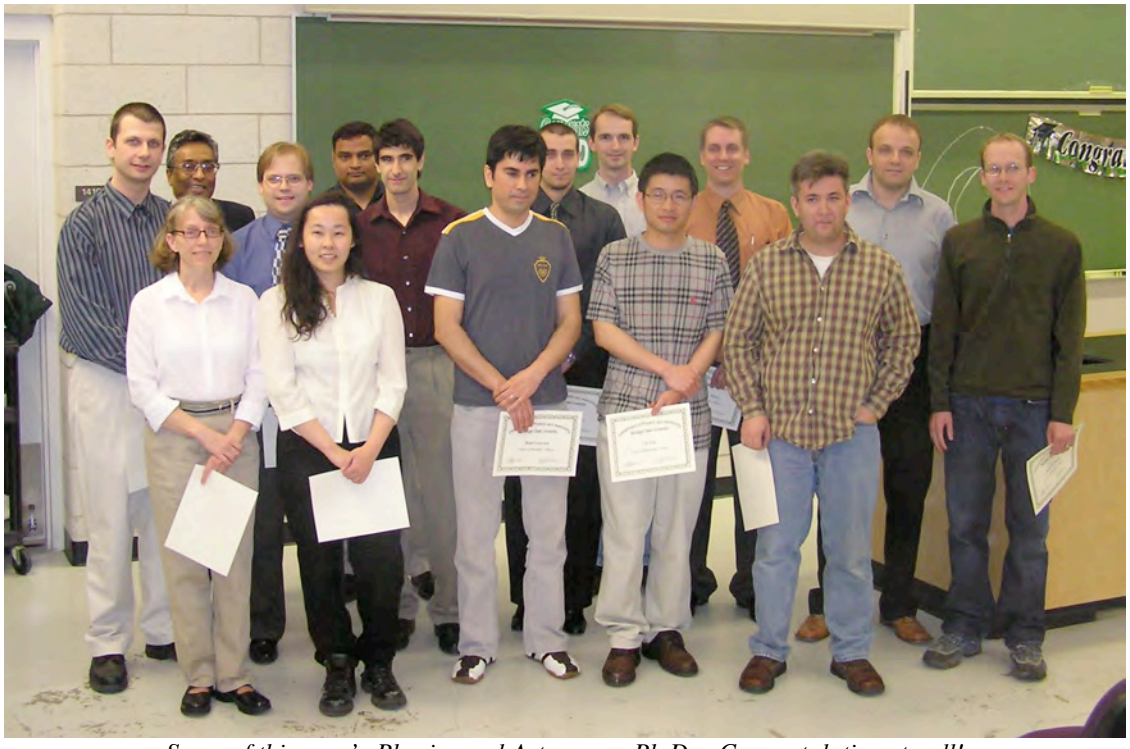

Some of this year's Physics and Astronomy Ph.D.s. Congratulations to all!