Momentum

Department of Physics & Astronomy –University of Kansas

Fall 2006

Judy Wu awarded Kemper–Fifth for Department!

For the past decade, a KU tradition has been the 1st day of class surprise visit of the Chancellor or Provost to the classrooms of new Kemper Award winners. This year, Physics and Astronomy faculty member Professor Judy Wu received such a visit at the start of her Introductory Physics I class (Judy is shown in the photo with KU Provost Richard Lariviere). The Kemper award, which recognizes outstanding teachers, includes a monetary prize of $5000 and the challenge of developing a 3-minute summary statement of the winner's teaching philosophy.

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National Student Honors.

Shawn Henderson, shown presenting his research in the left-most picture at the top of this page, has been awarded an NSF Graduate Fellowship to study particle physics at MIT.

Daniel Hogan and Luis Vargas have been awarded Goldwater Scholarships for 2006. Since 1993, 16 students within the Department of Physics & Astronomy have been awarded Goldwaters. Since 2001, KU has had 18 Goldwaters, 10 of which have been within Physics & Astronomy. Luis is expected to finish his triple major in Astronomy, Physics and Mathematics in May '08. He is a Prosser Award winner. In addition to his course work, Luis is also serving as co-president of the Department's chapter of the Society of Physics Students. Daniel, a 2003-04 Chancellor's Club scholar and Prosser Award winner, will also be finishing his undergraduate studies in May '08 with majors in Physics and Mathematics.

A full rundown of awards and honors garnered by our students is presented under the "Students" section of this year's Momentum.

Outstanding Research Award goes to Tom Cravens...

Professor Tom Cravens has been awarded the Olin Petefish Research Award in the field of Basic Sciences. This award, one of four Higuchi-Endowment Association Research Awards, is given to a Board of Regents faculty member in recognition of research accomplishment in the basic sciences.

Professor Cravens has been a key contributor for over 25 years to the development of our current understanding of how solar radiation and charged particles flowing from the Sun control the structure and dynamics of the upper atmospheres and ionospheres of planets and satellites. As a member of the Cassini research team, Prof. Cravens has most recently been studying the the upper atmosphere and ionosphere of Saturn's satellite Titan. The Higuchi award carries a $10,000 prize that can be used for research purposes.

Contents:

The Chair's Corner

This past year has seen a number of changes for both the Department and for the University. We start the Fall '06 term with a new Dean of the College of Liberal Arts and Sciences (Joseph E. Steinmetz, formerly Associate Dean at Indiana University) and also with a new Provost (Richard W. Lariviere, formerly Dean of Liberal Arts at the University of Texas). Although it is too early to assess how these leadership changes will affect the Department, we are very encouraged by the initial statements of our new Dean and Provost that suggest they share many of our priorities.

Within the Department, Professor Carsten Timm has now taken up residence and is getting people thinking about how spin effects can be exploited in circuit elements and, even more speculatively, how single molecules might be structured into circuits. As a condensed-matter theorist, Carsten fills a hole that we have had in our staffing since the retirement of Professor Ken Wong.

Professor Doug McKay has entered a one-year phased retirement period. Anyone associated with the Department over the past few decades will understand just how much we are going to miss Doug when he leaves at the end of Spring, 2007. While Doug has been the official mentor of a significant number of graduate students, he has had a direct influence on almost all of our graduate students for many years, as the person in charge of graduate advising and, more recently, as our Director of Graduate Studies. Doug's tireless advocacy of our graduate program has had a major impact. Professor Alice Bean took over as Director of Graduate Studies this past year, and now Professor Tom Cravens has taken on this role. Alice and Tom have had a difficult act to follow. Other departures include Professors Linda and Jeff Olafsen, who have now taken up residence at Baylor University.

An exciting new development for the Department is the formation of an Alumni Advisory Board. The Department decided to create such a group last year after our Committee on Alumni Affairs recommended that we take this action. Other departments in the College that currently have such boards speak very highly of them. It is a way to improve lines of communication with alumni, to promote communication between our alumni and the Dean's Office, and to allow the Department to benefit from the experiences of our former students. Ultimately the board is expected to have ten members. The initial board will be set up with six members, in part to allow board members to influence the selection of new members. I have been very gratified to have all of the individuals that were contacted to be part of the initial six member board accept their appointments. The current board members are: W.B. Anderson (EPHX BS '67), Tom Armstrong (PHSX BS '62, Retired Faculty), John Beacom(PHSX BS '91), W. Legler (PHSX BS '52), R. Sapp (Retired Faculty), and E. Sion (ASTR BA '68). Tom Armstrong has agreed to act as the initial Chair and will help organize the first board meeting later this Spring.

In separate mailings to undergraduate and graduate alumni this past summer and early Fall, respectively, the Department engaged in its first ever active solicitation for endowment funds support. I have been very gratified by the response so far, and hope that you will continue to keep us in mind! Your support allows us to maintain and, hopefully, improve the strength of our program. It promotes interactions between students and faculty and it helps us attract exceptional students into the department.

This Newsletter details many of the Department's accomplishments during the past year. Of course, what this really means: the many accomplishments of our students. These achievements are summarized in the discussion of the Departmental Banquet later in this issue of Momentum. The strength of our students at both the graduate and undergraduate level enable the diverse research program discussed in this issue of Momentum.

We were all very saddened to learn over the summer of the passing of Emeritus Professor Jack Culvahouse. A summary of some of Jack's accomplishments in the Department is part of this year's Momentum. I joined the Department about five years before Jack's retirement. During that time I was fortunate to have Jack as a mentor for the first time that I taught a class in the advanced lab sequence. Jack's understanding of mechanical and electrical systems was phenomenal, and I continue to be thankful for his willingness to share some of his knowledge of how things work.

Steve Sanders

Kemper: continued from cover.

Professor Wu exemplifies how teaching and research merge at a major research university. She has an international reputation for her research in superconductivity and nano-scale structures. Her laboratory is leading to major discoveries and some important patents. A visit to her laboratory will find high-school students, college undergrads, and graduate students all working together on the next discovery. The excitement that Judy bears for her work is clearly conveyed to her research students. Perhaps this is not so surprising for a research group. However, Judy also manages to express her love of Physics and the excitement of physics research to the classroom, where she has been equally successful in lower-level introductory physics classes and advanced solid-state physics courses.

Judy joins previous departmental Kemper Award winners: Professors Bruce Twarog (1998), Phil Baringer (2003), Barbara Anthony-Twarog (2004), and Dave Besson (2005).

What Happened to Pluto?

Clyde Tombaugh (KU class of '36) at the 1980 dedication of the KU Tombaugh Observatory. Last year noted the 75th anniversary of Tombaugh's discovery of the ***planet*** *Pluto and the 100th anniversary of his birth.*

It's Uranus, not "George"; Pluto, not "Zeus" or "Lowell" or "Constance" (the name of Percival Lowell's widow); Neptune, not "Leverrier." The tendency to politicize scientific discoveries is ever-present. Since 1919, the International Astronomical Union has worked to remove some of that pressure by establishing objective guidelines for the naming of newly discovered objects and classes of objects. If you discover a comet, it is named for you. If you discover anything larger, the best you may do is to propose a name (in the interest of full disclosure, there are two minor planets Banthonytwarog and Btwarog out there, names proposed by the Northeast Kansas Amateur Astronomical League). In the end, names and rules for nomenclature are approved by the IAU.

Like most large organizations (IAU membership is nearly 9000, about ¼ of it from the United States), much of the real work is done by smaller commissions to produce proposals for endorsement by the larger General Assembly at its meetings every 3 years. The IAU assembled a special working group comprised of astronomers and historians (readers might recognize the names of astronomers and historians among the members, including Owen Gingerich, Dava Sobel, and Rick Binzel) to come up with a self-consistent definition for "planets" that will carry us forward into exploration of the outer reaches of our own solar system and extra-solar systems. The definition proposed one physical criterion to distinguish a planet from other bodies orbiting a star: is it massive enough to morph itself into a spherical shape?

Anyone who has ever worked on a committee should not be terribly surprised to learn that the IAU rejected the definition recommended by its own commission. The IAU amended the recommendation in such a way as to effectively eliminate Pluto from the current definition. To be termed a "planet" now, the body must have also cleared interplanetary space in its region of orbit about the sun (If I were Neptune, I'd be a little worried—Pluto's path brings it closer to the sun than Neptune...). In short, it sounds like the definition was re-worked to eliminate Pluto and an indeterminate number of trans-Neptunian bodies.

Within days of this decision, planetary scientists and astronomers in the U.S. gathered more names on a petition than the number of voting astronomers at the IAU General Assembly. Signatories include all three of KU's astronomers as well as KU alum and Urey prize winner, Dave Tholen. The brief summary notes that "we, as planetary scientists and astronomers, do not agree with IAU's definition of a planet, nor will we use it." This issue is almost certain to come up again at the next IAU general meeting in 2009. We've joined the resistance; stay tuned. (BJAT)

Research Programs

Accelerator Physics

Professor Jack Shi's nonlinear beam-dynamics group has been concentrating on theoretical problems related to beam instabilities in high-energy particle accelerators. Currently, his group is working on two projects: a) a Large Hadron Colider (LHC) luminosity upgrade study and b) a project on the energy-recovery linac (ERL) X-ray facility at Cornell University. These projects are funded by the U.S. DOE and the NSF.

The LHC research is being done under the aegis of the U.S. LHC Accelerator Research Program (LARP) with the goal of studying a possible luminosity upgrade for the LHC (which is located at CERN in Geneva, Switzerland). For many years, a significant increase in the luminosity of current and future high-energy storage- ring colliders has been one of the major priorities of R&D for high-energy and nuclear physics research. For the past two years, LARP has planned a series of beam-dynamics experiments using the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory to study possible scenarios of LHC luminosity upgrades. In order to have a better understanding of the experimental measurements, the KU group is working on the numerical simulation of the experiments.

The ERL program involves a study of the effects of coherent synchrotron radiation (CSR) on high-intensity electron beams. The design of future high-energy accelerators, especially the next generation of light sources, will require the manipulation of high-intensity short electron bunches around bends with small radii. When the bunch length is shorter than the wavelength of synchrotron radiation, the radiations from individual particles add constructively to form coherent synchrotron radiation and this coherent radiation can in turn interact with particles within the bunch. This collective radiation-particle interaction can be a strong nonlinear perturbation to beam dynamics and can result in instabilities of the beam. An understanding of the CSR effect is therefore important to the development of future accelerators. The KU group is developing a numerical simulation method to study this collective CSR effect.

Astrobiology

Astrobiology is a highly interdisciplinary research area which focuses on life on Earth and its possibilities elsewhere in the Universe, particularly in the context of knowledge based in astronomy and astrophysics. Astrobiology research at KU has been led from within our department, with Professors Melott and Medvedev, and has included KU faculty in Geology, the Biodiversity Research Center, and the Department of Ecology and Evolutionary Biology. External collaborators exist at the NASA Goddard Space Flight Center, the University of Illinois, and now at Washburn University in Topeka. Brian Thomas, a 2005 Physics Ph.D. who worked with Prof. Melott, is continuing his research as a new Assistant Professor at Washburn.

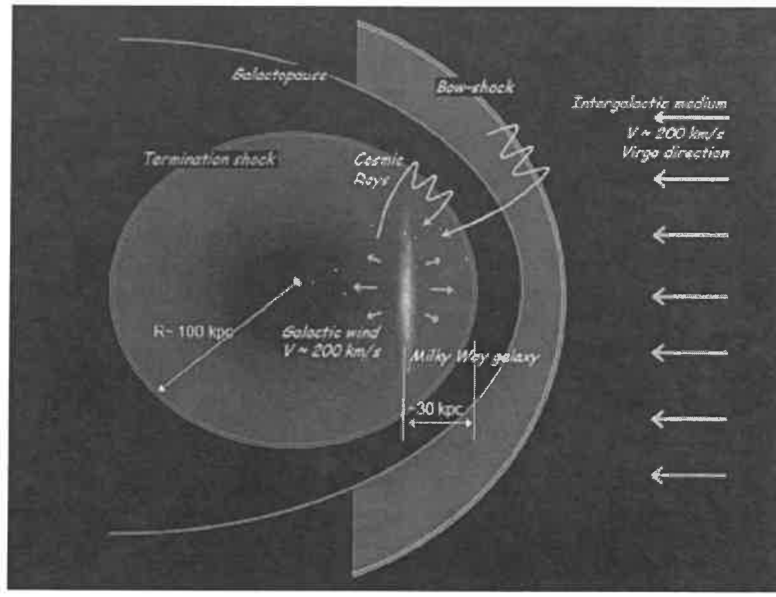
Brian Thomas, a 2005 KU Ph.D. who is now on the faculty at Washburn University.

Astrophysical ionizing radiation and the Earth's atmosphere

Prof. Thomas was the central computational figure in a series of publications which elaborated the effects of a gamma-ray burst striking the Earth. GRBs are the most powerful explosions in the Universe, going off at the rate of a few per day. This translates into a substantial probability that one would go off on "our side" of the galaxy, pointed at us, every few hundred million years or so. The work showed that such a burst, lasting only seconds, could severely damage the protective ozone layer such that damaging ultraviolet light from the Sun would approximately triple, causing widespread cancer, mutations, and killing off single-celled organisms which are at the base of the food chain in the oceans. This could have been responsible for one or more of the "mass extinctions" that have affected the Earth in the past.

In 2005-2006, Larissa Ejzak, an undergraduate, began working on the same problem. Her noteworthy research, after assisting with some earlier work, was to examine how varying the duration of the "burst" (from 0.1s to about 3 years) and varying the typical energy of the photons (from about 2 keV, in the soft X-ray up to 200 GeV, a hard gamma-ray energy) affected the results. Understanding this is important, because other threats exist, such as "short" GRBs, with higher photon energies, and supernovae, which take months to fade away. Supernovae have been known for some time to constitute a threat, and in recent years Fe60 deposits have been found in the oceans which indicate a supernova within a few hundred light years about 2.8 million years ago. There has been speculation that this may have been related to the climate change that boosted hominid evolution around that time. On the other hand, short GRBs represent a new possible threat, because recent research has shown that their rate has been increasing as the Universe ages, rather than decreasing like that of ordinary "long" GRBs. Larissa's work will make it possible to better understand the effects of such events upon the Earth.

Another activity related to the work has caught public attention. Larissa (who graduated in May, and is now attending Wisconsin in their physics Ph.D. program) was a double major in physics and theatre. Yes, theatre. She was required to present her own play as an honors graduation project (in theatre, not physics), and she chose to do BURST, a play about survivors on a modern-day Earth irradiated by a gamma-ray burst. Presented in KU's Inge Theatre on May 10, the play created a talk-back discussion which lasted as long as the play. People are obviously fascinated by this crosstalk between the natural sciences and the humanities. The item was highlighted on the KU website and the Lawrence Journal-World. For stories, see http://www2.ljworld.com/news/2006/may/08/physics_theater_collide_ku_students_play/ and http://www.news.ku.edu/2006/may/4/ejzak.shtml.



A diagram of the local environment in the rest frame of our galaxy. The galaxy should have one or more shock fronts corresponding to the expansion of hot gas from the galaxy itself, and a bow shock at galactic north at it falls at about 200 kilometers per second through the intergalactic medium toward the Virgo Cluster of galaxies, about 60 million light years away. The Sun and its planets are exposed to increased cosmic rays from these shocks when it emerges on the north side of the disk.

Larissa Ejzak, 2006 Physics B.A., author of physics research publications and her own play dramatizing some of its implications. Image courtesy University Relations.

Larissa was one of two graduates whose stories were highlighted by Chancellor Hemenway in his Commencement address:

"— Larissa Ejzak is graduating with a 4.0 in her double major of physics and theatre. She made a perfect score on the GRE. She recently starred in the one-person drama she wrote in fulfillment of her honors degree in theatre. It is called "Burst," about gamma-ray bursts, the brightest known explosions in the universe. Such bursts can seed destruction or supply powerful illumination.

That is a thought worth keeping for a future commencement. Each one of you is a bright explosion in the universe, about to take off for a destination beyond KU. We will watch how your bright bursts illuminate the galaxy. Know that we care about you and want you to be a shooting star for the rest of your life. Be a beacon to others so they, too, can be dazzled by the power of the Jayhawk. And remember, you may go a long ways, even to Halimuhfack, but the hill will bring you back.

Congratulations, Jayhawks!"

Well, that's a hard act to follow. The group has just started a collaboration with researchers at the University of Illinois, to combine its methods with work there on the propagation of cosmic rays and the blast wave to produce the first unified attack on understanding the overall effect of a nearby supernova. Graduate student Dimitra Atri has begun to work on this. He'll be attending a Computational Astrobiology summer school at the University of Hawaii to learn more advanced techniques. Hard duty!

Biodiversity oscillations, galactic dynamics, and cosmic rays

A new line of research has opened with a new idea by Profs. Medvedev and Melott. In spring 2005, a paper was published in Nature by UC Berkeley physicists Rohde and Muller, who noted a strong 62 million year periodicity superimposed on the long-term growth of biodiversity on earth over the last 550 million years. Because of the high significance of the signal, the authors and editors decided to publish even though there was no very plausible explanation for the effect. The KU team think they may have found one, involving cosmic rays and the motion of the galaxy through the larger Universe.

The fascinating thing is that the period of the signal coincides with the period of the oscillation of the Sun perpendicular to the plane of the galaxy—bobbing up and down as it follows its elliptical orbit around the galactic center. But most things you can think of would affect the environment at maximum or minimum distance from the midplane, not once per period. Well, it happens that not only does the period coincide, but the phase does too: big drops in biodiversity coincide with the Sun's maximum excursion to galactic north. And galactic north is the direction of the Virgo Cluster, the major mass concentration in the Local Supercluster toward which the galaxy is falling at about 200 kilometers per second. Such a motion should create a major shock front in the hot plasma that permeates the supercluster and its interface with the galaxy's own hot "wind", which would accelerate cosmic rays. The galaxy's magnetic field, much stronger toward the midplane, normally shields us from most of these cosmic rays. And, when the Sun pops up out of the galactic plane, the Earth along with it, it is bathed in a greatly increased flux of such cosmic rays, with their potential for direct radiation damage to organisms, climate change through atmospheric effects, etc. The bad news: we are above the midplane and on the way up. The good news: any new danger from this problem is millions of years in the future.

By the way, the "demise of the dinosaurs" mass extinction, the one most people know about, does not fit into this mechanism. It happened not when the Sun was at galactic north, but when it was near midplane crossing. But this, too, makes sense: that extinction event is associated with an asteroid impact, and such an event is more likely to happen near midplane crossing, when the Solar System is facing increased perturbations from nearby stars, encounters with molecular clouds, etc. So it does fit the model, in a more general way.

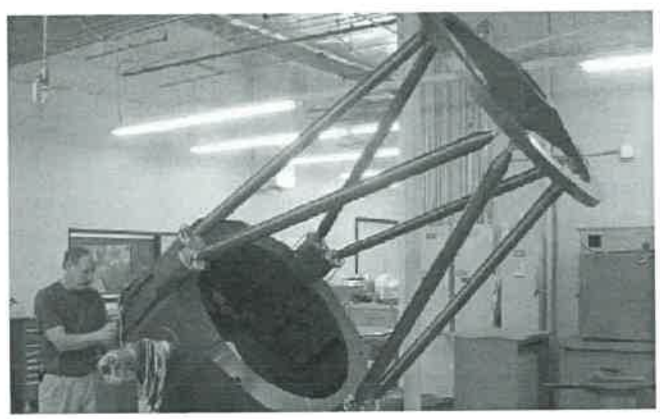
The group continues to present its results at scientific meetings such as the American Physical Society, the American Astronomical Society, and Geological Society of America. During the summer, members of the group were filmed for a National Geographic Channel TV documentary, to premiere Nov. 2 and be repeated periodically thereafter.

There are many other research irons in the fire, including studies of isotopic evidence for cosmic ray fluctuations and climate change in ice cores; bone cancer in dinosaurs; modeling biodiversity changes as a fractal process; the role of climate change in recent species extinctions; and many others. The group has funding from NASA, but funding continues to be a challenge, as the work definitely does not fit any pigeonholes!

Astronomy

The end of the Spring semester closes out an extremely full but successful year for the Astronomy program in both research and student development. On the research side, the dominant focus last year continued to be the ULTRA Telescope Project. The key pieces of the project are nearing completion, with installation of the components scheduled for summer 2006 at Mount Laguna Observatory (MLO) in California. Aerospace Engineering graduate students Riaan Myburgh and Sylvia Bianchi, under the direction of Drs. Ray Taghavi and Rick Hale, completed their MS theses analyzing the response of the composite structures and mirrors to the stress of the environment expected for the day-to-day operation of the telescope, leading to significant revisions in the design of the final optical tube assembly and mirror cell. Following approximately a year of testing and revision using 16-inch mirrors, Composite Mirror Applications (CMA) of Tucson began producing the first in a series of 1-meter class mirrors in November 2005. With the fourth mirror in the 1-meter series generated in April 2006, the optical components are meeting the specifications required for a research-quality telescope. At ACE, Inc. of Tucson, the telescope mount, the telescope drive system, and filter-wheel instrumentation have been completed. Integration with the optical tube assembly and mirrors from CMA is expected in early June, with the parts delivered to Mt. Laguna outside San Diego by mid-June. Renovation of the former 16-inch telescope building at Mt. Laguna has been underway since April 2006 and, with the arrival of a new 22.5 ft diameter Ash dome in June, construction of the complete system will be the top priority. It is expected that full integration of all pieces of the puzzle, including the CCD camera, for remote-access operation will take 2-3 months, with full-scale imaging programs planned for Fall 2006.

Speaking of Mt. Laguna, the cooperative program with San Diego State University has already paid dividends in the form of funding from NSF for a Research Experience for Undergraduates summer program at MLO. Two of our majors, Lindsay Mayer and Luis Vargas, spent six weeks in summer 2005 learning the ropes of using a CCD camera and a photoelectric photometer. The latter project was designed to evaluate an apparent discrepancy among cooler stars where a photometric index indicated that stars with higher than solar metal content appeared evolved when, in fact, they aren't. Both the data obtained and followup analysis of literature results have confirmed the phenomenon, though its origin remains a mystery. The project led to a 2006 Goldwater Scholarship for Luis Vargas, who is spending this summer at an REU program at the University of Wisconsin. Lindsay Mayer completed her degree in December 2005 and, after working at Science City in Kansas City, has entered the graduate program in Geophysics at KU, with a long-term interest in studying planetology.



ULTRA telescope undergoes testing in Tucson.

The ongoing program by Anthony-Twarog and Twarog to evaluate the fundamental properties of open clusters within the context of galactic evolution continues, involving undergraduate majors Elisabeth Callen, Stuart Jack, and Nikki Taylor in a variety of tasks associated with the analyses. On the publishing front, NGC 752, a nearby sparsely populated system, was brought into the Calcium-filter fold using data obtained a number of years ago using the 24-inch telescope and photometer at MLO. The results from the Calcium system mesh beautifully with recent photometric and spectroscopic results for this slightly sub-solar-metallicity cluster. In contrast, CCD data for a richer, southern open cluster, Melotte 71, for the first time has reliably defined the cluster reddening and metallicity and, in the process, resolved a variety of inconsistencies among past studies of this 1-Gyr old open cluster, removing it as an anomalous representative of the cluster population within the solar neighborhood.

Following up on last year's report, the high photometric metallicity obtained for the old open cluster, NGC 6791, has now been confirmed spectroscopically, though the cluster shows no sign of enhanced alpha-particle elements such as Ca, O, Mg, etc., removing this option as an explanation for the high reddening and old age. Fortunately, the Ca-filter system is extremely insensitive to the value of the adopted reddening. Past work identifying the old, southern cluster, NGC 6253, as the most metal-rich cluster known has led to a collaborative project with Con Deliyannis and his group at Indiana University to do a spectroscopic study of the cluster stars from the brightest giants to the unevolved main sequence. From two "transparency-challenged" runs in 2005 and 2006 on the 4m telescope equipped with the HYDRA multi-object spectrograph at CTIO in Chile, high resolution spectroscopy reveals a metallicity well above solar and an absence of Li among the giants, indicative of the effects of atmospheric evolution of the stars. We should have a definitive estimate of the cluster's role within stellar and galactic evolution by the end of the year.

Part of Steve Shawl's phased retirement time during the spring went into teaching one section of introductory astronomy at Pima Community College in Tucson. Having no previous community-college experience, he felt it would be an interesting experience to have. Additionally, he had to use a competing textbook, which showed him how good a book he has helped produce. With a class of only 25 students, he was able to learn the names of 100% of the class! He found the students to have varied backgrounds that were, in general, lower than that of KU students. However, the school expects that mathematics be included in the course, which is a challenge for both teacher and student. He expects that the experience will influence his KU course in fall 2006.

Biophysics

Chris Fischer, currently the department's only biophysicist, has been busy collecting preliminary data and submitting grant proposals. His initial research has focused on studying the chromatin remodeling and DNA translocation activity of the ISW2 chromatin remodeling enzyme from S. cerevisiae. With help of collaborator Dr. Timothy Richmond (ETH, Zurich), Chris has obtained preliminary data demonstrating that ISW2 is capable of translocating along both double- and single-stranded DNA. Furthermore, significant progress has been made toward developing a stopped-flow fluorescence assay for studying nucleosome mobilization by ISW2. In addition to work with ISW2, Chris has also started a new collaboration with Dr. Brad Cairns (University of Utah School of Medicine) performing similar studies with the S. cerevisiae RSC remodeling complex.

Chris has several research proposals currently under consideration at the NIH and the NSF. In addition to this, he has been awarded both a General Research Fund (GRF) award and a New Faculty General Research Fund (NFGRF) award this year for his efforts.

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 led, in the past five years, to the development of the "Standard Cosmological Model." These advances, observational, experimental and theoretical, have led to great excitement in the cosmological community in general and the Cosmology group here at KU in particular. The members of the Cosmology Group continued in their research efforts and started branching to various new directions.

Prof. Feldman has continued his investigation of large-scale cosmic flows to study the distribution of matter in the Universe. With graduate student Devdeep Sarkar and a researcher from Willamette University in Oregon, he showed that velocity field surveys are optimally suited to probe the cosmic mass distribution dynamically. Prof. Feldman has also ventured into the direction of the interface between cosmology and particle physics, receiving a grant to put constraints on the mass of the illusive neutrino (a particle that travels through our bodies, and through Earth, without our notice) using cosmological data sets with collaborators from University College in London, UK. The neutrino mass has direct, but subtle, effect on the large scale structure of the Universe. He also collaborates with researchers from Poland, Fermilab and China on the Sunayev-Zeldovich Effect. Also, with our own Prof. Marfatia, he began an effort to study the coupling of the neutrino to the postulated Dark Energy in the very early Universe.

Prof. Feldman has continued his public outreach effort, discussing science with diverse audiences. Discussing extra dimensions to elementary school children, the formation of structure in the Universe to church and civil groups, the history and evolution of the Universe with middle and high school students and public lectures at Benedictine College and the KU Math Department. He also gave more technical talks to Physics Departments at the University of Florida, Gainesville, UMKC, Fermilab, etc.

Prof. Feldman organized and ran a four-lecture series on "Science, Education and the Public" at the Dole Center for Politics here at KU. The talks centered on the questions "What is science?" and "How do scientists go about studying the universe and how a variety of phenomena started and evolved in it?" Topics included cosmology, evolutionary biology, geology, global warming and other politically "controversial" natural sciences. There is a bizarre "controversy" around the nation regarding the evolution "debate" and Intelligent Design but perhaps much more egregious is that the Kansas Board of Education took it upon itself to redefine science to include supernatural explanations. The lecture series (http://mactania.phsx.ku.edu/Lecture-series/) addressed these issues and achieved great success bringing many people (sometimes with overflow crowds) to the Dole Institute.

Professor Feldman has continued his public outreach efforts, giving talks at Bethel College (Kansas) and Blue Valley Community College (Missouri) on the relation of cosmology to broader public issues and concerns.

Prof. Shandarin in collaboration with Roya Mohayaee from l'Institut d'Astrophysique de Paris France studied the structure of the first dark-matter halos formed in the universe. The nature of the dark matter making up the most mass in the universe is one of the most intriguing puzzles in modern physics and cosmology. There are several ongoing experiments aiming to detect the dark matter particles and even more are planned for the future. One suggestion was to look at possible annihilation processes in the dark matter halos. The dark matter density profile in the halos has a spiky character due to formation of caustics and these regions are natural candidates for a strong annihilation signal. The current work has carried out a detailed study of the density profile in the vicinity of caustics including the smoothing effect of small thermal velocities; the results are used in estimates of the annihilation fluxes from dark matter halos.

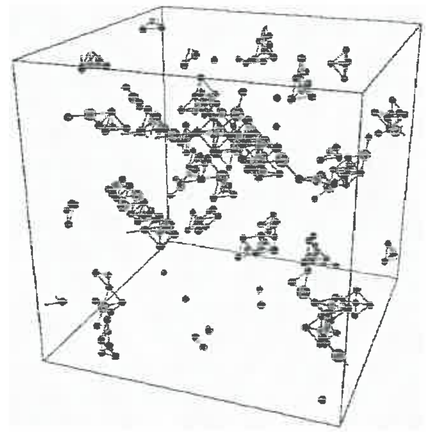
Profs. Hume Feldman and Sergei Shandarin in collaboration with researches from Los Alamos National Lab (Los Alamos, New Mexico) studied the shapes of voids of galaxies in numerically simulated models of the universe. They found that the voids have complex shapes that can be approximated only poorly by ellipsoids. The largest voids have also a very rich substructure in the form of the filaments running through them. Both findings challenge the modern theoretical models suggested to explain the observations.

The results have been published in Monthly Notices of the Royal Astronomical Society and have been reported at several national and international meetings and institutions including the workshop on Voids of Galaxies at Aspen Center for Physics at Aspen Colorado, Nonlinear Cosmology Workshop at Observatoire de la Cote d'Azur in Nice France, at the workshop "The World a Jigsaw: Tessellations in the Sciences" at Lorentz Center at Leiden Netherland, at the Centre de Physique Theorique in Marseille, France, and at Canadian Institute for Theoretical Astrophysics in Toronto Canada.

Condensed Matter Theory

After being absent for several years, the Department once again has a condensed-matter theory program being led by Professor Carsten Timm. Professor Timm brings expertise on unconventional superconductivity, the quantum Hall effect, nonlinear optics, magnetic ordering in chains, thin films, and in-bulk systems, two-dimensional liquid crystals, and electrons tunneling through single molecules.

Currently the main direction of research in Timm's group concerns diluted magnetic semiconductors and electronic transport through molecules. Diluted magnetic semiconductors (DMS) are conventional semiconducting materials such as silicon or gallium arsenide doped with magnetic ions, for example manganese. This means that some fraction of the atoms in the semiconductor are replaced by magnetic atoms. It turns out that the resulting materials are often ferromagnetic (like a bar magnet or a fridge magnet). But they are also still semiconductors, which leads to a number of interesting effects. For example, changing the electron concentration affects the magnetic properties. DMS are also strongly disordered materials. This is because the dopand atoms are incorporated in at least partially random positions. Therefore, DMS are an ideal way to study the interplay between disorder, electronic transport (currents), and magnetism. In the DMS Ga1-xGdxN the magnetism is not understood at all. One project in the group concerns the study of this material in collaboration with Prof. Wu's group.



Simulations of defects in a feromagnetic semiconductor.

The other field of work of Timm's group concerns electronic conduction through molecules. In recent year, experimentalists managed to create metallic contacts (leads) to single molecules—even to H2, which is an amazing feat. The group's interest is mainly in magnetic molecules. One important question is how the electrons tunneling through the molecule on their way from one lead to the other interact with the magnetic moment of the molecule. The group is also working on fundamental questions regarding the theoretical description of the molecule in contact with the leads.

Condensed Matter Experimental

Thin-film and nanoscience group

The thin-film and nanoscience group led by Professor Judy Wu has had a fruitful year in their research sponsored by NSF, DOE, AFOSR and ARO. The group has developed experimental approaches in engineering the microstructure of the highest-T_C superconductor (HTS) films at nanometer scales to improve the critical current density J_C, which has been one of the most important parameters for various applications in electric power related devices and systems. One of the long standing puzzles is that the "optimized" J_C in HTS films is more than one order of magnitude lower than the theoretically predicted "depairing" J_C—the ultimate limit of J_C. By inserting nanopores into the HTS films, her group has doubled the J_C over the value "optimized" over the past 20 years. This novel approach that her group has developed originates from a fundamental physics concept: Nanopores divide the electric current path into multiple filaments. When the dimension of the filament cross-section is approaching the London penetration depth, magnetic vortices can no longer form inside the superconductor, which leads to high J_C!

A related project that her group has been working on, through a broad collaboration under an AFOSR MURI program with the University of Wisconsin, Stanford University and Oak Ridge National Laboratory is to resolve the mysterious decrease of J_C with the thickness of HTS films. After a series of experiments to exclude the microstructure as a dominant mechanism, her group designed a trilayered structure with two HTS films sandwiching a thin insulating layer of variable thickness. It has been found that the magnetic vortices can be decoupled in the two HTS layers when the insulating layer thickness is above the "Cooper pair" coherence length and the thickness dependence of the Jc can be eliminated by chopping the magnetic vortices short.

In a development that may significantly advance the goal of producing nanoscale electrical circuits, the thin-film and nanoscience group, in collaboration with the Royal Institute of Technology, Sweden, has produced boron nanowire "Y" junction arrays. In the well-documented vapor-liquid-solid (VLS) mechanism for semiconductor nanowire growth, a low-melting catalyst is employed to generate VLS interface for single nanowire growth. In the process developed by Prof. Wu's group, a second low-melting catalyst was introduced, which generated a modified VLS interface for multiple nanowire initiation from the same nucleation site, each with large tilt angles. By forcing two bundles to cross each other, two boron nanowires can be fused together and a Y-junction is formed if the growth continues after the fusion.

Shramana Mishra and Xin Gao defended their MS theses successfully in August 2005. Shramana joined her husband in India and Xin has joined the Ph.D. program for Statistics at the University of Michigan. Undergraduate student Alan Dibos graduated this May and is now attending Harvard as a student in the Applied Physics graduate program.

Quantum Computation and Quantum Information

The QUantum Electronics Science and Technology (QUEST) Laboratory, led by Professor Siyuan Han, has Research Associate Chui-Ping Yang, postdoctoral researcher Shao-Xiong Li, graduate students Wei Qiu, Bo Mao, Zelin Zhang, Ming Wang, and Richard Alexander, and undergraduate student Matthew Natheny. The group's research activities are focused on the development of quantum computer using solid state superconducting electronic devices and circuits.

Quantum computing merges three of the most successful scientific and technological developments of the 20th century: quantum physics, computer science, and nanotechnology. Although technological developments are still in their infancy, there have been a variety of theoretical and experimental concepts, methods, and results that clearly demonstrated the great potential of quantum computing.

Following are some of the most important applications of quantum computing:

- Cryptograph – perfectly secure communication
- Searching, especially algorithmic searching
- Factorizing large numbers very rapidly
- Simulating quantum-mechanical systems efficiently

The field of quantum computing is growing rapidly. Although practical quantum computers lie years in the future, this formerly fanciful idea is gaining plausibility.

The fundamental element of any quantum computer is the quantum bit (qubit). Unlike a conventional bit–the basic unit of today's digital information technology–that can represent one of the two possible logical values (0 and 1) but can never be both simultaneously, a qubit can be 0 and 1 at the same time. It is this intrinsic quantum parallelism that lays the foundation for the incredible power of quantum computing.

A dramatic example of quantum computing can be made with a comparison to today's conventional computing technology. Consider a computer program that analyzes every possible combination of 100 flipped coins, which means that there are 2 to the power 100 possible different configurations. Using a traditional PC with 64-bit architecture and a 4 gigahertz clock speed, the analysis would require in excess of 250 billion years to complete. In contrast, a quantum computer with 100 qubits could complete the same task in less than a second.

However, before a practical quantum computer can be built, one must overcome many hurdles. One such challenge is to isolate qubits as much as possible from their environment which is the source of decoherence—a process that destroys quantum coherence and thus turns a qubit into a classical bit. Dr. Han's group is developing qubits and quantum circuits that are based on Josephson tunnel junctions. Compared to other approaches to quantum computing, such qubits are relatively easy to control and to scale up to sizes required for practical quantum computing. The major task is to identify the sources of decoherence and find ways to reduce their effects to the level needed for useful quantum computation. In 2002 Dr. Han's group and collaborators demonstrated the operation of the first superconducting phase qubit in the world. This has stimulated intensified research activities in this field.

In addition to quantum computing, the group also works on the realization of macroscopic coherence—i.e., creation of Schrodinger's Cat with Superconducting QUantum Interference Devices (SQUIDs) and macroscopic quantum phenomena in devices made from unconventional superconductors.

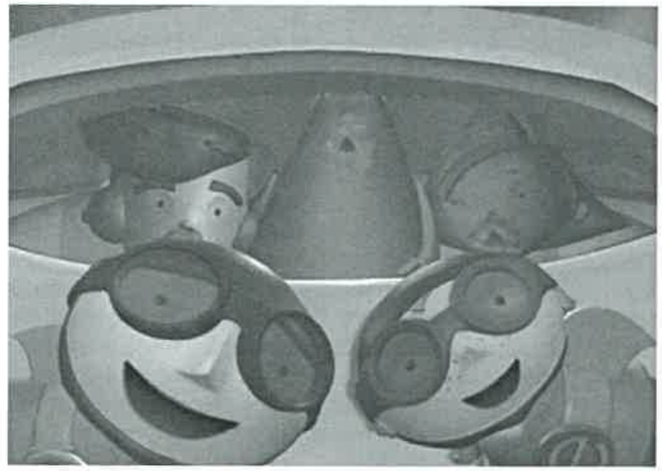
New class 1000 clean room. Not seen in the figure is an even more controlled class 100 clean room with entry from the class 1000 room. This facility was largely funded by a DOE grant of the high-energy group, with additional Department, College and University support. The facility is now used by both the high energy and condensed matter groups.

High Energy Experimental

During the past year, two silicon projects were completed by the experimental particle physics group. For the D0 detector, the Layer0 detector was successfully installed as the innermost layer in April of 2006. This detector consists of 48 silicon strip sensors mounted on six facets on a 1.68 m long, 1.6 cm radius carbon fiber support structure. This new detector is expected to help improve the b-jet tagging efficiency by 15%. The Kansas group helped to design the detector and build and test the electronics with Prof. Alice Bean as a co-project manager. In addition to postdoctoral research associate Len Christofek, grad students Peter Bryant, Justace Clutter, and John Gardner, as well as undergraduate students David Hover, Vitaly Kheyfets, and Jake King were crucial to the success of the project. For the CMS project, the group has helped to build and test over 5000 modules for the Tracker Outer Barrel Detector. The bulk of this construction project took place at Fermilab's Silicon Detector Facility and module construction was complete in April of 2006. These modules are currently being installed on rods which are then installed in the larger mounting structure located at the CERN laboratory in Geneva, Switzerland. Postdoctoral researcher Don Coppage helped to lead the assembly effort at Fermilab. Undergraduate students located at KU were able to help manage the database issues associated with the assembly and included: Carl Hinchey, Lawrence Percival, and D'Arcy Stone. Graduate student Jie Chen joined the effort during the Spring 2006 semester and will travel to CERN to help install and commission the detector. The CMS group, which also includes Professors Baringer and Bean as well as postdoctoral researcher Tania Moulik now plans to help understand the calibration and database software as well as the tracking plans for the detector.

KU physicists working on the D0 experiment also had a busy year for data analysis. Two Ph.D. students completed their dissertations. John Gardner graduated in October 2005 after successfully defending his analysis of W and Z boson production. Shabnam Jabeen completed her thesis in April 2006. She looked for electroweak production of the top quark. Postdoc Leonard Christofek has also been heavily involved in D0's search for electroweak production of the top quark. He was a main author on two recent publications about the search. Postdoc Tania Moulik was a main author on an exciting recent publication on Bs mixing. D0 is the first experiment to establish a finite value for the oscillation frequency of the mixing. Undergraduate David Hover worked with Moulik on the analysis. Members of the D0 collaboration at KU are Profs. Baringer, Bean, and Wilson, postdocs Christofek, Coppage, Hensel, and Moulik, former graduate students Gardner and Jabeen, and current graduate student Clutter.

After several years of germination of an idea, the "Quarked! Adventures in the Subatomic Universe" project was given a big boost when a Kansas NSF EPSCoR grant was awarded in June, 2005. Imagine a world in which kids are as excited about science as they are about their favorite animated characters on TV and in the movies. What would happen if instead of fictional characters, their animated heroes and nemeses were actually based on real scientific principles? An interdisciplinary group of physicists (Profs Alice Bean and Phil Baringer), designers, writers, and educators is now testing these ideas with the arrival of the Quarked website in February, 2006 (www.quarked.org). The group has produced three short 3D animations and developed lesson plans and other materials to present particle physics in an engaging way to elementary aged children and yes, even adults. The project facilitator, Dr. Connie Hallberg, went on the road to Kansas schools to present hands-on activities programs, reaching over 1000 kids. The group received another grant from the Kauffman Foundation that will allow expansion of the website and hopes to convince PBS Television that they need a half-hour animated series about quarks.



The QUARKED! crew.

Prof. Graham Wilson continued to spearhead the local effort to secure the International Linear Collider (ILC) in the US. This next-generation experiment is widely conceded to be the successor experiment to the Large Hadron Collider (LHC), based in Geneva, on which Profs. Wilson, Bean and Baringer all collaborate. The projected turn-on of this experiment in 2016 anticipates a 10-year lead in time necessary for defining the hardware and also using the results from the LHC to guide the construction and design of the ILC. With a strong background in calorimetry, Prof. Wilson is expected to play a seminal role in the fabrication of the ILC's electron and photon detection apparatus.

Led by undergraduates (and 2004-05 Goldwater Scholarship recipients) Shawn Henderson and Hannah Swift, the KU CLEO group continued its studies of data taken from electron-positron collisions at the Cornell Electron Storage Ring (CESR) in 2005-06. Shawn Henderson, after 3 years of work on a measurement of the inclusive photon spectrum from bottomonium states, had his paper accepted for publication in Physical Review D. Included in that work are the first-ever measurements of the photon spectrum from the Upsilon(2S) and (3S) systems, as well as a pain-staking estimate of the background to the direct photon spectrum. These measurements afford an extraction of the strong coupling constant, which is found to be in agreement with several other measurements of this quantity made at LEP; a subsequent search for exclusive radiative decays is already well in progress. Hannah Swift has worked over the last year on a determination of baryon production in gluon vs. quark fragmentation. It has long been known that three-gluon decays of the narrow Upsilon resonances produce approximately twice as many baryons per event than does quark-antiquark fragmentation at a comparable center-of-mass energy. This mystery has remained largely unprobed for the last twenty years. Using a sample of radiative Upsilon decays and also a sample of quark-antiquark collision events accompanied by initial state radiation, however, allows for the first time, a direct comparison of two-gluon fragmentation with two-quark fragmentation. Hannah's work indicates that the gluon→baryon enhancement observed in 3-gluon decays largely disappears when one directly compares two fragmenting gluons to two fragmenting quarks. Unfortunately, this effect is not reproduced in the current theoretical simulations of gluon and quark fragmentation, indicating that there is still considerable work to be done in that arena. Following presentation of preliminary results at the 2006 APS meeting in Dallas, Hannah and Shawn spent the summer preparing papers for publication, prior to their departure for graduate school (Berkeley and MIT, respectively).

Nuclear Physics

The Nuclear Physics group is led by Professors Michael Murray and Steve Sanders. For all or part of this past year, the research has also involved postdoctoral research associates Selemon Bekele, Oleg Grachov, Eun-Joo Kim, Erik Johnson, and Dipali Pal, graduate students Theresa Wilkerson and Nobuyuki Tsuchlya, and undergraduates Brennan Metzler, Jennifer Snyder, and Laura Stiles.

Last year marked a milestone for the program with the final data being taken by the BRAHMS experiment this past Spring. BRAHMS has achieved its goal of surveying identified particle production from 3.2^{o} to 90^{o} at the Relativistic Heavy-Ion Collider (RHIC). It is expected that final analysis of the tremendous amount of data obtained by the experiment during its six year run will take another one to two years. As the work on BRAHMS moves into an analysis phase, the group is ratcheting up its hardware development work for the next-generation relativistic heavy ion research program to be run using the Compact Muon Spectrometer (CMS) detector at the Large Hadron Collider (LHC) located outside of Geneva, Switzerland.

In addition to helping with the final data collection at BRAHMS, the nuclear group was involved with a number of different analysis projects. Professor Sanders and Erik Johnson worked on determining the azimuthal asymmetry of the identified particle production in Au+Au collisions at a center-of-mass energy of 200 GeV/nucleon. This asymmetry reflects the initial spacial asymmetry of the interaction zone. The observed production asymmetry in the plane perpendicular to the beam direction by the other RHIC experiments has been interpreted as signaling very early thermalization for RHIC reactions with the formation of a near-perfect fluid. BRAHMS has the unique potential to extend these measurements to forward angles with good particle identification, thereby exploring the longitudinal extent of the reaction zone. The initial analysis at forward angles suggests the surprising result of an extended region of near constant spatial asymmetry of the reaction zone.

The KU group is also involved in a number of additional BRAHMS analysis projects. Professor Murray and undergraduate Laura Stiles have been exploring the angular dependance of the relative abundance of different particle species produced in relativistic heavy-ion collisions based on statistical models of the final hadronization stage of the reaction. Laura presented these results at the Fall Meeting of the Division of Nuclear Physics of the American Physical Society as one of the undergraduate fellows invited to attend this meeting in Maui, Hawaii. Eun-Joo Kim is working on the ratio of meson to baryon particle production as a function of angle. Definite predictions for this ratio can by obtained using recombination models, where the production rates of the observed hadrons are determined by the phase-space density of the up and down quarks prior to hadronization. Selemon Bekele has been focussing on analyzing data from a Cu+Cu run that was done at RHIC about two years ago. Comparison of Cu+Cu and Au+Au collisions results should make it possible to disentangle effects that might be solely a consequence of the overall system size. Dipali Pa joined the group at the beginning of the Spring term. She has been working on extracting production rates for the phi-meson using the BRAHMS spectrometer. This is interesting since it helps determine the relative abundance of the strange quark and strange antiquark early in the reaction.

Under the leadership of Prof. Michael Murray, the KU group is responsible for developing a zero-degree calorimeter (ZDC) to be part of the CMS experiment. This past year saw the initial designs for this apparatus turned into physical hardware. Oleg Grachov and undergraduates Brennan Metzler and Jennifer Snyder have been working closely with Prof. Murray on this project. The ZDC detectors will allow the heavy-ion program at CMS to determine the extent of the overlap of the colliding nuclei. These detectors are located on either side of the interaction vertex at the point where the common beam pipe that is shared by the intersecting beams are split into separate lines for the clockwise and counter-clockwise moving beams. The ZDC's are therefore located literally at zero degrees. They detect those neutrons that come out of the reaction essentially unaffected by the collision. The more of these "spectator" neutrons that are observed, the more peripheral the collision.

Professor Michael Murray and undergraduate Jessica Snyder at CERN for a test of the ZDC detector.

During the year there were a number of personnel changes in the group. Graduate student Chaitanya Kalavagunta finished his Masters degree under the supervision of Prof. Murray and switched to a medical physics program. Theresa Wilkerson left the program to work on a Physics Education topic for her Masters degree. Finally, Eun-Joo Kim has left to take a faculty position at the Chonbuk Nation University in South Korea.

Space Physics

Professor Tom Cravens and post-doctoral 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 has made several encounters with Titan since then. Prof. Cravens is a member of the instrument team for the Ion and Neutral Mass Spectrometer experiment, which in April 2005 made the first measurements of the composition of Titan's ionosphere, discovering that this ionosphere contains complex hydrocarbon species. Models of the upper atmosphere and ionosphere, developed at KU with the help of current and past students, are now being improved using measurements returned from the spacecraft. Graduate student William Rowland is working on electron temperature calculations for Titan.

Post-doctoral researcher Ina Robertson, Prof. Cravens, and Prof. Misha Medvedev continue to work 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. Dr. Robertson attended the 5th annual International Astrophysics Conference in Hawaii, which was organized by the Institute of Geophysics and Planetary Physics at the University of California-Riverside, and presented a paper on heliospheric x-ray emission, and Prof. Medvedev attended the spring American Geophysical Union meeting in Baltimore and presented a paper on predicted x-ray spectra for the outer heliosphere.

In other projects, Professor Medvedev is working 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.

Professor Medvedev also continues his work on the physics of Gamma Radiation Bursts (GRBs). He, along with collaborators from the Instituto Superior Tecnico in Lisbon, Portugal, is studying the long-time evolution of magnetic fields at collisionless shocks. He is also studying radiation mechanisms operating at these shocks. Without full understanding of these two crucial theoretical questions, it seems impossible to understand how gamma-ray bursts shine.

In October 2005 Medvedev and 3 graduate students attended the 47th Annual Meeting of the Division of Plasma Physics (of the American Physical Society). Medvedev gave a talk on "Collisionless Shocks in GRBs: From Speculations to Physics," and also had a poster on "Anisotropic Radiation Spectra from Strong Weibel Turbulence." Grad student Juthika Khargaria had a poster entitled "On the Radiation Spectrum of Hot Quasi-Spherical Accretion Flow onto a Neutron Star" (co-authored by Medvedev). Students Sarah Reynolds and Harsha Pothapragada presented posters, co-authored by Medvedev, on "Effects of Magnetic Turbulence on Radiation Spectra in GRB Shocks," and "Correlation Analysis of Temporal Variation of Spectral Parameters of Prompt GRB Emission."

Theoretical Particle Physics

Theorists sailing on their own imaginations. Helmsman John Ralston with deck crewman Danny Marfatia, Captain Doug McKay, Captain Emeritus Herman Munczek, and an anonymous Nobel Laureate preparing to bail. Artist rendering by Adriana Marfatia.

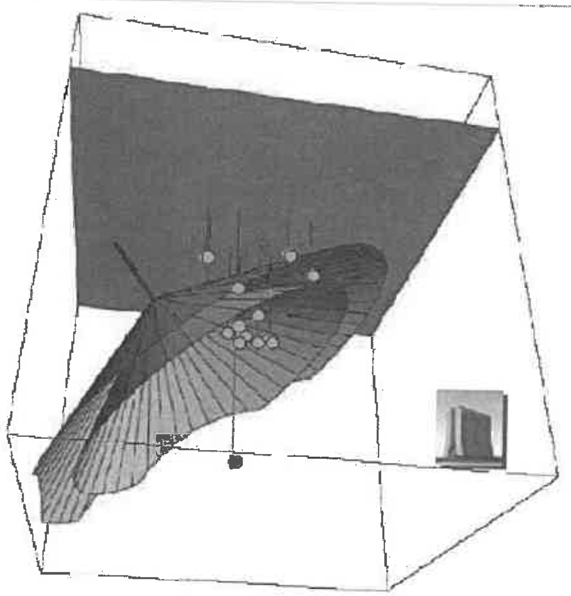
Theoretical physics is like running a sailboat. First there must be wind! You can't go straight against the wind, and there's no thrill running downwind with the lubbers. The KU theory group of Professor Danny Marfatia, Doug McKay and John Ralston enjoy broad reaches, and going at right angles to the flow.

This year's news is all about Danny, Danny, Danny. Danny won an NSF First Award. Danny won a prestigious, nationally competitive NSF Career Award. Danny keeps writing highly cited papers about neutrinos. Then why does nobody know what neutrinos are or how they work? Are there three flavors, called strawberry, banana, and chocolate, or more nu food types? Is the neutrino it's own anti-particle, which sounds illegal in Kansas, or is the mass term strictly a marriage between a neutrino and its lawful anti-partner? Danny published gobs of papers and gave a gazillion talks last year, and he's still confused about these elementary topics. "We learn more about neutrinos every day," said Danny, "unless it changes tonight!"

Doug and John are happy disabling the status quo. In papers with student Shahid Hussain (KU PHD 2004), and in talks at Madison and Trieste, Doug showed that micro-black holes can be made whenever and wherever they might be made in cosmic ray events. The RICE project will detect them soon. "How small a black hole can be, and still not be seen," that is the question. KU theory graduates Soeb Razzaque and Roman Buniy also work on cosmo subjects. Soeb (PhD 2003, postdoc at Penn State) is a world expert on gamma ray bursters, and manages his own personal supernovae. Roman (PhD 2002, postdoc at Vanderbilt and now Oregon) has proven that energy can't be too negative, nor time machines too timely, else the Universe will collapse. (Good thing these two are not experimentalists.) Meanwhile John is positively polarized. He reports data shows five (5) independent cosmic axes aligned in the direction of constellation Virgo. The data come from the cosmic microwave background, the polarization of quasars, and the alignment of galactic radio vibrations (Borge Nodland, KU PhD 1996). Why did Nature choose Virgo? "My Mom's a Virgo," he says.

The RICE Experiment

RICE stands for the Radio Ice Cherenkov Experiment, currently operating at the South Pole. Its purpose is to detect ultra-high energy neutrinos undergoing interactions in cold polar ice. It is an exotic area of physics at the frontier using new technology. RICE has been almost entirely developed at KU by PI Dave Besson. Many collaborators work with Dave, including KU Faculty Professors Bean, McKay and Ralston. Students who have most recently worked on this project with Dave include Ilya Kravchenko (KU PhD, now MIT staff) and brilliant KU undergrads and Goldwater scholars Josh Meyers and Hanna Swift (both now at UC Berkeley) and Daniel Hogan.



Radio Cherenkov radiation expands on a huge umbrella-like shape illustrating a new principle of ultra-high energy neutrino detection used in the RICE experiment. The Fermilab high rise shows the scale.

Where do the neutrinos come from? They are all around in cosmic rays, and detecting them can make a *neutrino telescope* to look into space. Why Radio? When neutinos collide, particle showers emit copious radio waves, the higher the energy, the more radio signal. What is Cherenkov? It is the marvelous emission of a "sonic boom" of light by particles moving faster than light...that is, faster than light can move! in the solid material. Why Ice? Ice is very transparent to radio waves (GHz frequencies). Plus there's a whole lot of clean ice at the South Pole. And get this: the experiment is automated and runs all year, sending data during 11 months nobody can live at the Pole!

What has RICE accomplished? For the past several years, RICE has established the best performance of the whole world in energy regime of 10^{18} eV and above. This is a very hot area: it is a place where new physics might be found! KU has something to be proud of, and it was done by hard work, not nearly enough money (although several NSF grants have provided support), and not anywhere near the manpower of the competing big-science groups RICE trumps. Not only that, but the technology of radio detection has become accepted and is planned for incorporation into the $250 million dollar project ICECUBE under construction. Wow! It's been a long road, and yet RICE is still going to the stars despite difficulty. "Ad Astra, Per Aspera."

During February Tom Laming (BS PHSX '81), current President of Trend-Star Advisors, called on his extensive background in Physics, Aeronautics, and Economics to promote the value of understanding Math and Physics in achieving success in a wide variety of endeavors, but particularly investing. Tom presented a talk entitled ***The Role of Science in the History and Future of Investing*** to over 100 student and faculty in Alderson Auditorium.

Student and Alumni News

SPS Activities

(From the SPS Secretary)

Another school year ends, and first of all SPS would like to thank the outgoing SPS officers, especially those graduating and leaving us for bigger cities and perhaps nicer climates. This year, Shawn Henderson and Sarah Reynolds led SPS as co-presidents. Sarah is staying as co-president next year, but Shawn is departing for MIT. David Hover was our "trial-run" mascot, and took to his role with professionalism. He starts graduate school at Wisconsin next year, but leaves behind a new tradition for SPS. We wish them the best of luck. We would also like to thank our treasurer, Rainer Schiel, for his work.

Though most of our meetings fell under the traditional cookies and socializing format, we did have actual activities sometimes. We started the year with a fun game of physics Pictionary, which culminated in Shawn forcing Rainer to "act out" a schleronomic transformation for his team to guess. Some time afterwards, SPS members helped Prof. Melott plant Vinca minors in Malott Hall's "inner courtyard". As for "Bad Physics/ Hilarious Movie Days", this year the selections included "Ghost of Mars", "A Sound of Thunder", and the Charlie Pye-sponsored "Young Einstein". Each movie screening was, of course, complemented with quality pizza. Outside of our regular meeting time, we were present in the Chemistry Carnival, as well as the Family Arts Festival, which took place at the Lied Center. Both students and faculty were involved in this effort.

Shawn Henderson presents his research results.

SPS students made presentations on their research. Hannah Swift discussed how data from the CLEO high-energy particle detector is being used to explore the differing manner in which quarks and gluons decay to form massive particles. Her research compares decays of the Upsilon resonance system (which decays into gluons) to decays of general quark-antiquark interactions. By assessing the number of massive particles (such as the protons and lambdas) that are produced in these two types of events, she has compared the production of these particles in quark versus gluon decay and found that more are produced in gluon decay than in quark decay. Daniel Hogan presented a talk titled "Energy loss of relativistic magnetic monopoles in matter, or how I spent my summer vacation." He summarized his studies conducted while at an REU at SUNY Stony Brook, which focused on modelling energy loss and Cherenkov radiation produced by magnetic monopoles. Shawn Henderson and Luis Vargas also presented small talks on their current research.

A typical SPS meeting. Around table from left: Nobuyuki Tsuchiya, Brennan Metzler, Shawn Henderson, Hanna Swift, Charlie Pye, and, by blackboard, Daniel Hogan.

SPS members were not the only speakers. We also had various faculty presentations. Prof. Bean, Baringer, L. Olafsen, Melott, Feldman, Besson, Wilson and Murray introduced various research projects going on in the department, and discussed potential opportunities for undergraduates. Prof. Murray also talked in another occasion about the solar eclipse he witnessed while in Africa. Prof. Carsten Timm gave a separate talk on condensed matter physics and possible research projects for interested students. Prof. Bruce Twarog and Jeff Olafsen gave a talk about graduate school and fellowships. One of our former members, Andy Womack, gave an impromptu speech on Fourier transforms.

We thank all the faculty members who volunteered this year for these activities, and our advisors, Dave Besson and Judy Wu, for their support.

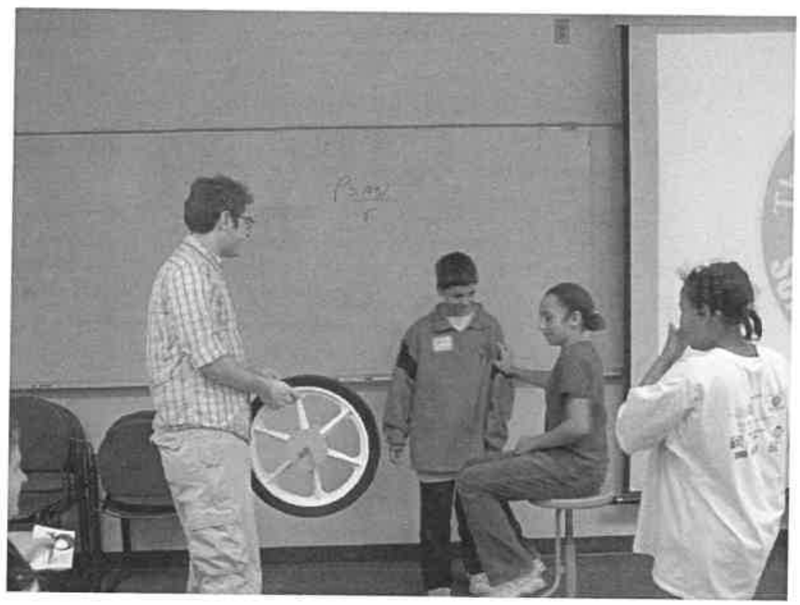
Luis Vargas

Engineering Physics

Gabe Schmidt overseeing an electrifying experience.

PESO Activites

The Physics and Engineering Student Organization (PESO) had an active year. Our Engineering Physics students and other interested parties met every other Wednesday evening for pizza and conversation. Their February Engineering Expo exhibit was a big success. It featured favorite physics demos like the floating superconductor and the Van de Graaf generator along with Powerpoint slides explaining what engineering physics is all about to the Expo visitors. PESO also took their demos on the road last year, visiting area schools and showing the students the joys of engineering physics. Officers for 2005-06 were President Sara Holt, Vice-President Gabe Schmidt, Secretary-Treasurer Laura Stiles and Engineering Student Council representative Dan Pierron. Phil Baringer serves as faculty advisor.



Angular momentum being explained by Dan Pierron

Alumni News for Engineering Physics students is located in a separate section on the Alumni News page.

Sarah Holt explaining a subtle idea.

Departmental Banquet

This year's Departmental Banquet was held at the Circle S Ranch located about 10 miles north of Lawrence. It was a great location to celebrate the achievements of department members during the past year.

The Awards and Recognition part of the program started with presentation of this years graduates. The undergraduate program set a recent record with 15 new graduates: **Lindsay M. Mayer** (BS PHSX and ASTR), **Shawn W. Henderson** (BS PHSX and MATH), **Alan Dibos** (BS PHSX and CHEM), **Hannah K. Swift** (BS PHSX, MATH, and ASTR Honors), **David Hover** (BS PHSX Honors), **Larissa Ejzak** (BA PHSX and Theater & Film Honors), **John B. Lancaster** (BS PHSX and MATH), **Benjamin Bammes** (BS PHSX and EECS Honors), **Miles A. Garrett** (BA PHSX and PHIL), **Andrew R. Ra** (BS PHSX), **Efe Ekpere** (BS PHSX), **Kenny Johnston** (BS EPHSX), **Chris Patrick** (BS EPHX), **Stuart A. Jack** (BA ASTR), and **Steve Drullinger** (BS PHSX and ASTR).

The students receiving MS degrees include: **Carissa Hill**, **Richard Alexander**, **Leah Bowen**, **Jan Kurzidun**, **Peter Bryant**, **Xin Gao**, **Rainer Schiel**, **Shramana Mishra**, **Chaitanya Kalavagunta**, **Benjamin Anhalt**, **Devdeep Sarkar** (Honors), **Darius Gallagher**.

Four students finished their Ph.D. degrees this year: **Brian Thomas**, **Lihui Jin**, **John Gardener**, and **Shabnam Jabeen**.

Facing camera, from left: Nataly Jager, Shantanu Dikshit, Rainer Schiel, and Mihailo Backovic.

The Engineering Physics outstanding senior award went to **Kenneth Johnston**.

The Stranathan outstanding senior award was shared by **Hannah Swift**, **Miles Garrett**, and **Larissa Ejzak**.

The Prosser award for an outstanding major was shared by **Michael Merz** and **Andrew Wooten**.

Summarizing some of the other awards and honors achieved by students during the year: **Laura Stiles** (APS Conference Experience for Undergraduates Award), **Jonathon Voisey** (NSF/REU San Diego State University/Mt. Laguna Observatory), **Luis Vargas** (NSF/REU University of Wisconsin), **Daniel Hogan** (Chancellor's Club Scholar), **Rainer Schiel** (Graduate School Outstanding Research Project Award), **Hannah Swift** (KU Woman of Distinction), **Hannah Swift** (Sally Mason Award for an Outstanding Woman Student in Science), **William Peck Pflug** and **Jennifer Marie Harness** (National Merit Scholars Freshmen), **Shawn Henderson** (NSF Graduate Research Scholarship), **Daniel Hogan** and **Luis Vargas** (Goldwater Scholarships).

As customary, Bob Curry, Director of Laboratories, announced the E.E. Slossen Award for outstanding graduate teaching assistants: **Daniel Fisher**, **Rainer Schiel**, and **Mihailo Backovic**.

Departmental scholarship winners include: **Chad Kyle** (Engineering Physics Hansel Fund Scholarship), **Elisabeth Callen** (Badgley Fund Scholarship), and graduate student **Mihailo Backovic** (John W. Lowry Enhancement Award).

The Undergraduate Faculty Teaching Award went to **Professor Steve Sanders,** while the SPS Staff Person of the Year was presented to **Mr. Don Nieto**.

Professor **Dave Besson** was acknowledged for receiving the 2005 Kemper Award for Teaching Excellence and a Fulbright Senior Scholar Award).

Overall, a very successful year!

Seated around table, clockwise from left: Professors Graham Wilson, Ray Ammar, John Ralston, Alice Bean, Doug McKay, and Steve Sanders.

Physics and Astronomy Alumni News

Paul Draper (BA PHSX '78, MS '80) reports: "After getting a doctorate at Indiana University, I worked in particle physics until 1998. Along the way, while developing course materials, I started working with educational publishers which eventually turned into a career switch. Since then I've worked with science textbooks and other materials for both Prentice Hall (college division) and Holt, Rinehart & Winston (high school). Austin is an incredible city—a good place to be with teenagers."

Brad Roth (BS PHSX '82) was elected a Fellow of the American Physical Society (Division of Biological Physics), for his theoretical and numerical studies of bioelectric and biomagnetic phenomena, especially for his contributions to the bidomain model of the heart. Brad is currently an Associate Professor of Physics at Oakland University in Rochester, Michigan. (email: roth@oakland.edu)

Jounghun Lee (PhD PHSX '99) writes: "I became a tenure track assistant professor in the Department of Physics and Astronomy at the Seoul National University in August 2005, and I have been so far extremely busy here with settling down. Now that I have settled down almost completely, I would like to say greetings to my friends, especially those who I could not see for a long time since I left America." (email: jounghun@astro.snu.ac.kr)

Brent Harris (BS EPHSX '04) has moved into the Technical Security Division of the Secret Service.

Stephen Floor (BS PHSX '05) is now a graduate student in biophysics at the University of San Francisco.

Engineering Physics Alumni News

Cooper Snapp (BS EPHX '00) reports: "I am currently working for NASA at Johnson Space Center in Houston, TX. I am the NASA subsystem engineer for the thermal protection system for the Space Shuttle Orbiter. This means that I am responsible for all of the hardware related to the thermal protection system of the vehicle. Most recently I participated in the Return-to-Flight mission STS-114. As many people know there were several thermal protection system issues that came up during that mission. These included the damaged blanket and the protruding gap fillers which Steve Robinson made an unprecedented EVA and removed during the mission. Both of the issues brought national attention to our subsystem. We are currently working towards the next mission. We are involved with many activities to make the system more robust so that those issues do not come up again. We have developed a rigorous inspection of the blankets and also have attempted to remove and replace all gap fillers with a new improved installation process. I also spend approximately 25% of my time in the development of the thermal protection system for the Crew Exploration Vehicle (CEV). The CEV will be the next generation of exploration that will take man to the moon, mars, and beyond.

We want to hear from you! Please email your news items to <u>momentum@ku.edu</u> or use our new upload form described on the inside back cover.

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Jack W. Culvahouse

1929 - 2006

Professor Jack Culvahouse died June 7, 2006. Jack was born Sept. 15, 1929, in Mountain Park, Oklahoma, the son of Victor Hugo and Sybil Nichols Culvahouse. He received a Bachelor of Science from the University of Oklahoma, and a Master of Arts in 1954 and a Ph.D. in 1958 from Harvard University. He was a physicist for General Electric from 1951 to 1953; an assistant professor at the University of Oklahoma and the University of Kansas; an associate professor at the University of Kansas from 1962 to 1964; and a professor from 1964 until he retired in 1994. He was a visiting professor at the University of Wisconsin, Oxford University, Ames Laboratory in Ames, Iowa, and was also associated with Western University. He was a Guggenheim Fellow in 1968; an NSF Fellow at Harvard University, a member of Tau Beta Pi, Phi Beta Kappa and Sigma Xi, and a Fellow of the American Physical Society-Fellow. Professor Culvahouse authored 31 major publications on solid state and nuclear physics. He worked with many Ph.D. dissertations and Master of Science theses.

A more complete summary of Professor Culvahouse's achievements can be found at: http://www.physicstoday.org/obits/index_2006.html or http://www2.ku.edu/~physics/top/culvahouse.pdf .

Reminiscences

Robert Friauf: Jack arrived at Kansas University in the fall of 1958 with a new Ph.D. from Harvard and lots of enthusiasm. He was ready, and more than able, to help build our field of solid state physics, as it was called then, and soon developed a virtual empire of magnetism. At first he collaborated with Dick Sapp, and then with Peter Richards and Wesley Unruh as they were added to the Department. Jack was a cheerful and very hard worker, and was sometimes heard to comment that he was glad when the weekends arrived, because then there were fewer distractions to interfere with research! His work was mostly complementary to my endeavors in ionic crystals, but we both shared many general interests in research. For many years we shared a solid state physics seminar with our graduate students, even meeting at some Professors' homes on a few occasions. Jack was also very helpful with one of my graduate students, Gerry Holmberg, during the ESR and ENDOR studies of color centers.

We also enjoyed traveling to various scientific meetings, For quite a few years we were active in the annual Midwest Solid State Conferences, which rotated among places such as the University of Missouri at Columbia, Kansas State University, Argonne National Laboratory, Indiana University, and the University of Arkansas. For one meeting at the University of Kansas, Jack through his Harvard connections, persuaded Prof. Bloembergen to come and present the featured talk on masers, which were quite a new topic at that time. On another occasion a group of us learned more than we wanted to know about rare earth ions, and observed most of the world's supply of the newly separated materials, in Prof Spedding's quarters at the Ames Laboratory associated with Iowa State University!

We also attended many of the large APS March meetings, which were devoted primarily to solid state and condensed matter physics. On one particularly memorable occasion the four horsemen—Jack Culvahouse, Gordon Wiseman, Dick Sapp, and Bob Friauf—ventured off to Boston. Early in the week we had an enjoyable diversion at a Winslow Homer exhibit at the Boston Art Museum. And the last night was spent on a lounge in the Boston Airport because of a snowstorm in Cleveland!

Everybody knew Jack as a gentleman and a scholar. But he was also blessed with some homespun charms stemming from his background in Oklahoma. While dining at fine restaurants in Europe, I was sometimes chided gently about imbibing coffee before dessert, being gently reminded that caffeine tends to dull the taste buds. But in my experience there are three kinds of coffee drinkers in the world: the European connoisseur enjoying coffee with, or preferably after dessert; the typical American, joining coffee with the main course; and Oklahomans, who order coffee immediately upon entering the restaurant!

Jack has always been an active and agreeable member of the Department. We've had many intriguing conversations about the joys and tribulations of teaching. And he has always participated effectively in the necessary committee jobs. It has been a real pleasure to know Jack as a colleague and a friend.

Richard Sapp: When I first interviewed for a job at KU, Jack was the host. He showed me around the department and of course his lab. I remember well that I was very impressed with his setup as well as the problems he was working at the time. He also told me KU was adding another good experimentalist, Peter Richards. Pete was working on similar problems at the time. Through the years, Jack had helped me a lot with his opinions, whenever I had a question, even though our area of interest was quite far apart. To my knowledge, the graduate students in the department at that time, that is from the 60's to the 80's, considered working with Jack as very desirable, and they all had high opinion of him. In my personal opinion, I felt Jack and Pete represented the strength of KU's condensed matter research, and the 60's and 70's was the best and strongest period for the department. Jack will always be sorely missed by me.

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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. If you have a news item to share, please either fill out the form below, email us at momentum@ku.edu , or upload your item at http://www2.ku.edu/cgiwrap/physics/alumniform.php .

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