Momentum

Department of Physics & Astronomy - University of Kansas

Clyde W. Tombaugh: This picture was taken by Professor Steve Shawl when the observatory at KU was dedicated to KU Alum Tombaugh in 1980; Clyde is at our old 27-inch telescope, that he helped make operational as part of his master's thesis, in about 1937.

The Astronomy program at KU is fortunate to be part of the dual celebrations of the 75th Anniversary of Clyde W. Tombaugh's discovery of the planet Pluto in 2005 and the 100th Anniversary of his birth in 2006.

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Teaching Award

Congratulations to Professor Dave Besson, winner of a 2005-6 Kemper Award for teaching. Chancellor Robert Hemenway made the presentation during Dave's first day of class on August 19th in Malott Hall.

Department Kemper Award winners:

1998	Bruce Twarog
2003	Phil Baringer
2004	Barbara Anthony-Twarog

Dave Besson

Tombaugh Anniversaries

Reflections on events surrounding the 75th anniversary of Clyde W. Tombaugh's discovery of the planet, Pluto, held February 18, 2005:

-by Barbara Anthony-Twarog

I swear, the first words out of my mouth were "This is *soooo* Lawrence." There I was, in the living room of a lovely Old West Lawrence home, preparing to give an evening lecture to an attentive crowd of about 30 folks. This was the flavor of activities the Lawrence Journal World had in mind when it opined that the anniversary of the discovery of Pluto would be "observed in events around Lawrence."

Readers of David Levy's biography of Clyde Tombaugh can learn much about Clyde's Lawrence years, and particularly about the house on Mississippi Street where he lived for a time. The house was owned by Patsy Edson's (Clyde's future wife's) family. The current owners of Clyde's Lawrence residence are seeking recognition of the small house near 7th Street as an historic site. Neighbors with a larger living room organized an evening soiree to honor the anniversary and rally the neighborhood behind this effort.

It should come as no surprise to KU alumni that Lawrence treasures its history. Since the Department of Physics and Astronomy cherishes this bit of alumni history as well, it was a pleasure to address a gathering and inform them a little bit about Clyde's history: his career accomplishments, the search strategy he devised for finding Pluto, the coverage of the discovery story in Kansas newspapers in 1930, and the status of current knowledge and research on the 9th planet, including the work of fellow alumnus, Dave Tholen (BS astronomy, physics, 1978).

While I was sipping my chardonnay at the Clyde Day reception, fellow KU faculty and husband Bruce Twarog was hosting the monthly meeting of the Astronomy Associates of Lawrence. Graham Bell of the Northeast Kansas Amateur Astronomy League (NEKAAL) recounted the long and sometimes distressing story of the Pitt 27" telescope. But now, it's a story with a very happy ending! With a grant from NASA, this small but dedicated group of amateurs proposed a redesign of the mount of the 27" mirror removed from the roof of Lindley in 2001 and consigned to NEKAAL on indefinite loan from the University. NEKAAL is funded to continue their minor planet searches and astrometry in addition to the hefty load of public service that NEKAAL carries out. We think that Clyde would be delighted at the transformation of the telescope he used, its translation to a darker site and its frequent availability to student and community groups.

We now look forward to another wonderful anniversary next year, the 100th anniversary of Clyde Tombaugh's birth. With the help of many of our alumni, we hope to close our year of celebration with that anniversary and the completion of the development campaign, Tombaugh 7500, for a scholarship for astronomy students named, as our observatory at KU continues to be, for Clyde William Tombaugh, class of 1936.

The newly mounted Tombaugh telescope is already in operation at Farpoint Observatory on the grounds of Mission Valley High School near Eskridge, Kansas.

NASA administrator and astronomy alum Lindley Johnson (BA astronomy, 1980) came out to present a suitable decoration to NEKAAL officers Gary Hug and Graham Bell at the April 2, 2005 dedication.

CHAIR'S SPOT

When a physicist thinks of "momentum", at least someone who has recently taught one of our introductory classes, it is usually in terms of either "conservation of" or "change in". The latter is clearly the more appropriate connection as we consider the current state of the department. This past year has witnessed a number of changes and accomplishments for Physics & Astronomy, as highlighted in this issue of Momentum.

The first change should be obvious to anyone who might hold on to past issues of this newsletter. Our long-term editor, Professor Steve Shawl, has entered into phased retirement and has passed on the newsletter to our new editor, Professor Jeff Olafsen. Steve talks about his new life in an article on page 14; it hardly seems like retirement! Jeff brings new ideas on the organization and appearance of Momentum. I was given a chance to read through the current, "new" Momentum before writing this column. I think Steve can be assured that the newsletter is in good hands!

For each of the past three years I have had the honor of taking part in a surprise Kemper Award presentation. The Kemper Award is one of the highest honors that the University bestows on exceptional teachers. Faculty are nominated by their departments, with the testimony of past and current students being a central component of the nomination package. The Chancellor or, in his absence, the Provost makes a "surprise" visit to the winning faculty during their first class in the Fall semester, thus totally destroying any plans the instructor might have made for this class. This year, Professor Dave Besson received such a visit by the Chancellor. Although I have thought Dave to be unflappable, I think even he was shocked when the "suits" barged in on his Introductory Physics lecture! Dave's award brings the total number of Kemper awardees in the department to four—an impressive feat for any single department and one that I believe reflects the high emphases that our faculty places on their teaching mission.

A previous Kemper awardee, Professor Phil Baringer, worked last year on developing a new format for the first term of our calculus-based physics course. The changes that he implemented, going from the traditional three lectures a week to a two lectures and one breakout discussion session format, grew out of an earlier reassessment of our introductory courses that was led by last year's Kemper award winner, Professor Barbara Anthony-Twarog. We are now in the third term of this experiment and, by all accounts, both the faculty and students are welcoming the new format as one that is leading to greater learning.

As reported last year, the department is working to develop a biophysics program. Professor Chris Fisher joined the faculty a year ago in this area and has already established a well functioning laboratory, as discussed on page 6. The student interest in this field has been very high. As we start to become attuned to talk of "DNA translocation" and the like, the department is now working to fill a second faculty position in the area of biophysics. This should bring the staffing to a level where we can start considering curriculum changes that will facilitate the type of interdisciplinary work that biophysics entails.

Whether a side-effect of all the bio-speak that we were exposed to in our biophysics search two years ago, or perhaps the result of watching too many disaster movies, or maybe just a fortuitous merging of expertise and interests, last year saw cosmologist Professor Adrian Melott getting together with space physicist Professor Misha Medvedev to start up a new astrobiology program in the department. This program, which is described on page 5, has generated tremendous national and international interest as it attempts to explain one of the largest mass extinctions known to have occurred on Earth in terms of a gamma-ray burst originating from a supernova explosion in the galaxy. Adrian and Misha have brought together an impressive array of interdisciplinary talent to explore this exciting, if somewhat frightening, scenario.

Rather than focusing on our vulnerabilities to cosmic events, perhaps an even more intriging prospect emerges with the direct evidence that has been accumulated over the past few years of numerous extra-solar planetary systems. This observation leads to the possibility that life might have emerged on one of these planets. Barring a direct "Here we are" message, our best hope of finding evidence of life elsewhere in the galaxy might be with ultra-large optical telescope arrays that have the resolving power to achieve spectroscopic measurements of distant planets. A project being undertaken by KU astronomers Professors Twarog, Anthony-Twarog and Shawl, together with collaborators in the KU Engineering School, may bring us closer to being able to achieve these capabilities. As described on page 4, the KU group is in the prototyping phase for a new type of ultra-light optical mirror and support. By putting together a large number of such units, it should be possible to create a huge, adaptable optics device that can probe fine details in our galaxy and beyond.

In this space I have only been able to highlight some of the activity going on in the department. Elsewhere in this newsletter you will find discussion of many other areas being explored by our faculty. Of course, students supply the driving force for all of our programs. Specific student contributions are noted throughout the newsletter, but on page 15 there is also a list of the many awards and accomplishments garnered by this group. I think it is fair to say that the department's momentum is increasing.

Steve Sanders

ASTRONOMY

ULTRA – Telescopes!

In theory, there's a formula that governs the apportionment of faculty time: 40% to teaching, 40% to research, and 20% to service. Although most of our faculty will laugh if you inquire about how well that works at any moment, over the course of a year, it probably averages out in similar proportions. What *has* been different recently is the nature of the research and collaborative time occupying KU's astronomers. A large fraction of our work in the past year has been devoted to project management and technology development, as well as the usual data reduction and textbook writing.

The ULTRA telescope project *(see adjacent story)* entered its second year and moved from a basic design phase to construction of a 16-inch prototype for optical and engineering testing, the latter carried out by our collaborators in Aerospace Engineering. A great deal was learned from this hands-on testing, enough to confirm that no major obstacles exist in the current path to building a workable 1-meter class system. The progress was significant and warranted two presentations at the January AAS meeting in San Diego, with enough interest from the community to produce both a press release and inclusion in a press conference at the meeting.

ACE, Inc. of Tucson won the bid for the design of the mount and drive system. Construction is expected to begin this summer and, by the end of this year, we hope to have a 1-meter telescope installed at the site. When the eventual goal of the ULTRA telescope as a fully remote, robotic facility is completed a year from now, the fun will really

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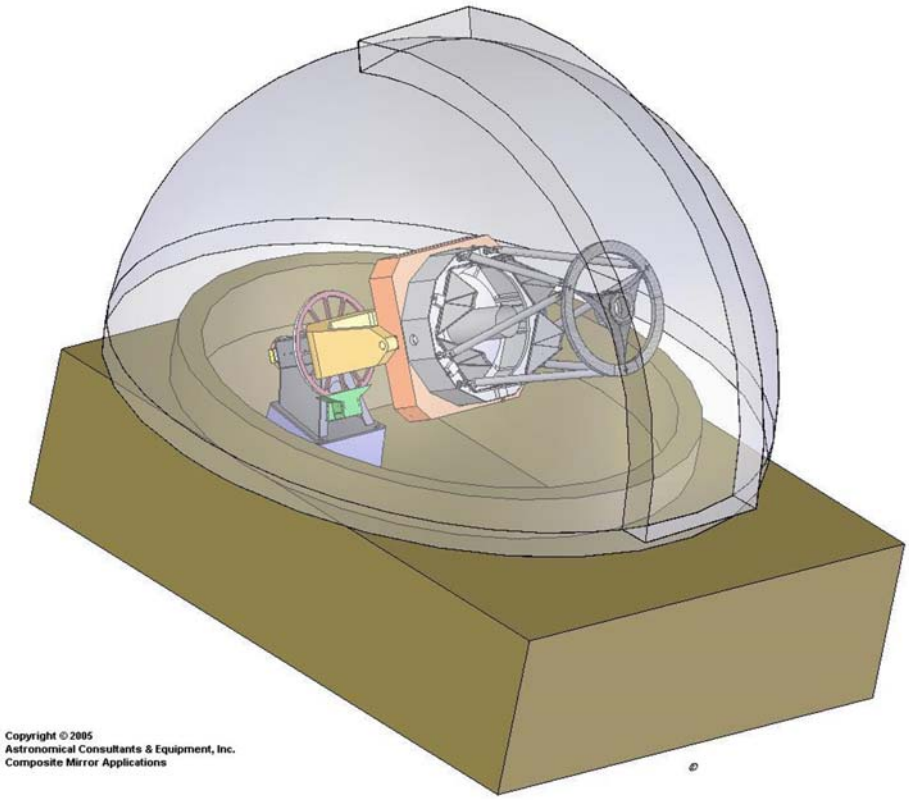

An illustration for the ULTRA telescope and dome at Mt. Laguna.

Light as a feather

Most astronomers consider a 2.5-meter telescope small, so it's rare to find any who are interested in building a 1-meter telescope. This, however, hasn't stopped KU Professors Bruce Twarog, Barbara Anthony-Twarog, and Steve Shawl from securing an NSF grant to do just that. What makes their small telescope so remarkable is that it only weighs roughly 20 pounds, while most telescopes of the same measurement are as hefty as a refrigerator. Their featherweight is nearing completion and the team expects that it will be ready to install in Mt. Laguna Observatory at San Diego State University late in 2005. Once it's up and running, KU astronomers will have exclusive access to 40% of the telescope's operational time.

"If we just wanted a telescope, I'm not sure that we'd go through all this trouble to make the world's lightest 1-meter telescope," Barbara Anthony-Twarog says. "The [grant] money is to find out whether this technology is suitable for making telescopes."

The technology that is crucial for telescopes to shed pounds involves composite materials, and specifically a composite mirror. Usually, a telescope uses a hand-ground mirror that is expensive and heavy. Because of the mirror's weight, the supporting tube must be sturdy, and is usually made of heavy steel. By building with composite materials, a telescope's load can be lightened in every part of the instrument, from the base that supports it to the precision optics inside.

A lighter telescope is useful for a number of reasons. In the 1980's, there was interest in lunar observatories, but the heavy, inflexibile traditional telescopes were a major problem. The weight and flexibility issues turned engineers' attention to the possibility of making telescopes of composites, thus creating a new industry of composite mirrors. Now, lunar observatories are not a major goal, but a lightweight telescope could still be sent

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PHYSICS

Astrobiology

Astrobiology is a new research area in our department. Much of the work in this field generally concerns the possibility of life elsewhere in the Universe, but the emphasis here at KU has been on effects of astrophysical events on life on Earth. Most people are familiar with one example: the Big Rock that likely ended life for the dinosaurs. However, there are many other possibilities, including bursts of radiation for which there is increasing evidence. Exploring this possibility from many different angles has been the focus here.

The work has been interdisciplinary from the beginning. The program got underway early in 2003 in a joint meeting between Professors Adrian Melott and Mikhail Medvedev in our department and Professors Bruce Lieberman from Geology and Larry Martin from the KU Natural History Museum. The mating of physics and paleontology was intended to explore the idea of possible effects of gamma-ray bursts (GRBs) on the Earth. GRBs are very powerful bursts of high-energy photons which are observed on a daily basis coming from deep within the distant universe. It is easily estimated that a large number could have gone off in our galaxy at a possibly dangerous proximity to Earth since life arose here. Although this idea had been examined before by astrophysicists, only estimates of the effects had been made, with no attempt at coordination with the fossil record.

Rather early in the conversations, the group identified a strong possibility of a GRB in one of the "big five" mass extinctions in the Earth's past: the Late Ordovician Extinction, 443 million years ago. This is the second-worst mass extinction found in the fossil record. It came on suddenly, killing mostly shallow-water organisms. (This is important because there was very little life on land then.) It was accompanied by an ice age with no obvious cause in the middle of a very warm, stable climate period. The shallow-water mortality may be a signature of ultraviolet light-mediated damage, because it requires a few meters of water to shield UV. GRBs are known to be capable of damaging the Earth's ozone layer to some degree, letting much more solar UV radiation through.

NASA is providing research funding through its program on Astrobiology: Exobiology and Evolutionary Biology. The early work for this study involved graduate student Brian Thomas, Courtesy Asst. Professor Claude Laird, and collaborators at NASA Goddard Space Flight Center. (Goddard is the home of SWIFT, a new orbiting telescope which can rapidly pinpoint new GRBs, so that observers can determine

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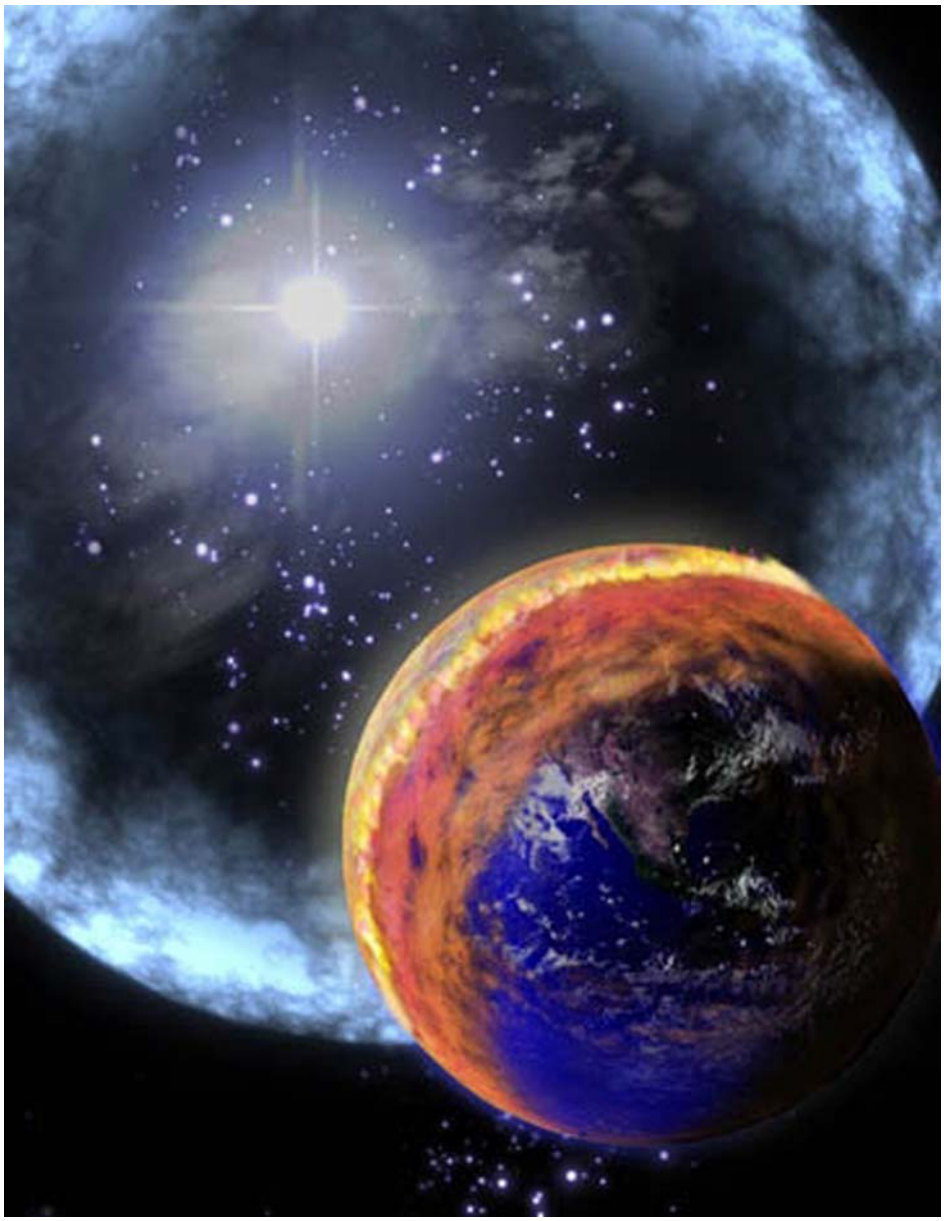


NASA illustration of a GRB irradiating a planet.

PHYSICS

Biophysics

The first KU Symposium for Biophysical Sciences was held on January 18, 2005 at Abe and Jake's Landing in downtown Lawrence. The organization and promotion of the symposium was the responsibility of the Biophysics Initiative Committee of our department which includes Professors Raymond Ammar, John Ralston, Judy Wu, Siyuan Han and Chris Fischer. The purpose of the symposium was to provide a venue in which researchers from various departments on campus could get together to discuss common interests and form new collaborations.

The symposium was well attended with over 60 KU faculty from the main campus in Lawrence and the KU Medical Center in Kansas City presenting talks or posters. John Ralston gave the introductory remarks for the gathering and Chris Fischer gave a brief presentation summarizing the biophysics research and expertise in the department. In addition to these talks, Linda Olafsen, Jeff Olafsen and Chris Fischer each presented a poster covering the recent biophysics research in their groups.

Similar events will be taking place in the future as we take the lead in developing an interdisciplinary life sciences research community at KU. For example, we are currently planning a Biophysical Sciences Workshop which will outline future research directions for the university as a whole. This workshop is tentatively scheduled to take place later in the fall of 2005.

Chris Fischer

Focus on Biophysics

A view of science excerpted from the new NIH roadmap, an interdisciplinary plan for the future of biomedical research: "Biomedical research traditionally has been organized much like a series of cottage industries, lumping researchers into broad areas of scientific interest and then grouping them into distinct, departmentally based specialties. By engaging seemingly unrelated disciplines, traditional gaps in terminology, approach and methodology might be gradually eliminated. With roadblocks to potential collaboration removed, a true meeting of minds can take place: one that broadens the scope of investigation into biomedical problems, yields fresh and possibly unexpected insights, and may even give birth to new hybrid disciplines that are more analytically sophisticated."

"It's radically visionary," KU physicist John Ralston says of the road map. "It looks like I wrote it." Although Ralston has worked under the label of theoretical particle physicist for over 20 years, questions about biological research have been on his mind for the last 25 years. He has even spent some of his free time talking with biologists and applying traditional physical analysis to masses of biological data. It seems that now the NIH is looking in a similar direction.

The KU physics department has seen the potential advantages of interdisciplinary research as well. In the fall of 2004, Assistant Professor Chris Fischer joined the department to study proteins involved in DNA structural changes. Fischer is the first professor in the new biophysics research group at KU. In addition to his own research, Fischer is looking to start an interdisciplinary undergraduate program that draws on resources from the departments of mathematics, biology, chemistry, physics and the school of engineering.

"I would argue that a lot of the boundaries that exist between science (disciplines) are fairly artificial," Fischer says. So he has taken a research problem that could be found in a biology lab, but applies physics tools to understand the fundamentals in a different way. "I'm approaching biochemistry the way a physicist would approach the problem," Fischer explains. "As physicists we're interested in analyzing problems quantitatively and mathematically as opposed to qualitatively."

Specifically, Fischer has quantitatively shown that a certain protein known to be responsible for reorganizing the structure of DNA actually marches along a strand of the molecule. "Most people in the field believe this doesn't happen," Fischer says. But it is important to fundamentally understand how this protein works. Some people with genetic mutations that keep the protein from working properly have a greater chance of cancer. There is a potential for future drugs to target processes that involve this protein. But before this can happen, more needs to be known about it. Fischer has started by looking at the protein's DNA translocation. His results are quite promising and he expects to be ready to publish within a year.

Biophysics research is moving forward in the physics department, and it is also forging ahead at the university level. Physics professors, including Ralston and Fischer, helped sponsor the first KU Symposium for Biophysical Sciences in January 2005. The group converged at Abe and Jake's landing, a downtown Lawrence pub. The purpose was to start a dialogue that would enable shared resources across labs and disciplines. Beyond the symposium, KU has also invited about a dozen visitors to give biophysical talks in the last year. "Some were quite spectacular," Ralston says. This sort of discourse is progress, Ralston believes. And the progress looks good for physics departments, as they are at crucial crossroads on the NIH road map.

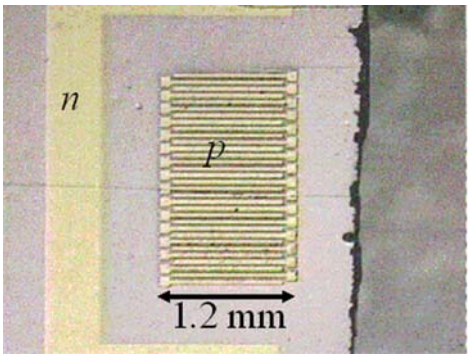
-Katie Greene

PHYSICS

Condensed Matter Physics (CMP): Laser Optics

The Semiconductor Laser Optics Group at the University of Kansas, led by Professor Linda Olafsen, has been expanding its study and development of semiconductor structures with the goal of utilizing such materials in both military and medical applications. Todd McAlpine and Michael Santilli continue this work toward their Ph.D. degrees, and first-year graduate student Kris Young has joined the group this summer. The group examines materials that are real-world implementations of the square-well problems everyone does in their first (and perhaps several subsequent!) quantum mechanics courses. These structures have many wells and barriers, but the fundamental ideas of energy levels that can be tuned with the width of the wells and height of the barriers still apply.

The group is completing the first year of funding from a new grant from the Department of Defense EPSCoR (Experimental Program to Stimulate Competitive Research) Program through the Air Force Office of Scientific Research. This grant totals $450,000 over three years, and was the only such proposal from Kansas funded last year. The Air Force is interested in the development of semiconductor quantum wells for infrared countermeasures, i.e., to keep their airplanes from being targeted by heat-seeking missiles. The 3-5 micrometer band of wavelengths is very important for this work, in part due to the fact that the atmosphere has a "window" across this band where light is not strongly absorbed. The group is studying semiconductors that can be optically stimulated or electrically injected, with the goal of having a compact electrically driven laser or laser array that can deliver lots of output power with small power input and cooling requirements. The grant includes significant funds for equipment that enables the design and fabrication of novel devices at KU—a nice complement to the clean room that has just come on-line.



Detector elements for glucose sensing

The equipment obtained through the Air Force grant very positively impacts all other research in the semiconductor group. In particular, the new equipment helps in a collaboration with the University of Iowa to develop semiconductor based optical glucose sensors for individuals with diabetes. The new capabilities help with adhesion of metal to semiconductor surfaces (to make proper contacts) and to minimize noise in individual detector elements, to name a few important impacts.

CMP: Quantum Electronics

The KU Quantum Electronics group has made significant progress in exploring coherent quantum mechanical processes in novel solid-state, superconducting, information processing devices that are based on Josephson tunnel junctions. Professor Siyuan Han, with his students, postdoctoral fellows, and collaborators have developed new modeling tools for evaluating decoherence originating from an apparatus used to manipulate and readout the states of quantum bits (qubits). Experiments at a temperature of a few tens of milli-Kelvin have shown that the control and readout circuits are the dominant source of decoherence. Currently, the group is developing advanced designs for the qubit bias and readout circuits that are predicted to decrease contributions to decoherence by several orders of magnitude.

The quantum computation project has involved an international team with leading experimental and theoretical groups from KU, SUNY Stony Brook, and the National Institute of Information and Communication Technology of Japan. The research is interdisciplinary by nature involving Physics, Electronic Engineering, Chemistry, Computer Science and Mathematics. Three Ph.D. graduate students, Bo Mao, Ming Wang, and Zelin Zhang, joined the group last August. They have made rapid progress in learning the basic skills needed to conduct research in quantum electronics including construction and operation of cryogenic equipment, ultra low-level signal measurement, microwave engineering, and modeling and testing of superconducting devices and integrated circuits.

Currently, Bo is investigating interactions between microwave and superconducting qubits, Ming is working on quantum electrodynamics (QED) using

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CMP: Thin Film

The KU thin film and nanoscience group led by Prof. Judy Wu has been hosting two post-doctoral researchers (Dr. Rongtao Lu and Dr. Roberto Aga), nine graduate students (Ronald Vallejo, Xiang Wang, Rose Lynn Emergo, Hua Zhao, Jonathan Dizon, Javier Baca, Xin Gao, Shramana Mishra and Dan Fisher), four undergraduates (Alan Dibos, Jesse Noffsinger, Andrew Ra and David Jones), and one visiting scientist, Dr. Sangho Yun, from the Royal Institute of Sweden. The group continues working on thin films, nanowires and devices of various materials including high T_c superconductors, ferroelectric materials, and semiconductors. This work is pursued through extensive collaborations with national labs and other universities. Exciting progress has been made in many research topics the group is carrying out (Please visit our website to see more details at http://www.physics.ku.edu).

PHYSICS

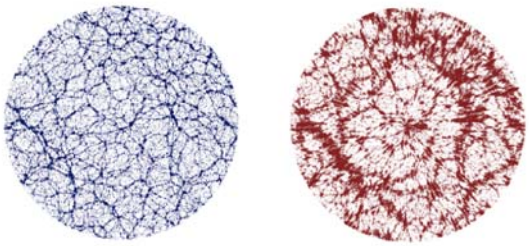
Cosmology

The large-scale structure of the Universe is the main topic of investigation of the Cosmology Group (Hume Feldman, Adrian Melott and Sergei Shandarin). Recent evidence for an accelerating expansion of the Universe and the measurement by astronomers, astrophysicists and cosmologists of the values of most cosmological parameters have led to the development of the "Standard Cosmological Model." These advances have resulted in great excitement in the cosmological community in general and the Cosmology group here at KU in particular. The members of the Cosmology Group continue their large-scale structure studies while also starting to address a more diverse range of questions.

Prof. Hume Feldman developed a new formalism to investigate the mass distribution on universal scales, mostly concentrating on the motion and dynamics of galaxies and clusters. Since galaxies fall into deep gravitational potential wells, studying galactic flows enables one to study the mass concentrations directly, rather than having to deduce the location of mass based on light concentrations. Together with graduate student Devdeep Sarkar, Prof. Feldman investigates the correlation of various recent galaxy surveys and the dynamical information that can be harvested from those types of observations. Devdeep Sarkar presented some of the results at the APS meeting in April 2005 in Tampa Florida, while Prof. Feldman presented various talks about these subjects in Santa Fe and at Los Alamos National Lab in NM; Fermilab; Benedictine University, KS; and University of Missouri in Kansas City.

In the last ten years a great deal of effort has been placed on detailed studies of the high-density regions, in particular the progenitors of clusters of galaxies. The density profiles, merging history, substructure and many other features have been accurately modeled, simulated and analyzed. These are the places where most of the action is: first objects, galaxy formation and merging, X-rays, gravitational lensing, etc. However, recent studies indicate a discrepancy between observations and theory in low and mild density regions, which are naturally associated with voids and superclusters respectively. Simulations show that clumps of mass in voids seem to be capable of developing into void objects such as clumps of stars. The morphology-density correlation seems to be in contrast to what is observed.

The study of low and medium density regions is demanding for both observation and modeling. However, the observational impediment is coming to an end: large redshift surveys are now on-line and starting to release data. As a result, valuable information on the attributes of galaxies in voids and void walls has been obtained. The relation of the observational results to the physical processes in voids and void walls does not seem to be trivial. Profs. Feldman and Shandarin started a concerted effort to study low (voids) and mild (Clusters of galaxies) density regions to address the seeming discrepancies between observation and modeling.



The Real (l) and Redshift Space (r) Mass Distributions to the Universe.

Since we live in an evolving Universe, the structures in it are expected to also change over time. Clusters of galaxies are the most recently formed in a hierarchy of larger and larger objects. As they "settle down" after forming in mergers, one might expect them to become more and more uniformly spherical. This process was confirmed to occur in earlier analysis work done at KU and by a group in Greece. Problem is, the process seems to have been happening much faster in the real Universe than in simulations that use generally accepted parameters. So, the unanswered question is "why?"

The cosmology program has a history of involving exceptional undergraduates. An example, Stephen Floor received a coveted Goldwater Scholarship last year and will be off to graduate school this year.

Prof. Sergei Shandarin has continued to work on several theoretical problems related to the large-scale structure in the universe. There are two closely related aspects in studies of the large-scale structure: nonlinear gravitational dynamics and morphology of the galaxy distribution in space. The morphology is simply a term for the quantitative characterization of sizes, shapes and other parameters astronomers measure in galaxy catalogs. Theory predicts the galaxies to group in very elongated filament-like clouds that are connected with each other forming a single network spreading throughout all observed parts of the universe. Astronomers seem to observe such a structure in the universe but have a problem in measuring it. The accurate quantitative descriptions of such a system is complicated. However, modern mathematics and statistics provide new techniques that are able to grasp many, although not all, features of these complex structures. Professor Shandarin reported his findings at the workshop on "Multiscale Geometric Methods in Astronomical Data Analysis" held at the Institute of Pure and Applied Mathematics University of California in Los Angeles in November 2004.

Prof. Melott has done a number of interviews about cosmology and science education standards for local media, NPR, a church religion and science video series, and a lecture at Hayden Planetarium in New York.

PHYSICS

High Energy

Members of this group, including Professors Phil Baringer and Alice Bean, postdoc Len Christofek and graduate students Shabnam Jabeen and Peter Bryant, are studying the top quark system. In particular, they are looking for electroweak production of the top quark. Previous observations of the top quark have come from the strong production mechanism. Electroweak production is also known as single top, because only one top quark is produced, as opposed to the top-antitop pair that you get in strong production. During the past year the D0 experiment has reported the world's most restrictive limit on the cross section for single top. In another year or so we hope to have enough data to observe the process. Measuring the single top cross section will provide unique insight into Standard Model parameters and impose limits on possible new physics such as a fourth generation of quarks or new flavor changing mechanisms. Shabnam Jabeen is writing her Ph.D. dissertation on a search for single top in the channel where the top decays to a b-quark jet and a W boson and the W in turn decays to an electron and a neutrino.

Postdoc Tania Moulik joined the group in Spring 2004. She has been stationed at Fermilab where she is working on the D0 experiment. Using her experience from her previous job, she has been exploring how to use electrons to tag jets that come from b-quarks. The D0 experiment can currently tag such jets using other techniques involving muons and secondary vertices. Identifying b-quark jets is crucial to much of the physics we want to do at D0, so we want to expand our ability to find them. Top quark physics, searches for the Higgs and other new particles, and, of course, studies of the b-quark itself, all depend upon separating out these b-quark jets from lighter quark-jets. Tania plans to apply her new technique of tagged electrons to studies of mixing in the B_s system.

A major responsibility of the group is developing various high precision tracking chambers made of silicon. Currently, for the D0 experiment, a four-layer detector made of silicon has been developed. This detector is the closest to the collision vertex audit records high precision hits when a charged particle traverses it. The KU group under the direction of Alice Bean is leading an effort to install a new layer of silicon even closer to the beamline this Fall which will provide for a better measurement on a particle decay vertex. Undergraduate students David Hover, Vitaly Kheyfets, and Jake King with help from graduate students Peter Bryant and Justace Clutter have helped to calibrate the current silicon detector and to build electronics for the new silicon detector. Professors Baringer and Bean, postdoc Don Coppage, and undergraduate students Lawrence Percival and Carl Hinchey are also helping to construct the tracker outer barrel (TOB) silicon detector for the CMS detector to be installed into the CERN LHC collider starting operation in 2007. The TOB detector consists of 6000 different silicon detectors and is being constructed mostly in the U.S. at Fermilab and at the Univ. of California, Santa Barbara. Our KU group is working at Fermilab on this project.

A new education effort started in the group about a year ago, called Quarked. Here, quark and other subatomic particle characters have been created in anticipation of making an animated video production for television and the web. This project has led to collaboration with the Department of Design, KU's museum of Natural History, KTWU (PBS station in Topeka), scriptwriters, child psychologists, high school physics teachers, executive producers, etc. Funding is currently being sought to develop the concepts further and produce an entertaining and educational web-site which includes interactive games.

Professor Baringer also hosted the 4th annual QuarkNet workshop here at the University of Kansas, during the summer of 2004. This workshop brings together high school physics teachers from all over Kansas to discuss K-12 curriculum issues, as well as expanding the scope of their interactions with KU Professors.

Professor Graham Wilson, a member of the D0 experiment, also leads the local effort to establish a leading role in the development of the "Next Linear Collider". This particle accelerator, proposed to begin operation within a decade, would collide electrons with positrons at a total energy that is a factor of 10 higher than previously achieved. The NLC, if built, will be one of the two main particle physics facilities of the next century (along with the LHC). Prof. Wilson's work has involved development of the "calorimeter," which will measure the energies of particles produced in NLC collisions. The national funding agencies have recently begun funding NLC-related work; hopefully, eventual construction of this facility will begin a new era in particle physics.

The characters Ushi (up quark), Harold (up quark), and Danny (down quark), ride in the proton "SUV"

PHYSICS

Nonlinear: Beam Dynamics

Professor Jack Shi's nonlinear beam-dynamics group has been working on a project aimed at understanding the collective beam instabilities in high-energy particle accelerators. For many years, a significant increase of luminosity has been a major priority of research and development for the current high-energy storage-ring colliders as well as future accelerator facilities.

Our current research activities include (a) development of a compensation scheme to control the long-range beam-beam effect that is a chief factor limiting the luminosity in the Tevatron; (b) the study of the coherent beam-beam instability that is important to storage-ring colliders with high-intensity beams; and (c) study of beam-beam effects in eRHIC. The eRHIC project is set to build an electron ring at RHIC (Relativistic Heavy-Ion Collider) in Brookhaven National Laboratory (BNL) with a highly polarized (>70%) 5-10 GeV electron beam (e-beam) and will provide collisions between the electron beam and the ion beam. Currently, this project is being developed in a collaboration involving MIT, BNL, DESY (Deutsches Elektronen-Synchrotron, Hamburg, Germany), and our group at KU. Because of the proposed high luminosity, an understanding of the beam-beam effects in eRHIC is crucial to the design of the eRHIC facility. Our research has been funded by the U.S. Department of Energy.

Fermilab in Batavia, Illinois

Isle Lab

Having moved into a new lab space in the spring and summer of 2004, the ISLE (Imaging Systems Lab Experiments) lab has seen multiple transitions in students and projects over the last year. Undergraduates Kevin Kohlstedt, Sarah Feldt and David Tenny have all moved on to graduate schools.

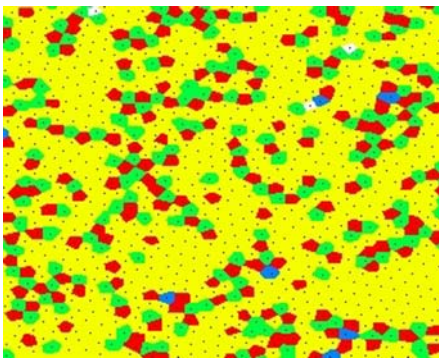
Kevin's first paper appeared in the January 2005 issue of Physical Review E. Entitled "Far-from-equilibrium Ostwald ripening in electrostatically driven granular powders," the article is the first of many anticipated to develop from Kevin's work involving the ISLE lab at the University of Kansas and the Material Science Division of Argonne National Laboratory. Kevin spent two summers, in 2003 and 2004, working with Jeff Olafsen and Igor Aronson on projects for both research programs.

Sarah's paper entitled "Inelastic Gravitational Billiards" was published the week of June 10, 2005 in Physical Review Letters. The paper is the first to report results of a carefully designed system to experimentally measure the effects of inelasticity on a gravitational billiard, confirming several behaviors theorized from numerical simulations pursued by other research groups hoping to better understand nonlinear Hamiltonian systems.

David worked to design a new large aspect ratio Taylor-Couette flow cell during his time in the ISLE lab, mixing his love of aerodynamics and engineering with his interests in physics. When completed, the next generation of his experiment should generate very interesting results.

With graduations, the face (and height!) of the ISLE lab has changed in the last year. Dana Maher and Ben Bammes are two (taller) undergraduates who have been performing research in the lab. Also, Nicholas Hunt, a graduate student in Civil Engineering and Tareq Alrafae, a physics graduate student have joined the group.

Ben is continuing to develop both experimental and numerical models of polymer folding using a novel macroscopic experiment. The first results of Ben's experiment were reported in a paper entitled "Polymerlike folding of a two-dimensional granular chain in water" in the December issue of the journal *Chaos*. The paper itself was the result of Ben's award-winning video in the First Annual Gallery of Images competition at the APS March Meeting in Montreal, Canada in March of 2004. Devoid of many of the chemical and electrical details that complicate real polymer systems, the model experiment allows Ben to examine the folding dynamic in a 2D geometry to generalize the folding configurations that will help us to better understand how real polymers fold.



Dislocations in a granular experiment driven far from equilibrium

Dana continued his work to develop a model for sound propagation in shallow sand beds to help detect invasive objects in sandy environments. Nicholas Hunt is working to develop a remote sensing technique for photogrammetric measurements of buildings and other structures. The work is a collaborative project between Adolfo Matamoros in Civil Engineering and the ISLE Lab. Finally, graduate student Tareq Alrafae has joined the ISLE group this summer. Tareq will be developing new image algorithms for particle tracking in granular flows of extended particles to better understand macroscopic mixing in multi-particle flows and to test equipartition in non-equilibrium systems.

PHYSICS

Nuclear Physics

The boundaries dividing the different areas of physics have always been ill-defined. This is particularly noticeable today in what is called "nuclear physics." Not so long ago it was possible to make a rough divide between atomic, nuclear, and high-energy physics in terms of energy scales: roughly corresponding to eV, MeV, and GeV scale physics, respectively. Now, however, the KU "nuclear physics" group, consisting of faculty Michael Murray and Steve Sanders, graduate student Chaitanya Kavalugunta, and postdoctoral research associates Eun-Joo Kim, Erik Johnson, and Selemon Bekeley, is exploring reactions with center-of-mass nucleus-nucleus energies on the order to tens of TeV. Moreover, the physical behaviors are discussed in terms of hydrodynamic flow and plasmas characterized by Debye screening lengths. Welcome to the world of relativistic heavy-ion nuclear physics! Here, the goal is to understand what happens when the energy density in nuclear matter exceeds the threshold where quarks from nearby nucleons can be freely exchanged, effectively dissolving the constituent nucleons into a soup of quarks and gluons—recreating conditions of the early universe a few microseconds after the Big Bang.

The KU group is currently playing a key role in the BRAHMS experiment at the Brookhaven National Laboratory Relativistic Heavy-ion Collider (RHIC). The group is largely responsible for the global measurements that characterize the overlap of the two colliding nuclei during a RHIC collision and has built the global charged-particle multiplicity array that surrounds the interaction region and that establishes the overall particle production in a given collision event. Moreover, the group is playing a key role in understanding the hydrodynamic behavior of the created medium during a collision of, for example, two gold nuclei. During the past year we have been exploring asymmetries in the azimuthal emission of charged particles in mid-central collisions to establish the strength of the collective azimuthal flow signal. When two gold nuclei collide in a mid-central collision, their overlap region has a roughly oval shape. Pressure gradients lead to a preferential emission of particles from this overlap region in the reaction plane defined by the impact parameter of the collision.

The measurements at RHIC by both the BRAHMS collaboration and by the other RHIC experiments have revealed totally unexpected behavior corresponding to what appears to be a strongly interacting fluid, most likely reflecting the creation of a quark-gluon plasma. However, the results of these experiments are not viewed as providing definitive evidence for the creation of this plasma. There has been no evidence of a first-order phase transition characterized by a specific latent heat. Moreover, the strongly interacting fluid that appears to be created was unexpected. While answering many questions, RHIC has raised new ones.

Professor Murray has been leading the effort of the KU group to make a transition to the CMS experiment at the Large Hadron Collider (LHC) being constructed at CERN. When this facility comes on-line towards the end of the decade, it will allow a study of heavy-ion collisions at energies over an order of magnitude greater than can be achieved at RHIC. The KU activity on the CMS project ramped up significantly in the past year. KU student Megan Lehnherr has done realistic model simulations of the ZDC detector being developed for CMS. Professor Murray has been awarded an NSF Career Grant that will fund a postdoc, Oleg Grachov, working specifically on the CMS project.

While it may once have been possible to characterize nuclear physics by an energy scale, such a definition would now encompass only one part of the field. Nuclear Physics appears to be once again reinventing itself, which just adds to its attraction for the practitioners working in the field.

Space Physics

Professor Tom Cravens and postdoctoral researcher Ina Robertson have been working on models of the upper atmosphere and ionosphere of Saturn's satellite Titan. NASA's Cassini spacecraft arrived at the Saturn system in July 2004, and the first of many encounters with Titan took place on October 26, 2004. Prof. Cravens is a member of the instrument team for the Ion and Neutral Mass Spectrometer, which detected both nitrogen and methane (i.e., natural gas) in Titan's atmosphere. During a more recent Titan encounter on April 16, 2005, the INMS instrument carried out the first ion composition measurements of Titan's atmosphere. The models of Titan's atmosphere developed at KU over the last decade with the help of current and past students (including graduate student Ned Keller and undergraduate Judy Yu) are now starting to be tested. Post-doctoral researcher Ina Robertson, Ned Keller, Judy Yu, and Prof. Cravens were all at the INMS team meeting at the University of Michigan when the April encounter data was returned from the spacecraft.

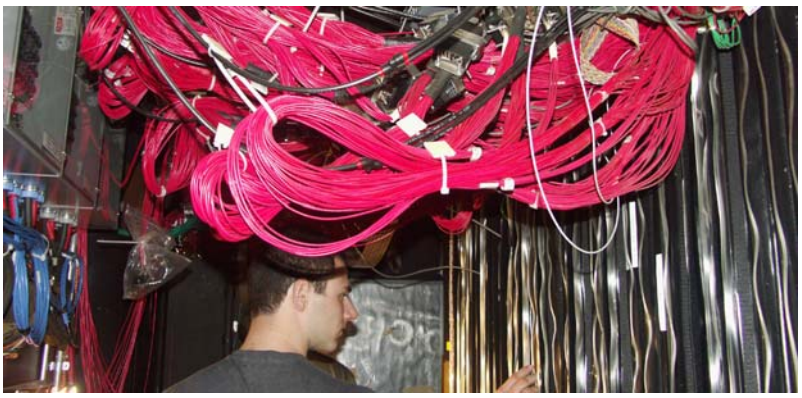
Ina Robertson, Prof. Cravens, and Prof. Misha Medvedev are working with scientists at NASA's Goddard Space Flight Center and at the Harvard-Smithsonian Center for Astrophysics to unravel the detailed physical processes responsible for x-ray emission due to solar wind charge transfer collisions with neutrals in the heliosphere and in the terrestrial magnetosheath. Prof. Cravens visited Harvard in January for a week in order to pursue this collaboration. During the last week of May, Ina Robertson and Tom Cravens presented their recent results on x-ray emission and on Titan at the American Geophysical Union in New Orleans.

Professor Medvedev is also continuing a collaborative project with Prof. Cravens and Robertson on x-ray emission from Mars and what it can tell us about the solar wind

(Continued on page 22)

PHYSICS

Theoretical Physics



Ali Soleimani methodically examines miles and miles of wire at Fermilab National Laboratory.

An anonymous 21st Century proser writes, "Some quail at scary mass less doublets; Some say they fly as swift as light. The color singlet neutral leptons fly matter wings in endless night. Probably!"

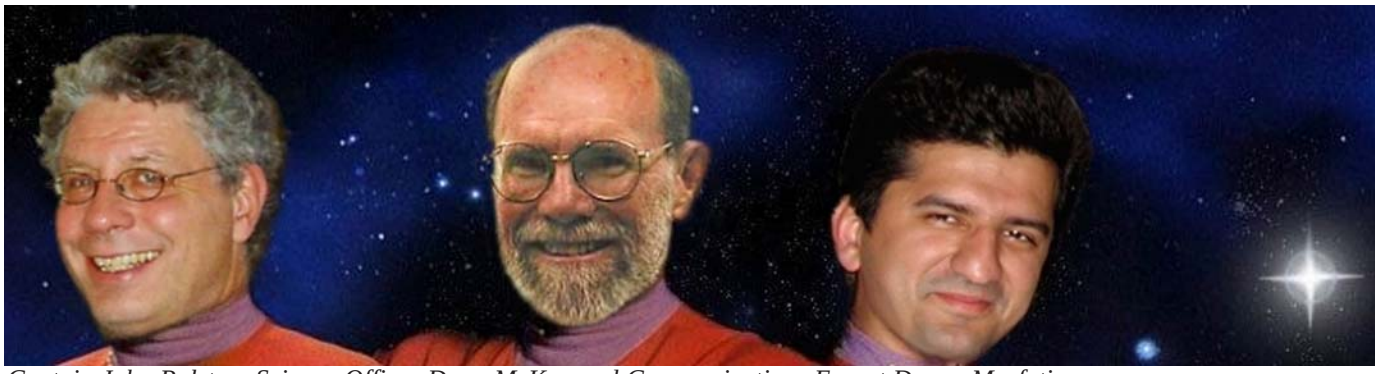
In Kansas we call them *neutrinos*, and find them interesting. National headlines were made when Professor Danny Marfatia, formerly of Boston University and the University of Wisconsin, Madison, joined the KU particle theory group recently (we like to think!).

What is it about these scary particles that have new theory faculty member Danny Marfatia and the old guard theorists Professors John Ralston and Doug McKay holding forth in strange tongues? Mainly it is data that has been painstakingly gathered by clever and diligent experimenters and observers over decades, with some big breakthroughs in the past couple of years. A coherent picture of neutrino properties is emerging, and the theory group is spending a lot of its time contributing to the development of this picture, sometimes by finding alternatives to the dominant view that neutrinos have tiny, fixed mass values and either "oscillate" from one type to another as they fly in vacuum or slice through matter feeling forces from surrounding matter.

Danny Marfatia and his collaborators have been showing how *mass varying* neutrinos can explain all the neutrino data from accelerators and from sources like the sun. This is a novel twist, requiring neutrino propagation through space different from our usual ideas of the vacuum. John has recently discovered a remarkable feature of classical radio wave propagation that may make the detection of ultra-high energy (a billion-billion electron volts) cosmic neutrinos much easier by carrying the radio "news" of an enormously energetic cosmic neutrino collision with atoms in Antarctic ice to waiting antennas with extraordinary efficiency. Doug and newly minted KU Ph.D. Shahid Hussain, with John, Danny and other members of the RICE (Radio Ice Cherenkov Experiment) have worked out the consequences that detection of such high energy neutrino events can have for our understanding of the fundamental forces between neutrinos and atoms.

The RICE experiment, conceived and implemented at Kansas, presented its newest results, based on data collected from 2000 through 2004, at the International Cosmic Ray Conference in Pune, India, in August. Though no neutrinos with ultra-high energies have been observed by RICE or any other of the dozen or so experiments around the world, RICE has placed the most severe limits of all on the numbers of these elusive particles impinging on us each second at the highest cosmic ray energies. All three theorists plus student Rainer Schiel and now former student, Shahid Hussain, are collaborators on the project.

The theory group is active on a wide variety of new ideas and new problems besides those inspired by the "swift as light" neutrino, but the focus these days is on the "particle of the opening decade of the 21st Century", the once lowly, now princely, neutrino.



Captain John Ralston, Science Officer Doug McKay and Communications Expert Danny Marfatia.

Advancing Labs

As part of a continuing effort to reinvigorate the undergraduate curriculum, the department has made significant investments in the upper-level laboratories. Funding has come from two competitive "Tuition Enhancement" awards of about $40k each, as well as about $20k in departmental and CLAS funds. These monies have been used to purchase new experimental equipment as well as computers and data acquisition systems.

The experiments have been almost completely revamped with a strong emphasis on atomic physics and quantum mechanics. For example, in PHSX 516 we now have experiments on quantum interference of single photons, x-ray structure of atoms, Faraday rotation of light, and electron cyclotron resonance. To dovetail with the department's biophysics initiative two Nuclear Magnetic Resonance (NMR) experiments have been purchased.

The Advanced Laboratory class now includes a significant emphasis on writing. At the beginning of the semester this seemed strange to the students. One student even remarked that in four years at KU no one had ever cared about her writing. However, good writing demonstrates that the student has understood what they have done and has taken the time to organize their thoughts. Since several of the experiments produce rich data sets it is important that students learn to present scientific data clearly. This is introduced at the beginning of the semester with several lectures on graphics and data presentation.

A fine adjustment of the Faraday rotation apparatus.

In order to prepare themselves for the workplace, students need to make presentations orally as well as in written form. Each student gives two presentations during the semester, which are critiqued by their fellow classmates. Near the end of the semester, all the students now prepare posters that are presented at a Society of Physics Students (SPS) pizza party.

New Faculty

Carsten Timm is the new condensed matter theorist who will be joining the department in January of 2006. We've asked him to tell us a little bit about himself as we look forward to his arrival in the spring. – *Editor's Note.*

Kerstin, my wife, and I both grew up in Hamburg. Many physicists know this city because of the synchrotron being there, DESY. I studied physics at the University of Hamburg, also took some computer science, and completed my PhD in 1996. I worked with the late Joachim ("Joe") Appel and my thesis was about the theory of vortices in high-temperature superconductors. Appel had strong ties to the U.S. and suggested that I go there.

So, after my PhD I went to Indiana University in Bloomington as a postdoc. Kerstin, my girlfriend at that time, (who had spent a year in Wichita, KS as part of a high school exchange program), followed a few months later. There, I worked mainly with Steve Girvin, now at Yale, on magnetism in the quantum Hall system (the two-dimensional electron gas produced in semiconductor heterostructures in a strong magnetic field). Kerstin and I got married in Bloomington in 1997. We both enjoyed our time there. In 1998, we went back to Germany and I became a postdoc in the group of Karl Bennemann at the Free University Berlin.

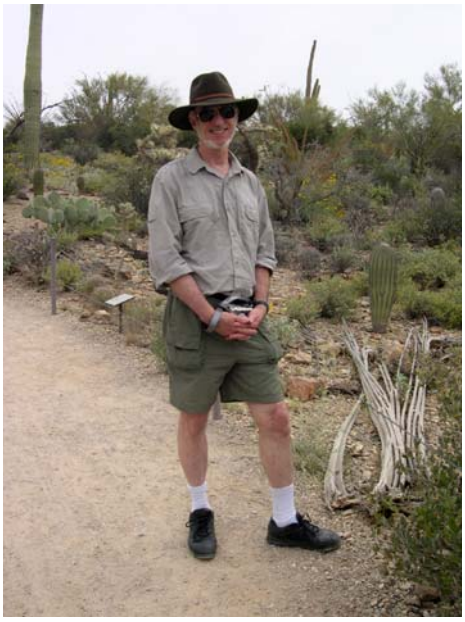
(As an aside: There is an interesting story behind this name. The old University in Berlin ended up in East Berlin after WW II.

Carsten Timm

While students from the western part could study there, the climate was not one of open scientific debate. Therefore students from West Berlin formed the plan to found a new university in the western part. They managed to get enough money together to do that, mainly from U.S. sources, and the new school was called Free University to set it apart from the eastern one.)

There, I worked again on high-temperature superconductors, on magnetic systems, and on nonlinear optics. Kerstin started to study education at the same university. Our daughters Birte and Lina were born here in 1999 and 2003. We live close to the city limits, where it is nice and green.

When Bennemann retired in 2000, I joined the group of his successor, Felix von Oppen, as an assistant ("Assistent"). This is a traditional position in the German system, each full professor used to have one Assistent (although this is changing now), for example, Werner Heisenberg was the Assistent of Max Born. It is a kind of senior postdoc. Around this time I became interested in diluted magnetic semiconductors and I am still working in this field. In particular, I am interested in the interplay between disorder, magnetism, and transport. I also helped to write the proposal for a Collaborative Research Center (a huge group grant) on bistable molecules on surfaces. Our interest here is mainly in transport properties. This Research Center is funded starting in July 2005 and I will be one of the heads of a subproject for half a year before coming to KU.



Steve Shawl at Tohono Chul Park

Astronomer Changes Phase

Physicists have studied the conditions and results of phase change from the beginning of the field's history. Now, astronomy professor Steve Shawl, the past editor of *Momentum*, is studying phase change—not in physical systems but in one particular living system: his own. He has entered into KU's phased retirement program. This program is available to faculty of age 55 or greater who have at least ten years of full-time service in the Regent's system. The program requires retirement within 5 years. Employment can be at a maximum of 75% or a minimum of 25%. Salary is prorated to the amount of effort contracted for; however, fringe benefits (health and retirement contributions) are at the 100% level. Thus, it is similar to but better than taking five sabbatical leaves in a row!

Professor Thomas Armstrong was the first of the physics faculty to avail himself of the program; he completed five years in 2003. Professor Robin Davis is now in his second year. The average length of time that a faculty member usually remains in the program is only 2 years! (You can use your imagination as to why!)

Shawl has taken the program one step beyond what others have done: he sold his house and moved, lock, stock, and barrel to Tucson! He will return to Lawrence from mid-August to mid-December to teach for the fall semester to fulfill his obligations, and then return to his new home in Tucson.

Why Tucson after more than 32 years in Lawrence? He and Jeannette lived and worked there for the two years immediately before coming to Lawrence in 1972. As the home of the National Optical Astronomy Observatories, it is a natural place for astronomers. Furthermore, having spent a number of summers and two sabbatical leaves there, and having given Jeannette full control of where they would retire, it was a natural place to go. Snow and cold would be encountered only when they chose to go to the mountains! No more grass to cut! No more hay fever! (Unfortunately, not true; this spring was worse in Tucson for him than in Lawrence!)

Steve tells us that the "retirement" part of his phased retirement has not yet kicked in. When not teaching his introductory astronomy class for the astronomy department at the University of Arizona, he was working on the fifth edition of his introductory astronomy textbook that is now available for students around the country. There was also trying to get settled into a new house while doing bathroom and kitchen renovations!

Unbeknownst to anyone until now, he jinxed KU's basketball team this spring when he told his University of Arizona class that he was from KU, where they really knew what basketball was all about! We can only hope that next time he will keep his mouth shut until after the NCAA tournament!

Steve Shawl and wife, Jeannette, set free in the wilds of Arizona

Student News

Josh Meyers was selected as the winner of the Class of 1913 Chancellor's Student Award for 2005 and received an honorable mention in the competition for an NSF graduate fellowship.

Luis Vargas has been named the recipient of an APS Minority Scholarship.

Matthew Matheny graduated this summer with a B.S. in Physics and Math and will continue his pursuit of quantum information research at Caltech as a new Ph.D. graduate student.

Undergraduate student **Jesse Noffsinger** graduated this May and is attending UC Berkeley in the fall of 2005. Besides many other awards he has received, he is a 2005 NSF graduate scholarship recipient.

Kevin Kohlstedt was awarded a McCormick Fellowship to attend graduate school at Northwestern University in Chemical Engineering starting in the fall of 2004. In the spring of 2005, Kevin received a DOE fellowship to continue his graduate studies.

Sarah Feldt chose to attend the University of Michigan and has been working on a graduate degree in biophysics. In the spring of 2005, Sarah received an NSF Graduate Fellowship to support her continued studies.

David Tenny applied to graduate school at Purdue University and started in the spring of 2005 working on a Master's degree.

Three for Three! Congratulations to undergraduate physics majors **Shawn Henderson** from Wichita, **David Hover** from Overland Park and **Hannah Swift** of Olathe for their selection as Barry M. Goldwater Scholars for 2005.

Charles Pye (physics), **Andrew Lake Wooten** and **Gianna Short** (both engineering physics) are three of the 16 new Chancellor's Club Scholars.

Ian Lewis and **Jake King** will be attending graduate school at the University of Wisconsin beginning in the fall of 2005.

Stephen Floor will be attending graduate school at the University of California in San Francisco in the fall of 2005.

Sigma Pi Sigma induction ceremony group picture. From left to right: Daniel Hogan (U), Scott Graham (G), Leah Bowen (G), Mohammed Alenezy (G), Javier Baca (G), Zelin Zhang (G), Larissa Ejzak (U), Shramana Mishra (G), Bo Mao (G), Ming Wang (G), Tareq Alrefae (G), Devdeep Sarkar (G), Chris Fischer (F), Danny Marfatia (F). (Undergraduate students: U, Graduate Students: G, Faculty: F)

Sigma Pi Sigma

This year on April 29, a group of 14 initiates, comprised of undergraduate and graduate students as well as two new faculty members in our department, were inducted into Sigma Pi Sigma, the honor society of the Society of Physics Students. The ceremony was presided over by Professor Jack Shi, Honors Coordinator for the Department of Physics & Astronomy.

Brian Thomas (KU PhD 2005) has taken an Assistant Professor position at Washburn University.

Photo right: Professor Jack Shi addresses the new SPS inductees at the induction ceremony.

STUDENTS

Department Banquet

The 2004 – 05 Annual Department Banquet was held at Badd Jacks in Tongonoxie on May 14. Prior to the award ceremony, and while people were still arriving, Mr. Curry and his wife provided wonderful musical entertainment. The crowd of over 80 faculty, students and staff enjoyed a tasty Mexican dinner while listening to an extensive list of accomplishments from within the Department.

Graduating this year at the undergraduate level, along with their specific degree, were:

Adam G. Lohoefener (BS Engineering Physics), **Andrew R. Bricker** (BA Astronomy), **Joshua E. Meyers** (BS, Astronomy, Physics), **Stephen N. Floor** (BS Physics), **Andrew Giebler** (BS Physics), **Jacob R. King** (BS Physics), **Ian M. Lewis** (BS Physics), **Matthew H. Matheny** (BS Physics), **Jesse D. Noffsinger** (BS Physics), **Andrew J. Womack** (BS Physics), and **Jason Shea** (BS Physics).

At the graduate level, graduating this year are: **Scott W. Chambers** (Ph.D. Physics), **Nurur Rahman** (Ph.D. Physics), **Lihui Jin** (Ph.D. Physics), **Brian Thomas** (Ph.D. Physics), **Shahid Hussain** (Ph.D. Physics), **Mike Santilli** (MS, Physics), **Jan Kurzidim** (MS, Physics), **Darius Gallagher** (MS, Physics), and **Carissa Hill** (MS, Physics).

Head cook at the fall picnic Bob Curry is cheered on by Don Nieto's kids and Steve Shawl.

Awards were also given out for the *Outstanding Senior in Engineering Physics* to **Adam Lohoefener**, the *Prosser Award for Undergraduate Majors* to **Daniel Hogan**, **Luis Vargas**, and **David Jones**, and the *E.E. Slossen Award for Outstanding Graduate Teaching Assistants* to **Evan Guarnaccia**, **Rainer Schiel**, and **Shramana Mishra**. The *Undergraduate Faculty Teaching Award* went to **Professor Judy Wu**, while the *SPS Staff Person of the Year* was presented to **Mr. Robert Curry**.

Also recognized at the banquet were the following recipients of Undergraduate Research Awards handed out by the University Honors Program: **Lori Smith**, senior in astronomy, mathematics and physics, daughter of Darrel and Kathy Smith; Baldwin High School, studies ***Correlating Cosmic Ray Flux with the Bone Cancer Rate*** with Larry Martin, professor and senior curator, Natural History Museum and Biodiversity Research Center and Professor Adrian Melott. **Brennan R. Metzler**, junior in mathematics and physics, son of Rob and Marcia Metzler; Rockhurst High School, Kansas City, MO., studies ***Front-End Electronics for the Zero Degree Colorimeter*** with Profs. Michael Murray, and Steve Sanders. **Laura A. Stiles**, sophomore in engineering physics, daughter of Mark and Brenda Stiles, Shawnee Mission East High School, studies ***Quark Chemistry: Is Chemical Equilibrium Attained in Relativistic Heavy Ion Collisions?*** with Profs. Michael Murray and Steve Sanders. **Benjamin E. Bammes**, senior in computer engineering and physics, son of Eugene and Ruth Bammes, Washburn Rural High School, studies ***Modeling Polymer Folding in a Poor Solvent*** with Prof. Jeff Olafsen. **Dana Craig Maher**, senior in physics, son of Susan N. Maher; Omaha Central High School, studies ***Attenuation and Dispersion in a 1D Stress Chain*** with Prof. Jeff Olafsen.

SPS visits Fermilab

Engineering Physics

EPHX 601 Projects

Graduating seniors of the EPHX program must complete a senior design course in the Department of Physics & Astronomy: EPHX 601, Design of Physical Systems. The course has recently been revamped as part of the curriculum restructuring of the senior level laboratory courses. As part of that restructuring, the course is now 4 credit hours and includes both minor and major projects that require the seniors to culminate their knowledge of mechanical, electrical and computational engineering in a deliverable product for our research and/or teaching laboratories. Here, we briefly profile our two graduating EPHX seniors and their design projects.

Chris Patrick designed an LED Pulser system to provide high-speed switching of virtually any LED on the market. The device works by skewing a low-speed clock signal from the National Instruments PCI-6221 Multifunction DAQ, and by using high-speed logic circuitry on a custom circuit board. LabView and the PCI-6221, which also provides power to the unit and to the LED, digitally control the pulse settings. The LED receives pulses of 2.2ns to 12.2ns long, adjustable in 10ps increments. The pulses can be repeated at any frequency up to 1 MHz, either continuously or for a specified number of pulses. This device is intended to interface with a photo-multiplier for use with Professor Graham Wilson's research.

Adam Lohoefener worked with Bob Curry to create a new user-control interface for thermometry experiments in our introductory physics labs. The project required interfacing two thermometers per workstation to the LabView platform through the PCI-6221 Multifunction DAQ board. Adam learned that pedagogical applications actually involve more, not less design, as care must be taken to provide an interface that our teaching assistants can use to instantly assess whether our lab students are performing their experiments correctly, while at the same time leaving the students with enough experiential learning opportunities to make the labs worthwhile. The software was prepared for students in this fall's offering of PHSX 211 and Bob Curry's development of a laboratory on Newton's Law of Cooling.

EPHX Alumni

Kyle Gonterwitz (2004) is working for the City of Lawrence Department of Utilities Engineering Division as a GIS Analyst (Geographical Information Systems). He was well prepared by his EPHX degree, passed the FE (Fundamentals' of Engineering) exam in 6 hours easily and is working towards a PE (Professional Engineer). At the Utilities Department, he handles the water treatment, distribution, and wastewater collection for the community. To continue to make use of his Aerospace Engineering background, he is also a student pilot.

Brent Harris (2004) is now working for the Secret Service.

Joni Jorgensen (2004) is pursuing her Masters degree in Aerospace Engineering Sciences at the University of Colorado at Boulder. She is a research assistant in the Structural Dynamics and Control Lab working on modeling the deployment dynamics of an elastic solar array. The prototype array is scheduled for launch this summer.

Nicholas Shea (2002) works at an engineering company in St. Louis called Lectro Engineering, which specializes in providing automated machinery for the downstream blow-molded plastics industry worldwide. The company is also involved with many innovative, custom automation projects in a variety of other industries. As such, Nick has put to good use the design experiences from his own EPHX 601 senior project in Professor Jeffrey Olafsen's laboratory (*see associated EPHX 601 story on this page*). He says he appreciates the work as a combination of elements of mechanical, electrical, and computer control systems design, all of which he was exposed to through the capstone course in Physics & Astronomy Department. After a year of overseas work experience in Asia, he enjoys city life in St. Louis.

Adrienne Juett (1999) finished her PhD in Physics at MIT in May 2004. Since then, she has been a postdoctoral research associate at the University of Virginia in the Department of Astronomy working with Professor Craig Sarazin.

Patrick De Lurgio (1999) has been working at Argonne National Laboratory as an Engineering Physicist. The focus of his work is the design of novel radiation detectors for two user facilities at ANL: the Advanced Photon Source and the Intense Pulsed Neutron Source. He currently resides in the Chicago area with his fiancée, Vanessa.

Taimoor Noor (1998) has been working at Sprint since July 1998, and is currently a Program Manager for a voice-over IP product. He has been selected to participate in the Sprint Leadership Development program and received the company's highest performance ratings in 2002 and 2003.

Don Eversmeyer (1965) is enjoying retirement in Kansas City, MO after a career in Systems Engineering with IBM. His newest interest is sailing and has led to a recent sailboat purchase.

Leo LeSage (1957) retired from Argonne National Laboratory in 1998 and lives in Naperville, Illinois, but has continued to work part time on various special assignments for Argonne. In 2002, he organized a NATO sponsored conference in Moscow on nuclear submarine decommissioning and disposal. More recently, Leo has been working on various issues related to the establishment of the World Nuclear University. Prior to retirement, he was Director of both the Applied Physics Division and the Engineering Physics Division. One of his most interesting duties during this period was his involvement in some of the recovery activities at Chernobyl. Currently, he also serves as a member of the KU School of Engineering Advisory Board.

From Lawrence to London

Katie Greene, a recent Master's graduate of the Department of Physics & Astronomy, was asked to share some of her recent experiences from her summer internship at *The Economist.* – *Editor's Note.*

The summer after my graduation, I hopped the pond. Physics was on my mind, but not in my job description.

My first experience outside of Heathrow airport in London was in a queue, as the British say, waiting for a taxi. I had an unexpected 80 GBP in my pocket from an incredibly gracious financial analyst whom I had just met on the plane eight hours earlier. He had admitted to me that he was quite fond of America. On his first trip to the States, he had the luxury of a warm welcome, and wanted to make sure I felt similarly welcomed in his country. Besides, he said with standard British humility, it's a shame how much they pay people in finance.

Confident I would safely be transported to my lodgings, I took a picture while waiting in line. "Katie's first queue," I thought it could be titled if I ever had the occasion to name it. Even though I knew it was time to start soaking in my new surroundings, I hadn't completely arrived in London yet. My thoughts were still back in Lawrence, thinking about everything I didn't have time to do before I left. I was actually still coming down from the rush of printing off the final drafts of my thesis and turning them in to the campus bindery on the morning of my flight.

I was in London for a three-month internship. It wasn't to continue research in a physics lab, however. I had earned the science journalism internship at *The Economist*—an international magazine that my mother was erroneously convinced was only sold in airports to businessmen. While I waited for my taxi and thought about that morning's rush to print my thesis, I felt relieved. I had made the Graduate School deadline and I would earn my Master's degree that summer. Yes, I thought, I just might make a fine journalist, working most fervently under the heavy pressure of an imminent deadline.

When I took the job that summer at *The Economist*, I joined the ranks of the 10% or so physics MS graduates with jobs that the American Institute of Physics calls "not science or engineering." It was scary. I wasn't trained for journalism. I had just spent the last two years of my life devoted to learning how to design, set-up and run an experiment in Professor Linda Olafsen's semiconductor laser optics laboratory. My experience with the press before the internship was limited to reading the Science Times as a treat in between data runs for my research project.

Katie Greene

But, in early 2004 I was finishing up my last official semester at KU and didn't have a distinct job opportunity. At this time, one of my professors, Michael Murray, showed me *The Economist's* annual call for the Richard Casement Intern. As their ad read, the aim was "more to discover writing talent in a science student than scientific aptitude in a budding journalist." It seemed worth a shot. As an undergraduate, my major was chemistry at a small liberal arts school where I was able to sneak in more than the required English classes. I even contributed science articles, over topics such as a simple explanation of the special theory of relativity and basic thermodynamics of the Challenger disaster, to the school's literary magazine. In graduate school, my primary writing outlet was as editor of a newsletter for the American Astronautical Society group. So, once I got it in my head that I could be the intern that *The Economist* was looking for, I became obsessed with applying.

The application was amazingly simple: a letter introducing oneself and a sample news article of 600 words. To be honest, I wasn't up-to-date on *The Economist's* science, so I went to the library and buried myself in recent issues, getting a feel for the writing and scope of their science. I thought about newsworthy stories that could come out of the KU physics department. My advisor, Dr. Olafsen, seemed to be a natural choice to highlight. Her lab was just starting to take-off and her projects touched on very socially relevant issues. One of the projects that I worked on was the characterization of mid-infrared semiconductor lasers. In particular, we were testing the laser performance at room temperature to determine if their structure offered promise for extremely sensitive chemical sensors for field use. Another project in her lab involved designing and fabricating detectors for a novel glucose monitoring system that wouldn't require a finger prick to measure glucose in a diabetic patient. No doubt that Dr. Olafsen's research was exciting and significant, but the more I looked at back-issues of *The Economist*, the more convinced I became that the application article needed to be something unexpected and maybe a bit more controversial.

In the end, I decided to write about Adrian Melott's proposed theory that a gamma ray burst was responsible for the second largest mass extinction in Earth's history. With the proofreading aid of KU's resident science writer, Roger Martin, I finalized my application and emailed it to London. Then, after a New York interview with *The Economist's* science editor, I ended up as the 2004 Casement intern.

I started out my London summer without any real clue about what it means to scour press releases for the most interesting research (by The Economist's standards). I didn't have experience contacting scientists and asking the right questions. And it was a

(Continued on page 22)

John Clark, Ph.D. student of Prof. Tom Cravens, currently on active duty (second from left) in Kosovo with his National Guard unit, writes: "As the S1 (Personnel Officer), I have adopted some additional duties: I am the primary liaison with the media here. Normally this was assigned to the S7 (Information Officer), but we had to change things up a little on staff. This has kept me rather busy as we do several TV/Radio shows every week"

Alumni News

Humberto Campins (BA Astronomy, 1977) continues to main-tain an extremely active research program involving comets. For example, in April 2005 in Varenna, Italy, he presented an invited talk at a conference on the role of water in the origin of life. The John Templeton Foundation sponsored this conference. A total of 20 scientists from around the world were invited participants, and he was the only astronomer invited. Then, in May 2005 he gave an invited talk at the Goldschmidt conference (geochemistry) on the contribution of comets to formation of the Earth's water supply. In July 2005, he made ground-based visible-light observations at Kitt Peak National Observatory of comet Tempel 1 before, during and after the impact with NASA's Deep Impact mission. Finally, in August 2005, he attended the "Asteroids, Comets and Meteors" conference in Buzios, Brazil. During a two-month summer visit to Tucson, he organized monthly moonlight walks in the desert, which were attended by his "old" KU astronomy professor, Steve Shawl.

As reported in the Athens Messenger in July of 2005, the Department of Physics and Astronomy at the University of Ohio has appointed **Joseph Shields** to be the new department chairman. Joe graduated in 1985 with double majors in Physics and Astronomy. He received the Stranathan Award, was the Outstanding Senior in Physics in 1985 and was selected as the Class of 1913 Award winner for graduation. Joe was also a University Scholar and a Summerfield Scholar while at KU.

Dr. **Roberto Aga** (PhD 2003) moved to a research scientist position at the Fisk University in Tennessee in March 2005.

Dr. **Albert Gapud** (PhD 1999) will join the faculty of the Physics department at South Alabama University in fall of 2005.

Dr. **Byeongwon Kang** (PhD 1998) has been appointed to a faculty position in the Physics Department of Chungbuk National University, one of the nine state universities in South Korea. She is the first female faculty member appointed by this department.

Brian Black (BS Geophysics 1987, BS Geology 1987) writes to us: "After wandering about in Europe and Turkey going on various and sundry Geophysical and Geological boondoggles, I've settled into the most mysterious realm of Computer Programming (ASP, .NET, SQL Server, you-name-it) and watching over a gaggle of Programmers and Business Analysts developing Enterprise-level applications for Web deployment. I'm living in Georgia and watching the amazing antics of the kids!"

Emeriti professors Herman Munczek and Tom Armstrong converse at the annual Departmental Picnic.

ALUMNI

The department relies heavily on contributions from alumni and friends to maintain a vibrant atmosphere of scientific enquiry. It is only through such donations that we are able to support the activities of our students.

Several years ago, Professor Emeritus Frank Prosser established a Prosser Award for an outstanding junior in physics or engineering physics. This was the first new scholarship program in the department since the Stranathan Fund was established over thirty years ago. Through generous donations, we have now been able to add several new scholarship programs: This past year we awarded our first Lowry Fellowship to an entering graduate student and our first Badgley Scholarship for a women undergraduate astronomy, physics, or engineering physics major. A new Tombaugh Scholarship will help support an entering astronomy undergraduate major in the fall. The Hansel Scholarship is now funding an Engineering Physics student.

The importance of these scholarship opportunities to the overall strength of the department cannot be overstated. At the undergraduate level, students (and their parents) are being asked to carry an increasing part of their educational expense. This is forcing some students to make difficult decisions on where to attend college based on financial considerations. The ability to offer some undergraduate scholarship aid is needed if we are to successfully compete for the best students. Although most of our graduate students do obtain some support through either teaching assistantships or research fellowships, a similar dynamic is at work where it is often necessary to augment our normal stipend to successfully compete for the best students.

With the creation of a permanent Committee on Alumni Affairs, the Department has begun to actively solicit funds to help in developing more scholarship opportunities for undergraduate and graduate students, as well as expanded resources for research and teaching. We hope to contact all of our alumni over the next year to describe the various ways they might consider helping to support the Department of Physics and Astronomy.

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September '04 - August '05

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Gary E. Hanson

Gary E. Hanson, a 1966 BS in Physics graduate of the department, paid a return visit to us on September 25, 2004. He spent the morning with Steve Sanders, who showed off the department and brought Gary up to speed on all the changes in research and instruction in the last 40 years.

We welcome the opportunity to show off the department. If you get back to Lawrence for whatever reason, please pay us a visit!

ASTRONOMY

(ULTRA – Telescopes!
Continued from page 4)

begin! The ULTRA project is taking most of Prof. Twarog's research time. As an immediate benefit from the project and our collaboration with San Diego State, Mt. Laguna Observatory has been designated a Research Experience for Undergraduates (REU) site by NSF. Two of our majors, Lindsay Mayer and Luis Vargas, have been selected for the inaugural program in 2005.

Currently, we have found some fascinating science targets to meet. In a rare confluence of luck and good weather, one run last May at the WIYN 0.9 meter on Kitt Peak provided enough photometric data to determine the reddening and metallicity of NGC 6791, one of the oldest and richest disk clusters. Undergraduate Lindsay Mayer spent her Tombaugh Fellowship summer reducing Stromgren photometric data while Professor Anthony-Twarog kept pace with calibration efforts. Using intermediate-band photometry of the unevolved stars in the cluster, the reddening was determined to be almost 50% larger than recent estimates using more indirect techniques. The interesting issue is the inability of the standard scaled-solar stellar models to match the combined effects of the higher reddening and high metallicity. Instead, a superior match is produced using isochrones generated with non-standard abundances for light elements relative to the scaled up iron abundances. Matched to "alpha-enhanced" isochrones with heavy elements boosted by 60% above solar, NGC 6791 appears to be 8 billion years old.

Steve Shawl has entered KU's phased retirement program; an article on that is included in the *Transitions* section. His professional efforts since September 2003 have been on the 5th edition of his introductory astronomy textbook, *Discovering Astronomy*. (He published a custom edition of the 4th edition last summer.) Since the original authors have now retired from the project, he solicited two additional astronomers as coauthors. One is past KU Adjunct Assistant Professor Keith Ashman, who is now at UMKC. Keith was brought into the project as an expert on galaxies and cosmology who has previous experience with publishing and creative writing. Professor Beth Hufnagel of Anne Arundel Community College in Maryland is a stellar astronomer whose PhD is from the University of California at Santa Cruz, and whose research specialty is astronomy education research. Her responsibilities on this edition were the writing of a new chapter on extraterrestrial life and working to make the writing style of the book as user friendly as possible.

(Light as a feather
Continued from page 4)

into space to orbit earth. The technology could also be used to build enormous, ground-based telescopes, larger than anything that exists now.

Bruce Twarog, the principle investigator on the grant, set the project into motion about five years ago. A college classmate of Twarog's told him that his company, Composite Mirror Applications, had succeeded in making optical mirrors for research quality telescopes. "They were looking for someone who they could work with to test out a small 16" telescope," Prof. Twarog says. At the time, Twarog didn't necessarily have money to fund such a project, nor did he have the facilities and technology to help the cause. As it turned out, however, Twarog learned that two KU aerospace engineers who are, in fact, experts in composites, were willing to collaborate on the project. But instead of settling for a 16" telescope, all parties involved decided to set their sights on a useful, one-meter instrument. "It worked out quite well," Twarog says.

One of the immediate benefits to the project and the collaboration with San Diego State University is that NSF has established Mt. Laguna Observatory as an official REU (Research Experience for Undergraduates) site and two KU astronomy undergraduates have been chosen to participate. Twarog also stresses the importance of using a telescope for 146 nights out of a year. "In a typical year, we might get 6-10 nights [with a different telescope]," Twarog says, "That's average."

The new telescope has the potential to operate remotely and have its images available for download over the internet. Twarog says the new images could supercede all of the data that's currently being used, and give more of it. "We'd like to get large samples," he says, "to beat the error down and get the kind of quality data we want." It seems a small telescope is still capable of some big things.

-Katie Greene

Daniel Nunes, former KU undergraduate, has defended his thesis and has lined up a postdoctoral research position at the Lunar and Planetary Institute in Houston, Texas.

Two-pound lightweight ULTRA telescope mirror.

CONTINUED...

PHYSICS

(Astrobiology
Continued from page 5)
their characteristics early on.) Most recently, a paper showing the results of detailed modeling of atmospheric ozone depletion and DNA damage appeared in Astrophysical Journal Letters. It showed that a short ten second burst can alter the atmosphere for a decade. NASA issued a press release on the work, including animations, which can be viewed at http://www.nasa.gov/vision/universe/starsgalaxies/gammaray_extinction.html.

Daniel Hogan, an undergraduate physics major, was a co-author of the APJ Letter. A total of five undergraduates have been involved so far, with other projects in the offing. Larissa Ejzak is co-author of a submitted paper exploring the sky-darkening and nitric acid rain effects additionally expected from a "nearby" GRB. Others working with our collaborators are looking at the pattern of extinctions in the Ordovician more closely. In addition, we are examining more recent events—say the last 40,000 years, including flight attendant cancer rates—for signs of cosmic ray impact.

As with all of the KU Biophysics efforts, the work is inherently interdisciplinary, and so far this research has involved high-energy astrophysics, paleontology, bio-geochemistry, atmospheric science, radiation/health physics, and stellar evolution. The group wants to look at similar risks posed by the fact that stars like our Sun have been observed to emit occasional giant flares (about 100,000 times stronger than anything our Sun has been observed to emit).

(CMP: Quantum Electronics
Continued from page 7)
superconducting qubits coupled to microwave resonator, and Zelin is studying correlations between microscopic structural defects, intrinsic noise, and decoherence in qubits. The senior Ph.D. student, Wei Qiu, is testing qubits that he modeled and designed last winter which are expected to have much improved physical properties. Richard Alexander developed a new qubit measurement method that will be several orders of magnitude faster, resulting in much better resolution when applied to study time evolution of qubits. Undergraduate student Matthew Matheny developed most of the software that has been used for manipulating and measuring superconducting qubits.

In this past academic year the group has published seven papers in peer reviewed journals including four in Physical Review A and two in Physical Review B (including one Rapid Communication) and has presented results at the Applied Superconductivity Conference and APS March Meeting.

(From Lawrence to London
Continued from page 18)
completely new thing for me to compile an entire article—complete with relevant background information—within the first two days of every week.

Even though I was still honing my writing skills, I had already learned how to distill the important information out of a heady research paper while at KU. In Dr. Olafsen's weekly group meetings we would read a paper, discuss its relevance, and often its obfuscated writing style. For Solid State Seminars, we had to take recent research, boil it down to its most fundamental points, supply background information and present it orally. In classes, we were required to figure out what was going on in the overwhelming sphere of specialized research and talk about it with the rest of the class. So while science journalism was new to me, I was well equipped by my graduate work at KU to do the most fundamental task of all science journalism: get to the core of the research.

Since the internship ended in the fall of 2004, I've taken the free-lance writing tack. But lasers are not entirely in my past. In fact, I'm currently working on a feature for a certain women's beauty and health magazine that delves into how lasers are used from anything from hair removal to de-wrinkling devices. For me, it's fun to learn about all sorts of research and write about it in a way that's accessible to many people. I know that the average person isn't interested in attending a science conference, or keeping updated on the latest research. Chances are, however, that many would like to learn about science discoveries through an interesting and engaging article or story. That's my goal. To me, this is the joy and challenge of science writing.

(Space Physics
Continued from page 11)
flow around that planet. This project has grown considerably and now includes studies of x-ray emission from the outer heliosphere as well as from atmospheres of nearby stars. This opens the possibility of remote studies of the composition and other parameters of stellar winds and their local interstellar medium. Ina Robertson will give a talk about x-ray emissions from the outer heliosphere at the Solar Wind 11 conference in Whistler, Canada.

Medvedev also continues his research on the physics of accretion flows and compact cosmic objects with strong gravity: black holes (BH) and neutron stars (NS). In particular, he has discovered a new self-similar solution for a boundary layer that forms when hot accreting gas settles onto a rapidly spinning NS. Such a boundary layer does not form in BH accretion.

Ali Soleimani and Jeff Wood examining some equipment at Fermilab

From the Editor

Greetings! That may be a funny way to end this year's newsletter, but by now you may have noticed that the newsletter has a slightly different appearance this issue. As reported in the Transitions section, Steve Shawl has entered phased retirement. As he's no longer in Lawrence during the part of the year that we construct the annual *Momentum* Newsletter, it was time for a new editor. I'd like to begin by thanking Steve Shawl for helpful advice and warnings from afar over email during the preparation of this year's issue, in addition to all of his hard work in previous years as the editor of *Momentum*. Having completed my first experience as editor, it has given me a deeper appreciation for the commitment of time that Steve made during his tenure.

I'd also like to take this opportunity to thank Teri Leahy for all her hard work in typesetting and generally "putting the whole thing together" in its final form. If you visit the department website in the future, you'll also find that we're upgrading the electronic presence of the newsletter and giving *Momentum* it's own page. On this page, we are going to have a color version of *Momentum* available for downloading and printing, as well as an archive of previous issues of the newsletter. Finally, I'd like to thank Katie Greene for contributing the freelanced articles "Light as a feather" for the Astronomy section, and the "Focus on Biophysics" article for the newsletter.

As usual, your feedback on how we can improve the newsletter is always welcome.

Jeff Olafsen

(Cut Here)

Keep in Touch!!

Let your KU friends know what you're doing…

If you would like to hear from the Department more often, you might enjoy our bimonthly in-house newsletter, which contains more details of what individuals are doing throughout the year. You can obtain it on-line at the Department Web site (www.physics.ku.edu), or we can send you a copy if you write to Ms. Teri Leahy in the Department with the request to the address given below, or email your request to momentum@ku.edu.

Please return to:
Department of Physics and Astronomy
Malott Hall
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To submit a news item for next year's *Momentum*, please complete and return the following form to the above address or e-mail to momentum@ku.edu

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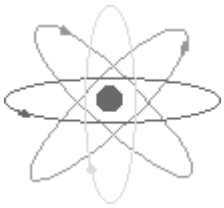

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The University of Kansas
Department of Physics and Astronomy
Malott Hall
1251 Wescoe Hall Dr., Room 1082
Lawrence, KS 66045-7582

Web site: http://www.physics.ku.edu

Editor: Jeff Olafsen
Desk Top Publishing: Teri Leahy
Freelance Contributor: Katie Greene