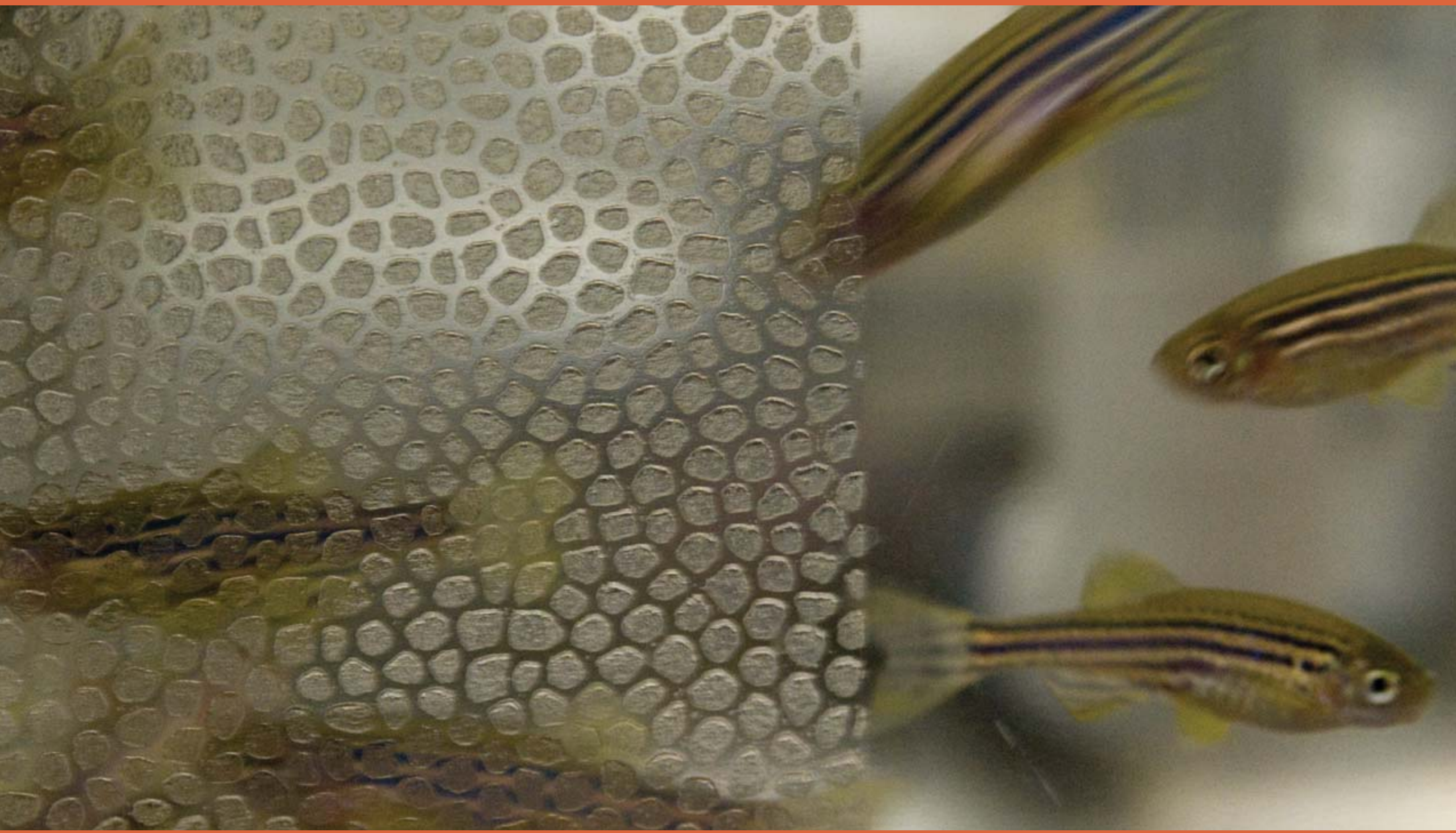
UCLA

Department of Physics & Astronomy



Annual Report 2007- 2008

UCLA Physics and Astronomy Department
2007-2008
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Ferdinand Coroniti

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<http://home.physics.ucla.edu>

image on cover: The zebrafish is an excellent organism for laboratory study due to its visual transparency during development (the stripes occur later) and its physiological makeup. See Feature Article: Illuminating Biophysics *Imaging cell interaction for clues to human development and disease.*

Department of Physics & Astronomy

2007-2008
annual report

University of California, Los Angeles

Message from the Chair:

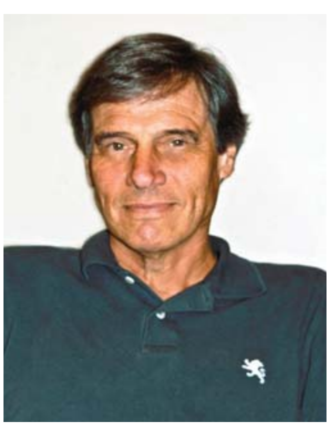
Ferdinand Coroniti, Chair

The start of the new academic year finds the Department of Physics and Atronomy in basic good health; however, the financial crises in the country and State, and the budget stringencies on the Campus, have already resulted in some painful adjustments, and further reductions to the program are quite likely.

First the good news. The Eight Year Review, which was conducted by the Academic Senate last February, found the Department's research and teaching programs to be fundamentally sound, and the Department will willingly implement the Review Committee's positive recommendations. Although last year's four faculty searches resulted in only one recruitment, the appointment of Assistant Professor Eric Hudson is especially valued since he brings a new research area – Quantum, Atomic, and Optical physics – to the Department. Professor Hudson is already establishing a super high-tech optics laboratory to investigate the properties of ionized molecules as possible storage elements in a quantum computer. This year, the Department is planning to conduct faculty searches in two experimental areas – an astronomer specializing in infrared instrumentation for large telescopes, and a biophysicist specializing in neuroscience. Several members of the faculty have recently received a remarkable number of very prestigious awards and recognitions: and they are featured in Focus in Excellence on page 10 in this report.

The research activities of the Department are as exciting as they are wide-ranging; space permits mention of only a few. The UCLA presence at the CERN Large Hadron Collider Compact Muon Solenoid (CMS) experiment increased as Professor R. Wallny joined his colleagues Professor D. Cline (who originated UCLA's membership in the CMS collaboration back in the early 1990's), Professor R. Cousins (who serves as the Deputy Spokesperson for CMS), and Professor J. Hauser (who designed, built, and successfully commissioned the CMS Endcap Muon Level-1 trigger)…NASA's Wide-Field Infrared Survey Explorer (WISE), with Professor E. Wright as the Principal Investigator, will be launched early next year…Professor K. Arisaka has continued to develop incredibly powerful high space and fast time resolution cameras and microscopes for biological imaging; he has joined forces with colleague Professor D. Bozovic and several faculty from the UCLA Medical School to use these novel instruments to conduct various biophysics investigations…Professors H. Huang and C. Whitten are leading the nuclear physics program into the area of neutrino physics by joining the Daya Bay nuclear reactor experiment in China and the CUORE experiment in the Gran Sasso tunnel in Italy…Also at Gran Sasso, Professors D. Cline, K. Arisaka and Dr. H. Wang have joined the Xenon 100 experiment that is searching for dark matter particles, and are busy designing a very large (one ton) liquid xenon dark matter detector…Like Phoenix, Professor Gekelman has raised the Electric Tokomak from its moth-balled slumber, and is converting it into a unique toroidal plasma device for investigating large scale wave phenomena… Professors R. Ong and V. Vassiliev are analyzing the initial high-energy gamma ray measurements obtained by the VERITAS Observatory… The Infrared Instrumentation Laboratory (last year's feature article) headed by Professors J. Larkin and I. McLean has undertaken major instrument design projects for the proposed Thirty Meter Telescope.

Now the not-so-good news. The Chancellor has assessed the Department a 6% cut in its total operating budget, which translates into a 23% reduction of the "cut-able" or discretionary part of its allocation from the State. This cut is not driven directly by the State's financial problems. The Campus has been running structural deficits in utilities, maintenance, and benefits. In the past few years, the Chancellor has covered these deficits, but has now decided to allocate them to the individual units to be paid out of permanent reductions in their operating budgets. This year the Department covered one half of the reduction with Indirect Cost Recovery (overhead return) funds that are generated by contracts and grants, and one half by canceling 10 courses (the Physics 1ABC and 6ABC Honors courses, sections of Physics 6 and Astronomy 6, various upper division Physics electives and graduate seminars), reducing the number of TA positions by 10%, and eliminating the use of Readers in lower division courses. From now on, homework will be submitted and graded electronically. Next year, provided the financial crisis does not deepen (likely an unwarranted assumption), the Department will have to reduce its permanent State allocation by an equal amount to reach the imposed 6% cut. Clearly, this year's reductions in the teaching program diminish the quality of educational experience that the Department is able to offer its students.



Mark Morris, Vice-Chair

As always, the Department deeply appreciates the interest and support of its alumni and friends. Your past generosity has significantly contributed to the enrichment of the Department's academic program and the quality of its academic life. Hopefully, the deleterious effects of the current budget crisis can be alleviated, and together we can once again proceed to build a truly excellent Physics and Astronomy program at UCLA.

CONTENTS • • •

Illuminating Biophysics

Imaging cell interaction for clues to human development and disease

At what point in development does a human being start thinking? Is it a gradual process or does it happen quickly? Is it nature or nurture? These are the questions that inspire **UCLA Assistant Professor of Neurology Dr. Carlos Portera-Cailliau** in his research. “We know that neurons start developing in the neocortex of the brain while we are embryos, but at that point they haven’t figured out what connections to make with each other.” For this reason, it’s unlikely that babies are capable of abstract thought *in utero*. But during infancy, they start knocking over blocks and shaking rattles; at some point, they begin to learn and remember.

“The cortex was not necessarily designed for enjoying Picasso or Hemingway; it was designed for survival; and so we believe that the absence of sensory input will not delay cortical development.”

There is a major debate in neuroscience as to the importance of sensory input for cortical development. Clearly it is a factor, but children’s brains are not blank slates that get filled in through sensory experiences alone. They are genetically encoded to send neurons to the right places, find the right connections, and generate the kinds of patterns of activity required for thought; if you add in Bach, even better. But Dr. Portera-Cailliau maintains that it is not essential. “The cortex was not necessarily designed for enjoying Picasso or Hemingway; it was designed for survival; and so we believe that the absence of sensory input will not delay cortical development. It is not essential for emotions, critical thinking or creativity. Also, we think that the appearance of abstract thought happens very quickly over a period of weeks, almost like a computer booting up for the first time.”

Neocortical Development Studies

For the last four years at UCLA, Dr. Portera-Cailliau has been conducting experiments using mouse models to explore neocortical development. He and his colleague Dr. Peyman Golshani, a UCLA neurologist, are studying the normal process of this development in order to build a foundation that will help scientists better understand mental retardation, autism, schizophrenia and epilepsy. These diseases do not show any obvious signs of abnormality under MRI or even a microscope, unlike stroke or Alzheimer's where the pathology shows up as a hole or plaque, respectively. That means that some neuropsychiatric diseases are not due to wiring problems, but to conductivity problems—neurons not firing properly. Says Dr. Portera-Cailliau, "Mental retardation or autism may be explained by differences or problems in how cells in the neocortex talk to each other."

Dr. Portera-Cailliau conducts his research with mice by imaging both the structures and activity of the neurons in the cortex. He is particularly interested in the mouse model for Fragile X syndrome, the most common inherited cause of mental retardation and autism. By comparing the cortex of this mutant mouse with a normal mouse, researchers hope to learn more about the defect that causes Fragile X. This is where physics comes in.

"I am a biologist," says Dr. Portera-Cailliau. "I need to collaborate with physicists because they are able to build microscopes that can image a lot quicker and deeper into the brain than the ones available to us now. Drs. Portera-Cailliau and Galshani had heard that UCLA Professor of Physics Katsushi Arisaka was interested in collaborating with researchers in neuroscience. One of Dr. Arisaka's several interests is the fast growing field of biophysics, specifically neurophysics. They found common ground and began working together in 2007.

Their task was to develop an imaging technique that would give the experiments the benefit of greater depth and speed. Says Dr. Portera-Cailliau, "We were very limited because we could not examine the cortex in vivo very easily. The signal of the calcium-based fluorescent dye we use faded as we imaged deeper into the cortex—we were only able to image the top 20 to 30 percent of the cells. Another problem is that we needed to take the pictures quickly. We were concerned that we were missing information because we couldn't image the whole area fast enough to reliably measure the firing of individual neurons."

Dr. Katsushi Arisaka was born and raised in Japan. He received a Ph.D. in physics from the University of Tokyo in 1985 where he participate in the Kamiokande Experiment, a set of groundbreaking neutrino experiments that have taken place over the past two decades. Thereafter, he came to the United States as a research investigator in the University of Pennsylvania, Department of Physics. In 1988 he joined the UCLA faculty in the Department of Physics and Astronomy where he teaches and pursues research in several areas, including high energy physics and astroparticle physics. His interest in understanding the origin of the Universe has led him to study rare kaon decays and CP violation and conduct ultra high energy cosmic ray experiments. His interest in biophysics, especially neurophysics, has led him to develop multi-photon microscopy, an imaging technology that promises to further research into human development. Dr. Arisaka derived the technology by combining a well known physics application—vacuum tube photo detection—with microscopy, at the same time dramatically increasing imaging speed and resolution. He and his graduate student, Adrian Cheng, have developed and built the equipment currently being used in several laboratories at UCLA where Dr. Arisaka collaborates with researchers in the neurosciences, especially those who have an interest in imaging cell interaction. He also conducts neurobiological studies in his own laboratory, applying his new technology to the tiny zebrafish. In development is a new version of the multi-photon microscopy equipment, which is part of a million-dollar research grant proposal submitted to the National Science Foundation.

"Most video cameras are designed to capture an image at 30 pictures per second. What we are doing is speeding that up by 100 times to 1,000 pictures per second."

Multi-Photon Microscopy

The imaging technology that provides such promise in furthering the research into human development is called multi-photon microscopy. Dr. Arisaka derived the technology by combining a well known physics application—vacuum tube photo detection—with microscopy, at the same time dramatically increasing imaging speed and resolution. Dr. Arisaka's involvement in vacuum photo tube detection dates back to his days as a graduate student at the University of Tokyo during the 1980s and continues to today. He was part of the Kamiokande Experiment, a set of groundbreaking neutrino experiments that have taken place over the past two decades. The experiments have contributed substantially to the advancement of particle physics, in particular to the study of neutrino astronomy and neutrino oscillation.

When Dr. Arisaka turned his interests to biophysics, he brought this powerful tool with him. He collaborated with Dr. Shimon Weiss, a UCLA chemistry professor, and his single molecular microscopy group. Their study of proteins, along with the other studies around the world, is an effort to take the human genome to the next level by investigating the smallest unit of life. Dr. Arisaka contributed to this effort by helping to develop new photodetectors for single molecule detection.

At the same time, Dr. Arisaka began neurobiological studies in his own laboratory in the physics department, applying his new technology to the tiny zebrafish. This research is bringing together neurophysicists and life scientists,including physics graduate student Adrian Cheng and post-doctoral biology researcher Dr. Luis Beltran. Both share an interest in neurobiology particularly the complicated cells of the nervous system. Adrian Cheng explains, "By examining the zebrafish during the first two weeks of life, while the fish is in its developmental stage, we be able to fully characterize the cortex as it has developed from infancy to adulthood. We will subsequently create a biological map of the cortex, which we will share as a reference for other researchers." The zebrafish is an excellent organism for laboratory study due to its visual transparency during development (the stripes occur later) and its physiological makeup. While genetically distant from humans, the zebrafish nevertheless has comp-arable organs and tissues, such as heart, kidney, pancreas, bones—and nervous system These attributes make the zebrafish a good supplement to mice as research models.

Picture of zebrafish. The zebrafish is used in Dr. Arisaka's lab to study the nervous system

By imaging the nervous system of the zebrafish, the Dr. Arisaka's group is looking at bulk tissue—not just a few cells—in vivo. The researchers have been able to capture the entire brain of the zebrafish on a cellular level, as it develops, including interaction

Dr. Carlos Portera-Cailliau was born and raised in Madrid, Spain. He obtained a B.A. degree in biochemistry and cell biology (magna cum laude) from the University of California, San Diego, in 1990. He then attended Johns Hopkins School of Medicine, earning a combined M.D. – Ph.D. degree in 1997 under mentors Dr. Donald L. Price and Dr. Lee J. Martin of the Alzheimer's Disease Research Center. After finishing a residency in neurology at Massachusetts General Hospital and Brigham and Women's Hospital in Boston in 2001, Dr. Portera-Cailliau moved to Columbia University for a post-doctoral fellowship in Dr. Rafael Yuste's Laboratory, which studies the neocortex. He completed a second post-doc at the Cold Spring Harbor Laboratory with Dr. Karel Svoboda who conducts research into information processing and plasticity in the mammalian cortex. Dr. Portera-Cailliau joined the UCLA faculty in 2004 with joint appointments in the departments of neurology and neurobiology. He is also a member of UCLA's Brain Research Institute (BRI) and ACCESS, an umbrella graduate program that represents 12 outstanding Ph.D. programs in the molecular, cellular and integrative life sciences. He is both a practicing physician and a scientific researcher.

between the cells. This is achieved by anesthetizing the fish with a paralyzing gel and examining it under multi-photon microscopy. Afterwards, the fish is released back into its tank.

Dr. Arisaka and Adrian Cheng developed and built the equipment that is currently being used in Dr. Portera-Cailliau's lab and in the physics department. Says Dr. Arisaka, "Most video cameras are designed to capture an image at 30 pictures per second. What we are doing is speeding that up by 100 times to 1,000 pictures per second. We are able to measure time while capturing a three-dimensional image."

Dr. Dolores Bosovic was born in Yugoslavia and came to the United States at the age of 12. She earned a B.A. degree in physics at Stanford University in 1995 and a Ph.D. in physics at Harvard University in 2001 with a concentration in condensed matter. Afterward, she developed an interest in biophysics, particularly the interface between physics and sensory neuroscience. She pursued this area of study through a postdoctoral fellowship at The Rockefeller University in the Howard Hughes Medical Institute Laboratory of Sensory Neuroscience under Dr. A. James Hudspeth. This laboratory studies the normal hearing process and the causes of hearing deterioration. In 2005, following her fellowship, Dr. Bosovic joined the UCLA faculty in the Department of Physics and Astronomy. She teaches physics and conducts auditory biophysics studies to further research into the mechanisms of hearing.

Exploring the mechanism of hearing using the frog as a model

Taking up the space of a breakfast table, the UCLA biophysics multi-photon microscope utilizes femtosecond laser pulses generated from titanium-sapphire crystal to penetrate as deep as a millimeter in tissues. A second harmonic generates visible wavelength fluorescence emission, single photons of which are collected by photo detectors. The result is a high resolution three-dimensional video of neuronal circuit activity in a living animal, particularly action potentials.

In development is a new version of the equipment, which is part of a million-dollar research grant proposal submitted to the National Science Foundation in collaboration with Dr. Portera-Cailliau. The new technology will be even faster and more sophisticated. The first phase is design, which is underway; concurrently, parts are being ordered from Japan. After the design is finalized, Dr. Arisaka and Adrian Cheng will build the device with the help of other physics students. They will build two pieces of equipment, one for Dr. Portera-Cailliau's lab and one for Dr. Arisaka's lab.

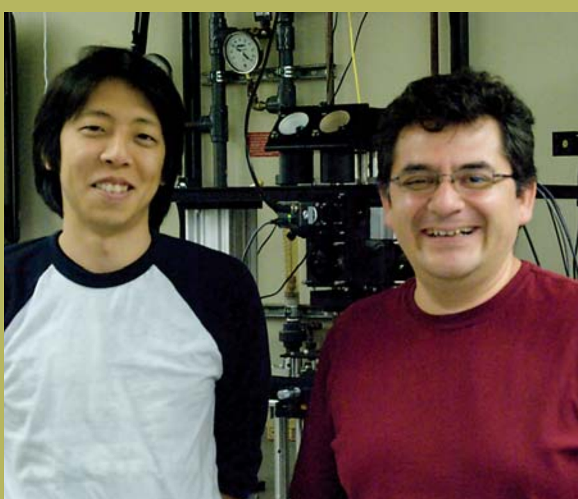
As photo microscopy takes off, other scientists outside of Dr. Arisaka's group will likely begin utilizing photo microscopy to conduct their own experiments. UCLA Assistant Professor of Physics Dolores Bozovic is already making good use of the technology in the physics laboratory to further her experiments in auditory neuroscience.

Auditory Biophysics Studies

Dr. Bozovic is exploring the mechanisms of hearing. Specifically, she is studying the hair cells in the inner ear—where sound first gets detected and processed—to help explain how hearing happens. Her interest in auditory biophysics dates from her post-graduate fellowship. She has been pursuing her own research for the last three years at UCLA, collaborating with Dr. Arisaka for the last year.

Describing her research, Dr. Bozovic explains, "These "hair cells" are actually tiny cells—tens of thousands of them in the human ear—that have a bundle of cilia on top, hence the name hair cells." Each of these cells detects sound at a particular frequency and the sound wave moves the cilia back and forth. The cilia function as biological, mechanical sensors, converting mechanical signals to electrical signals by opening ion channels. The electrical signal causes the release of chemicals called neurotransmitters, which in turn send signals to neurons that enervate the cells and initiate the process of hearing. This biological

Adrian Cheng received both a B.S. and an M.S. in physics and a second B.S. in pure mathematics (in 2006) from UCLA. Currently, he is a graduate student in the UCLA Department of Physics & Astronomy under Professor Katsushi Arisaka. He is interested in developing new methods for the measurement of activity of large neural circuits. Many of these complex networks work via a fundamental unit of information—the action potential. These signals take place at the scale of a single cell over periods of microseconds, beyond the reach of PET or MRI imaging. His work with Dr. Arisaka has focused on the continuing development of optical methods that can image hundreds to thousands of neurons in three dimensions faster than real time. These techniques include fast fluorescence microscopy combined with calcium sensitive dyes, as well as multi-photon microscopy and fluorescence lifetime imaging (FLIM). Ultimately he is interested in comparing direct observations with deterministic simulation and modeling of large networks.

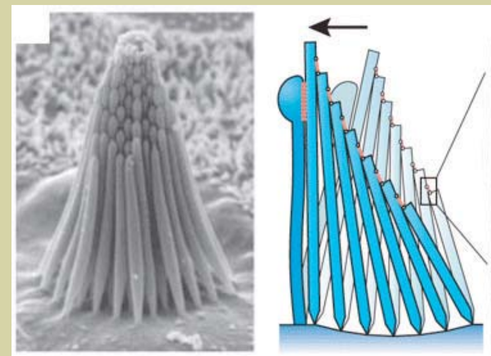


L-R Adrian Cheng and Luis Beltran-Parrazal

Luis Beltran-Parrazal earned a Ph.D. from the Universidad Nacional Autónoma de México under Dr. Martinez de la Escalera at the Instituto de Neurobiología. His work examined the role of GABA on immortalized GnRHhergic hypothalamic neurons. He subsequently pursued post-doctoral studies with Dr. Andrew Craig Charles in the UCLA Department of Neurology and with Dr. Ivan A. Lopez in the UCLA Division of Head and Neck Surgery. Dr. Beltran-Parrazal is currently a research associate in the UCLA Department of Physics and Astronomy where his research with Dr. Katsushi Arisaka focuses on the role of mitochondrial movement in health and disease in the nervous system. He is especially interested in the study of ion channels: how ion channels modulate and are modulated by key protein signaling cascades associated with electrical excitability.

mechanism of transduction is fairly well understood.

"What is not worked out," explains Dr. Bozovic, "are the details of the process, which require examination on a single cell level." And that is the focus of her research. Studying the inner ears of frogs, she is utilizing Dr. Arisaka's photo microscopy technology to image the motions of hair cells. "We believe that the interactions between cells play an important role in shaping the response of the whole organ, so we want to measure the strength of this interaction, and track the movements of many cells, in parallel, under various conditions. The patterns of the interactions have not yet been established and may provide the building blocks for this critical first stage of the hearing process." The questions are many: Do the cells synchronize? How many? Under what conditions?



(l) Hair bundle from a frog vestibular organ, composed of 60 stereocilia.(r) An excitatory deflection of the hair bundle (arrow) causes stereocilia to shear past one another, separating the tips.

Dr. Bozovic conducts her experiments in vitro. The hair cells are kept alive for several hours through immersion in an oxygenated solution while they are examined under photo microscopy. As a result of the equipment's superb speed and resolution, Dr. Bozovic and her students have begun to track the movements of hundreds of hair bundles and document their responses to specific stimuli. She concludes, "After just one year working with photo microscopy, we can see major benefits to our research, especially in terms of tracking multiple cells and scanning large areas of the organ."

> *"We are catapulting what's been in its infancy for the last 20 years into a definable research area by dramatically improving the quality of information through new technology."*

By illuminating the experiments of Drs. Bozovic, and Portera-Cailliau with photo microscopy, Dr. Arisaka is forging a new direction for biophysics and neuroscience research while furthering his own interests in neurophysics. Says Adrian Cheng, "We are catapulting what's been in its infancy for the last 20 years into a definable research area by dramatically improving the quality of information through new technology." The equipment he is building now in Dr. Arisaka's lab will provide even greater depth and breadth to biophysics research, particularly in the area of neurophysics, a subject that has not received much attention up to now, but is high on the list of Dr. Arisaka's favorite things.

Winstein/Holmes

Bruce and Joan Winstein

The Physics and Astronomy Department is pleased to announce an $85,000 gift-challenge, made possible by a $60,000 gift from Bruce and Joan Winstein and supplemented by Ben and Carol Holmes with an additional gift of $25,000. The Winsteins established this fund to encourage alumni to support students in the Physics and Astronomy Department. The department now hopes to raise an additional $85,000 to match this sum.

"My family and I are proud to be associated with the Physics and Astronomy Department," Bruce said. "I am pleased with the direction the department is taking, and thus I hope that my gift-challenge will serve to encourage other alumni and friends to contribute, thereby enhancing excellence in research and teaching in physics and astronomy."

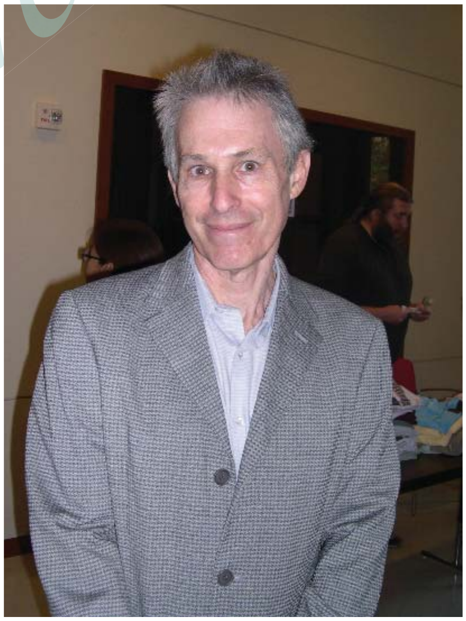
Bruce is the Samuel Allison Distinguished Service Professor in Physics at the University of Chicago, but he and his family are also dedicated Bruins. His late father was Saul Winstein, a UCLA alumnus and a distinguished professor of chemistry and biochemistry on the Westwood campus for 28 years. His sister Carolee is a UCLA alumna, and their mother, Sylvia, attended UCLA on its original Vermont Avenue campus. Bruce earned his undergraduate degree in physics at UCLA and a Ph.D. at Caltech, and has supported UCLA for 40 years.

Ben Holmes earned his B.S. in physics from UCLA and an MBA from USC. He is president of the Holmes Co. in Ketchum, Idaho, a firm that specializes in healthcare consulting, with a focus on the medical device industry. He is an active member of the UCLA Sciences Board of Visitors and serves on the UCLA Foundation Board of Governors.

These endowed funds, along with matching gifts received, will provide crucial support for outstanding students in the department for decades to come.

Preston gift

Howard and Astrid Preston recently provided key support for the work of Professor Andrea Ghez through the Astrophysics Graduate Colloquium. Their generous gift affords substantial funding for this distinguished series, which brings eminent scientists to UCLA from around the nation and the world to share their research and expertise with graduate students in astrophysics. The Prestons are long-time supporters of UCLA, and the department is grateful for their generosity. Howard received his B.S. and Ph.D. degrees in physics from UCLA, and Astrid earned her B.A in art. She is an artist whose work is exhibited in numerous museums in California, including UCLA's Hammer Museum. Howard is president of Preston Cinema Systems, a motion picture camera equipment company based in Santa Monica. He serves on the Physics Advisory Council, and he and his wife funded the Preston Reading Room in the Physics and Astronomy Building.



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"If your actions inspire others to dream more, learn more, do more and become more, you are a leader." John Quincy Adams

Career Day 2008

Undergraduates enthusiastically gathered in the Physics & Astronomy in room 4-430 to listen in rapt attention as eight members of the alumni sat at a panel and addressed the young and upcoming professionals of tomorrow. The night gathered momentum as this professional panel graciously shared their job workplace experiences to help the audience members gain some insight into the demands, pitfalls and opportunities the work world offers to new arrivals. One at a time, each panelist wrapped into their remarks just how their past physics' degree played a part in their present position. A vigorous question and answer period during and after the presentation energized the room and frequently the panel and audience engaged in an informative and friendly exchange to top off a most productive session.

Panel left to right: Cheng-Wei Cheng, Senior IT Architect IBM; Dan Dawes, Founding Partner Myers, Dawes, Andras & Sherman LLP; John Vaszari, Program Manager & Senior Engineer, L-3 Communications; Nzhde Agazaryan, Dept of Radiation Oncology, David Geffen School of Medicine, UCLA; Raymond Ellyin, Logistical and Electrical Engineer, JPL; John Taborn, Graduate Counselor Supervisor - UCLA Career Center; Darius Gagne, Principal and Co-founder - Quantum Wealth Management; and Tatiana Vinogradova,Senior Engineer, Space Sensors & Exploitation Systems Division, Northrop Grumman Corporation.

We welcome all of our alumni to join in our next Career Day in 2009. Help our upcoming graduates to be more informed when they plan their future. To volunteer to participate on our panel, please contact: Diana Thatcher: thatcher@physics.ucla.edu

2007-2008 PAAL Outstanding Graduates

Erin Smith is currently a NASA Postdoctoral Fellow at Goddard Space Flight Center in Greenbelt, Maryland. She is currently working on detector development and selection for the James Webb Space Telescope, a NASA mission slated for launch in 2013.

Peter Dong is currently teaching at the Illinois Mathematics and Science Academy; a public high school for high achievers in math and science from across the state of Illinois. He teaches classes in statistical methods and modern physics and is enjoying this assignment. In addition, Peter still does some research related to his thesis analysis at Fermi National Accelerator Laboratory.

Erin Smith and Peter Dong

Guy Weyl Fellowship Recipients

L-R: Henrik Johansson, Zvi Bern (Advisor), and John Joseph Carrasco

John Joseph Carrasco and Henrik Johansson are the first recipients of the Physics and Astronomy Alumni fellowship recently created by Guy Weyl(UCLA Ph.D. 1969). Guy Weyl received a fellowship while matriculating at UCLA and felt it only natural to give back and fund the first fellows.

Physicists have long believed that quantum mechanics is incompatible with Einstein's General Relativity in four dimensions and that no consistent point-like theory of quantum gravity can be constructed. Henrik and John Joseph, along with their advisor Zvi Bern and collaborators, are challenging this widely held belief by performing explicit calculations in the highly supersymmetirc theory of quantum gravity known as N=8 supergravity. So far all of their calculations point to the convention wisdom being incorrect.

Each real number represents an infinite amount of information. Should our fundamental description of the universe be so uneconomical as to really require an infinite amount of information simply to establish an observable, e.g. the distance between any two events? Best question posed by John Joseph Carracsco at Subnuclear Physics Meeting in Sicily.

Focus in Excellence

Wright wins David S. Saxon Presidential Chair in Physics

Ned Wright

Professor Edward Wright was recently awarded the Davis S. Saxon Presidential Chair in Physics. The Chair was established by the Regents in 1981 and renamed in 1986 for David Saxon. Presidential Chairs are intended to encourage new or interdiciplinary program development or to enhance quality in existing academic programs of the university. Appointment to this Chair is a most prestigious honor.

Professor Wright is a world-renowned astrophysicist and member of the UCLA faculty in the Department of Physics and Astronomy. He received his AB, AM, and PhD from Harvard University.

For three decades, Professor Wright has been a highly visible leader in cosmology and infrared astronomy. His accomplishments are extensive. Among his most noteworthy contribtions is his discovery of anisotropy in the Cosmic Microwave Background in theCOBE data se. These anisotropies are the small variations of temperature in different directions that show us how the Universe began to aggregate and presumably ultimately form galaxies.

This result has had far-flung impact within both astrophysics and particle physics, was awarded the Nobel Prize in 2007, and has been followed up on with the WMAP satellite, another project in which Professor Wright has played an active role. Ned continues to be at the forefront of astronomy; he is currently the Principal Investigator on WISE, a NASA satellite to survey the infrared sky.

Professor Wright has an extensive list of accolades, including elected membership in the American Academy of Arts & Sciences (2007), Gruber Prize in Cosmology as part of the COBE team (2006), and NASA's Exceptional Scientific Achievement Medal for COBE (1992). His work on the cosmic microwave background has fundamentally changed our view of the physical Universe.

Continuing his myriad of paeans, Professor Wright was also selected as this year's UCLA Faculty Research Lecturer. He made his presentation on October 28, 2008 at UCLA Freud Playhouse, MacGowan Hall on the subject "Observing the Origin of the Universe: A Century of Progress in Cosmology."

Genius

Professor Andrea Ghez recently won a 2008 MacArthur Fellowship. Recipients are selected for their creativity, originality, and potential to make important contributions in the future. Ghez is among 25 new recipients of the annual "genius" fellowship, each of whom will receive $500,000 in unrestricted support over the next five years to use as they see fit. MacArthur Fellowships offer the opportunity for Fellows to accelerate their current activities or take their work in new directions. The unusual level of independence afforded to Fellows underscores the spirit of freedom intrinsic to creative endeavors.

Dr. Ghez comments "…The MacArthur Foundation funding will allow me to be much more effective and flexible and will definitely help with the balancing act…I'm frequently away from home and from my children, conducting research. Now I will be able to bring them with me more often..." Adding to Professor Ghez' list of commendations are the Sackler Lecturer at Harvard University; Sackler Lecturer at Leiden University; UCLA Academic Advancement Program Faculty Research Award; Helen Hogg Distinguished Visitorship; and the Las Cumbres Observatory Lecturer.

Professor Steven Furlanetto was awarded a 2008 Packard Fellowship in Science and Engineering. The Fellowship, awarded each year to twenty of the nation's most promising young professors, assists them in pursuing their science and engineering research. With the Packard Fellowship, Professor Furlanetto plans to develop a variety of models for the evolution of the first galaxies that formed in the Universe and to predict their observational signatures for a wide variety of instruments, including UC's planned Thirty Meter Telescope. Professor Furlanetto is thrilled to receive this honor and looks forward to the research it will enable over the next five years.

Professor Yaroslav Tserkovnyak was awarded a Sloan Research Fellowship. The Sloan Research Fellowships were established in 1955 to provide support and recognition to scientists, often in their first appointments to university faculties, who were endeavoring to set up laboratories and establish their indpendent research projects with little or no outside support.

In recognition of contributions to the FEL field, from the physics of the electron beam to proof-of-principle experiments in high gain FELs, Rosenzweig was awarded, along with collaborator Ilan Ben-zvi (Stonybrook/BNL) the 2007 International Free-electron Laser Prize.

Professor Dolores Bozovic was awarded the 2008 Pierre-Gilles de Gennes prize 'From Solid State to Biophysics' for her remarkable contributions to the understanding of biophysics of active processes of the inner ear and the extraordinary sensitivity of hearing. The international jury was unanimous that her scientific work deserves the prize as it truly honors Nobel Laureate (1991) Pierre-Gilles de Gennes' legacy. She also received the 2008-2009 Faculty Career Development Award, awarded by the UCLA Office of Faculty Diversity & Development.

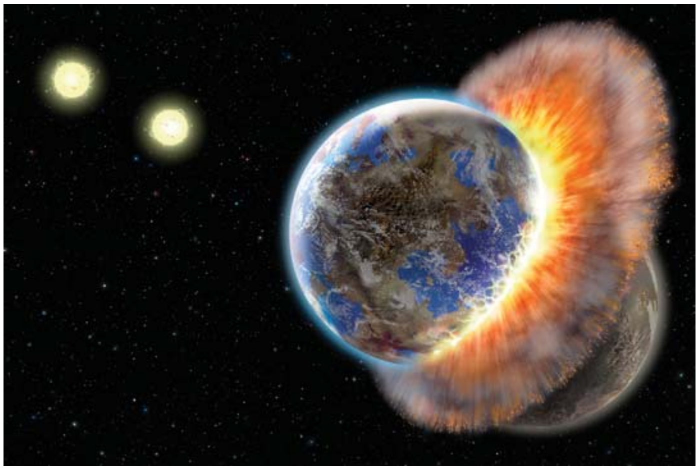
Professor Sergio Ferrara received the "2008 Amaldi Medal " European Prize for the "General Relativity and Gravitational Physics" presented by the Italian Physical Society of General Relativity and Gravitation. He also received the prestigious "Miller visiting research Professor Award" from the Miller Institute for Basic Research in Science at Berkeley where he presently resides. To cap off Sergio's plaudits on October 1, 2008, he was awarded an Advanced Investigator Grant from the European Research Council (ERC) of 1.7 million euros(about 2.5 million dollars) to conduct "frontier research" in Italy.

Gary Williams was among the recipients of the APS Outstanding Referee Award. This highly selective award program recognizes scientists who have been exceptionally helpful in assessing manuscripts for publication in the APS journals.

Too often we fail to recognize and pay tribute to the creative spirit. It is that spirit that creates our jobs… (Alfred P. Sloan Jr., 1941)

Astronomy

Ian McLean, James Larkin: The UCLA Infrared (IR) Lab has continued to work on the development of two major instruments. The first of these is Multi-Object Spectrometer for Infra-Red Exploration (MOSFIRE), a multi-object spectrograph for infrared exploration using the Keck 10-m telescopes in Hawaii. During the past year MOSFIRE has been in the construction phase. The second project is the Gemini Planet Imager (GPI) which is an infrared instrument designed to obtain images and spectra of planets around nearby stars using the 8-m Gemini South telescope in Chile. GPI passed its critical design phase during the year and is now beginning the construction phase. One Ph.D. student, **Erin C. Smith,** received her degree for work involving the development and application of FLITECAM which has been developed at UCLA for the Stratospheric Observatory for Infrared Astronomy (SOFIA); SOFIA is expected to begin science operations in 2009. Work has also continued under James Larkin's leadership on IRIS, the infrared imaging spectrograph for the proposed Thirty Meter Telescope (TMT).

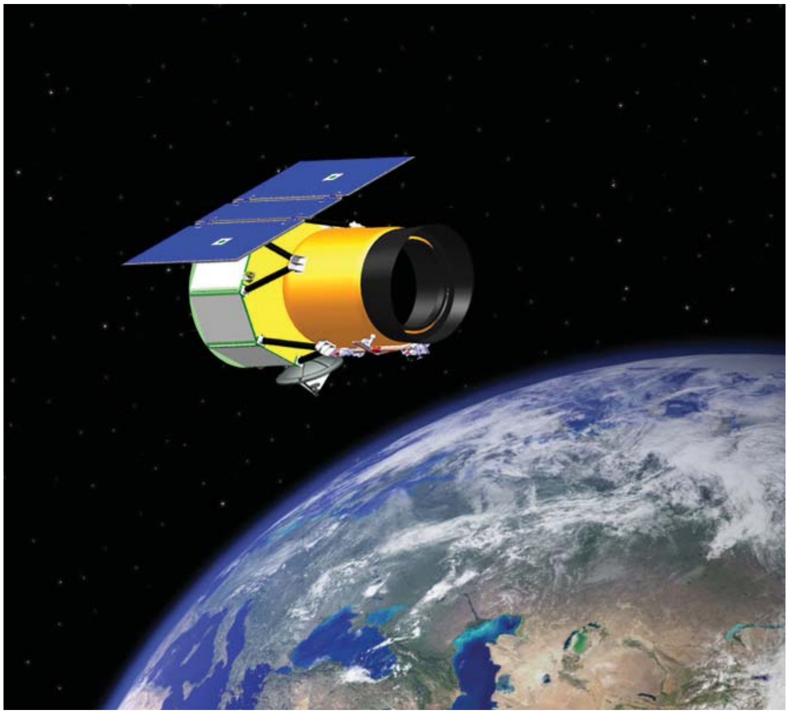


Planetary collision: An artist's rendering depicts planets colliding in a sun-like binary system about 300 light-years from Earth, in the constellation Aries. Artwork by Lynette R. Cook.

Ben Zuckerman is interested in the origin and evolution of planetary systems. Zuckerman and colleagues at Tennessee State University have been studying a remarkable planetary system that orbits a star located about 300 light years from Earth in the direction of the constellation of Aries. This star, called BD+20 307, is actually two sun-like stars locked in a 3.4 day orbit around each other. A cloud of warm dust grains orbits around the two stars at a distance similar to the distance of the planets Earth and Venus from the Sun. There is about one million times more warm dust in orbit around BD+20 307 than in orbit around our Sun. Indeed, there is more warm dust orbiting BD+20 307 than orbits any other known star. Zuckerman and his colleagues believe that the most likely explanation, by far, to produce so much warm dust is that not too long ago (astronomically speaking), two rock planets that were orbiting BD+20 307 collided with each other. Because the age of the BD+20 307 system appears to be at least one billion years and perhaps even 4 or 5 billion years, i.e., similar to the age of Earth, it is possible that life existed on one or both of the planets that collided at BD+20 307. If so, the collision surely would have wiped out life. Life or not, this is the first indication that astronomers have that long-lived rocky planets can exist around close binary stars.

Edward L. Wright and his graduate student **Louis Levenson** reduced the discrepancy between galaxy counts and the cosmic infrared background by showing that galaxy fluxes had been underestimated in previous work. Wright and graduate student Xi Chen showed that point sources could be found efficiently in CMB-free internal linear combinations of WMAP maps.

The Wide-field Infrared Survey Explorer (WISE) is undergoing optical and environmental testing, working toward a late 2009 launch. WISE will survey the entire sky in the mid-infrared and measure the diameters of 100s of thousands of asteroids, find the closest stars to the Sun, and the most luminous galaxies in the Universe.



Artist's concept of Wide-field Infrared Survey Explorer (WISE). A new NASA mission will scan the entire sky in infrared light in search of nearby cool stars, planetary construction zones and the brightest galaxies in the universe. Image Credit:NASA/JPL

Brad Hansen, along with former graduate student **Thayne Currie**, and undergraduate **Jenny Shih,** have been studying the formation of the planets around pulsars. The observed pulsar planet system is the only other known planetary system that contains earth-like planets, and the models for its formation shed light on the conditions that led to our own planetary system. Using these results, Hansen is now studying a new model for the origin of the solar system terrestrial planets, which provides a new scenario for the origins of the smaller planets, Mercury and Mars.

Brad Hansen, along with collaborators Travis Barman and Lisa Prato of Lowell Observatory, and graduate student **Ian Crossfield**, are using the Keck telescope to observe bright stars that host close-in giant planets. They are studying methods to separate light emitted from the planet from that of the star using high resolution spectroscopy to detect the Doppler shift of the planetary signal.

Andrea Ghez along with her group, **Jessica Lu, Quinn Konopacky, Tuan Do,** and **Sylvana Yelda**, have focused on taking advantage of the recent advent of laser guide star adaptive optics at the Keck telescope. In this past year, they have studied how well one can determine the properties of the central supermassive black hole using orbiting stars They have also investigated how young stars can form in the vicinity of a black hole, what can be learned from the accretion luminosity from the black hole, and evolutionary models for brown dwarfs (objects between stars and planets).

Results from UCLA's Galactic Center research group was featured in Smithsonian Magazine April 2008 cover story (*http://www.smithsonianmag.com/issue/April_2008.html) and Sky & Telescope (http://www.skyandtelescope.com/news/home/27621359.html.*)

The formation of stars within about 500 light years of the Galactic center occurs somewhat differently than elsewhere in the Galaxy because the initial conditions there are so much more extreme in many respects. The formation process appears to favor relatively massive stars. **Mark Morris** and recent (September 2008) Ph.D. recipient **Jon Mauerhan**, working with former Hubble Fellow Mike Muno, have carried out infrared spectroscopic measurements of candidate stars chosen from a deep X-ray survey of the entire Galactic center made with NASA's Chandra X-ray Observatory. Seventeen massive, young, emission-line stars were discovered; their X-ray properties imply that they are likely to be binary systems with colliding, strong winds. Work is now under way to determine whether they formed in isolation, or whether they escaped from very massive star clusters.

Three of the Galaxy's most massive young clusters are found near the Galactic center. In collaboration with Andrea Ghez and recent postdoctoral fellow **Andrea Stolte**, Morris has used the Keck Observatory to study the motions of two of these clusters. At least one of them is moving far faster than was expected, which provides a strong clue to where and how it must have formed. Another exciting new result is that some of the stars in this cluster are still surrounded by protoplanetary disks of dusty matter, presumably left over from the formation process a few million years ago.

Extra Galactic Astronomy

Jean Turner continued her research on star formation in nearby galaxies. Turner and student **Chao-Wei Tsai** obtained high resolution images of 7mm continuum emission from young, embedded HII regions in the starburst galaxy M82. They found that young, dense HII regions account for at least 6% of the flux from HII regions in M82. They infer that this embedded phase of star formation could last for a Myr or more, which means that the youngest star clusters and most massive stars are hidden from view even in the near-infrared. Turner and former student David Meier (New Mexico Tech) imaged the molecule 13C16O in the center of the spiral galaxy Maffei 2 using data from the BIMA Array and found the clearest kinematic evidence for bar motions outside the Milky Way. Molecular clouds in the center of this galaxy are elongated due to strong shearing within the bar arms. Turner and Meier speculate that this is why star formation is deterred in these arms, allowing gas to pile up in the central region of the galaxy, where a burst of star formation is occurring. Turner and Meier are working on "imaging chemistry" of the gas in the center of Maffei 2. Initial findings show that the chemistry of the molecular gas is strongly correlated with galactic structure and with the starburst.

Steven Furlanetto received the Bart J. Bok Prize, from Harvard University Department of Astronomy, which is given to a recent graduate (under the age of 35) for "outstanding work"

Astroparticle Physics

The astroparticle physics group led by **Rene Ong** and **Vladimir Vassiliev** is carrying out research in several exciting areas. The main project is the Very Energetic Radiation Imaging Telescope Array System (VERITAS), an array of four 12m diameter telescopes that detect very high energy (VHE) gamma rays via the atmospheric Cherenkov technique. The construction of VERITAS was completed in early 2007; a first light celebration was held in April 2007 at the VERITAS site on Mt. Hopkins in southern Arizona and routine observations started soon after that. In its first year of operation, VERITAS has detected over a dozen sources of VHE radiation at energies beyond a tera-electron volt (TeV). The sources include several supernova remnants such as the Crab and IC 443, the X-ray binary system LSI +61 303, and the giant radio galaxy M87. Another important result is the discovery of VHE gamma rays from several distant active galactic nuclei (AGN) - these objects are generally believed to harbor supermassive black holes at their centers. High-energy AGN are still relatively few in number and thus it was exciting when VERITAS detected two of these sources in the same field of view. The UCLA group has a major role in two of the key science projects of VERITAS: a sky survey of the galactic plane in the Cygnus region covering more than 100 square-degrees and a search for the annihilation of dark matter particles in nearby galaxies. The VERITAS group at UCLA includes postdoctoral associates **Stephen Fegan** and **Amanda Weinstein** and graduate students **Timothy Arlen, Ozlem Celik, Ken Chow,** and **Matthew Wood**. Fegan will move to a new position at Ecole Polytechnique in Paris and Celik will graduate in October 2008. She has taken a position at Goddard Space Flight Center in Maryland**. Alex Jarvis,** a student working on the earlier STACEE project, completed his thesis work on the study of gamma-ray bursts and graduated in June 2008. Jarvis is now working for Disney in their online research division. Looking beyond VERITAS, Vassiliev and Ong are also working to develop the next major ground-based gamma-ray observatory. This observatory, called the Advanced Gamma Imaging System (AGIS), could consist of as many as 100 telescopes covering an area of 1 square kilometer. The UCLA effort, led by Vassiliev, is concentrated on the development of a novel wide-field telescope using a design originally attributed to Schwarzschild and Coudet. The initial telescope studies look very encouraging and the group is now seeking funding for a major research and development effort.

Ong is also involved in two other interesting projects in astroparticle physics. The first of these is the Fermi Gamma-Ray Space Telescope (FGST). This is a major satellite observatory launched by NASA on June 11, 2008, and surveys the entire gamma-ray sky at giga-electron volt energies (GeV). Ong is an affiliated scientist with the Large Area Telescope (LAT) team of Fermi. Ong worked with **Jennifer Sierchio,** student in UCLA's **Research Experience for Undergraduates (REU)** program during summer 2008 to analyze some of the first exciting data from the Fermi telescope.

A second project is the General Anti-matter Spectrometer (GAPS) experiment. GAPS seeks to detect signatures for the mysterious dark matter that pervades our universe.

If stable supersymmetric particles (neutralinos) make up a large component of the dark matter, they could annihilate to give excess anti-matter in the galaxy. GAPS aims to detect anti-deuterons in the cosmic rays that would provide a tell-tale signature for neutralino annihilation. GAPS is in the development phase at the present time and it is proposed for a long-duration balloon flight in the Antarctic during the early part of the next decade.

Getting ready for observing at VERITAS on Mt. Hopkins, AZ. Two of the four VERITAS gamma-ray telescopes pointing upward"
photo credit (Stephen Fegan).

One of the activities as part of the HEP group is the direct dark matter search. As a Principal Investigator (PI) of Department of Energy grant, **David Cline** together with **Hanguo Wang** (PI) of National Science Foundation grant) have been investigating the

The UCLA Dark Matter lab in PAB. Foreground: Cryogenic system. Background: Class 1000 clean room.

dark matter problem using liquid xenon since the early 90's. Pioneered in the liquid xenon two phase technologies, Cline and Wang have successfully designed and built the ZEPLIN II central detector at UCLA and operated the detector in collaboration with the UK dark matter collaboration at Boulby Mine, UK and published competing results recently. Wang also leads the ZEPLIN team in the USA, collaborating with the University of Rochester, Texas A&M University and Southern Methodist University, in addition to the UK Dark Matter Collaboration.

In parallel with the US ZEPLIN team, the XENON10 collaboration, led by Elena Aprile of Columbia aided by a NSF grant. Using the same technology, she published the best limit soon after the ZEPLIN II result. At the conclusion of the ZEPLIN II project, UCLA has joined forces with the XENON collaboration now working on a larger detector, XENON100, funded by NSF. **Katsushi Arisaka** also joined the effort of UCLA dark matter search activities and added significant strength to the UCLA team with DOE support.

After Arisaka joined the team, together with Wang, a new photon detection device (QUPID) was invented in response to the special need of dark matter research communities. A prototype has been successfully developed and a joint UCLA, Hamamatsu patent is pending. This device opens the doors for future ultra low radiation background detector construction.

Looking into the future, the UCLA team, armed with the new invention and the long history of research using liquid xenon and liquid argon, will play an important future role in the very large scale dark matter search effort.

Graduate student **Weichung Ooi** was recently awarded a Ph.D. from his effort on ZEPLIN II work supported by Wang's NSF grant. Many graduate students have recently joined the dark matter team, they are: **Daniel Aharoni, Ethan Brown, Artin Teymourian,** and **Chi Wai Lam**.

In addition to the dark matter search activities, Cline and Wang are active members of the ICARUS collaboration. A 600 ton liquid argon time projection chamber for proton decay and long base line neutrino oscillation, currently in commissioning phase at Gran Sasso national underground laboratory in Italy. Cline is also member of the CMS collaboration on LHC (Large Hadron Collider) at CERN Geneva, together with other UCLA HEP professors. Also at CERN a LANNDD-5m, an experiment to test electron drift in liquid argon for up to 5 meters with Franco Sergiampietri of Pisa, Italy. **Kevin Lee** and David Cline are working on the NOVA long baseline project, a collaborative effort with FNAL.

Graduate Student Ethan Brown working on the XENON100 detector at Gran Sasso National Lab, Italy.

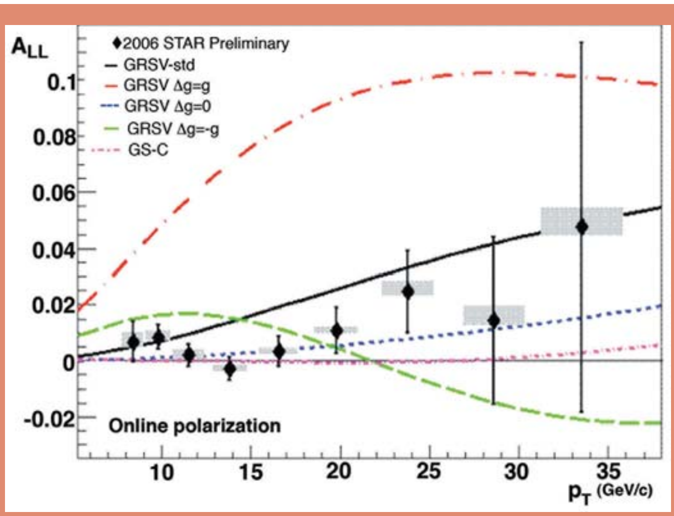
Nuclear Physics

The Nuclear Physics Group (**Charles Whitten, Jr., Huan-Huang, and George Igo**) has been focusing on Heavy Ion and Spin physics programs from the STAR (Solenoidal Tracker At RHIC) experiment at Brookhaven National Laboratory. The STAR experiment completed a Forward Meson Spectrometer (FMS) detector upgrade and had a successful run of d+Au and polarized p+p collisions in FY 2008. The FMS detector measures neutral pions at forward rapidity to probe parton distributions in the Au nuclei at the low Bjorken x region, where x is the fraction of nucleon momentum that is carried by the parton in the light cone frame. Recent theoretical development indicated that the number of low x partons may be saturated in heavy nuclei, thus limiting the number of parton-parton interactions in the soft physics regime. The d+Au collision data will provide a unique probe to the parton distributions at low x. In addition, the d+Au data will also serve as reference data for heavy ion collision physics where we have been studying properties of dense partonic matter formed in central nucleus-nucleus collisions at RHIC.

Our heavy ion physics program has been centering on strange and heavy quark probes. Our post-docs and graduate students will analyze the charm quark production cross sections, and the nuclear modification factors for non-photonic electrons from heavy quark decays at high trans-heavy quark induced jet traversing the dense partonic matter. We will install over 60% of detector trays for the STAR Time-of-Flight (TOF) detector upgrade project in the 2009 running and expect to complete the project by September 2009. The TOF upgrade will significantly enhance STAR physics capabilities.

Our spin physics program activities are mostly in the measurement of longitudinal double spin asymmetry (ALL) for inclusive jet and di-jet production in polarized p+p collisions. These jets originating from parton scattering processes can be described by perturbative Quantum ChromoDynamics (pQCD) calculations and are used to measure underlying gluon spin structure functions. One exciting development in the spin physics is the recent inclusion of RHIC polarized proton data in global fit analyses of proton structure functions *(D. de Florian et al, arXiv:0804.0422).* For the first time, the RHIC data present a dramatic improvement in the determination of the polarized gluon structure function, as well as coupling through the global fit to determinations of quark and anti-quark functions. As can be seen in the Figure, STAR data now has the strongest impact on determination of the gluon contribution to the proton spin, especially as it excludes both large positive and large negative contributions.

STAR will continue to improve the impact of inclusive jet asymmetries by adjusting trigger thresholds to emphasize the low transverse momentum jet regions where the gluon contributions dominate. At



2006 results for inclusive jet longitudinal double spin asymmetry as a function of jet transverse momentum. The curves represent proposed theoretical models for the gluon spin structure functions.

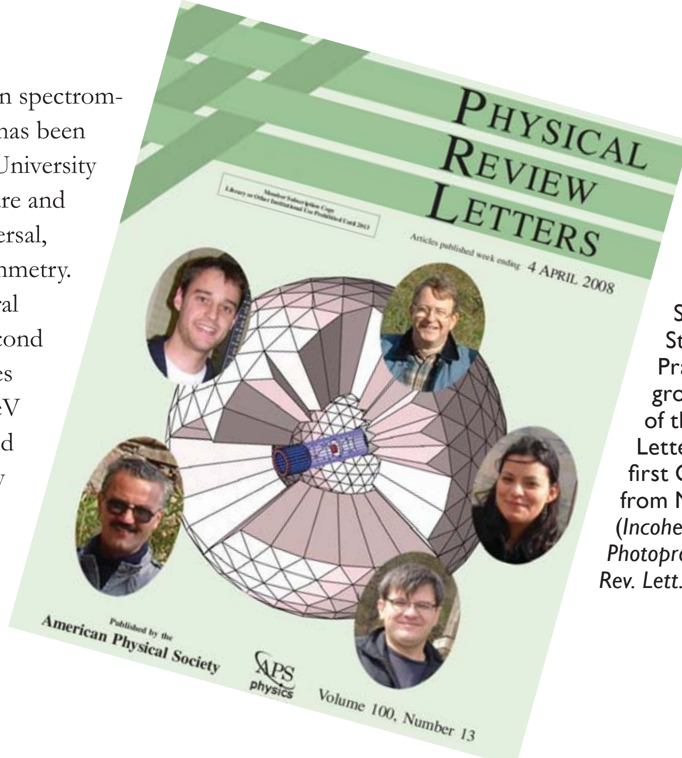
the higher data rates allowed by the DAQ1000 initiative (~250 Hz written to tape in 2009), we will continue to improve these error bars by about a factor of 3-5 next year, depending on the RHIC schedule under the FY 2009 budget constraints.

The UCLA Heavy Ion and Spin Physics group consists of staff scientists: **Stephen Trentalange**, **Oleg Tsai**; Post-docs: **Gang Wang, Shingo Sakai**, **Xiaohua Liu;** Graduate students: **Bertrand Biritz, Ramon Cendejas, Dhevan Gangadharan, Priscilla Kurnadi, David Staszak, Wenqin Xu;** Visiting Students and Scholars: **Mingjun Chen**, **Jian Tian;** and undergraduate student: **Xiaoyu Zhu.**

Nuclear and Particle Physics at Intermediate Energies

The main objective of the Research and Teaching Group, Nuclear and Particle Physics at Intermediate Energies, is testing the validity of the symmetries that control the new features found in subatomic physics. Much work is done on determining the structure of the chief building block of our universe, the proton. The group is led by **Bernard (Ben) Nefkens**. Post doctoral researchers are **Aleksandr (Sasha) Starostin** and **Serguei Prakhov**; a new researcher is in the hiring stage. Graduate student **John Goetz** has obtained the experimental data for his thesis this year, which is a search for doubly strange nucleons using the improved CLAS detector at Jefferson Laboratory. **Indara Suarez** graduated in 2007, and in 2008 she was awarded a stipend in the Postbaccalaureate Research Educational Program. Beside preparatory work for grad school, she is analysing experimental data obtained in the Crystal Ball experiment at the University of Mainz where the group is spearheading a collaboration of some 12 Universities in research on multimeson photoproduction.

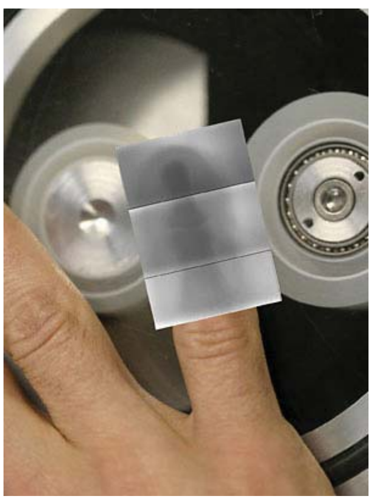
The group pursues two experimental programs. One is centered around a special detector, the Crystal Ball multi-photon spectrometer that has an acceptance of almost 4π steradian. It has been installed in the 1.5 GeV tagged photon beam of the University of Mainz. This enables measurement of the neutral rare and forbidden η and η' decays. This tests C, CP, time reversal, and isospin invariences, as well as flavor and chiral symmetry. Studies include the photoproduction of selected neutral mesons to probe the structure of the proton. The second program uses the large CLAS detector, which measures charged particles. This device is located in the 5.75 GeV tagged photon beam of Jefferson Laboratory. It is used to investigate cascade hyperons, which are rare, doubly strange baryon specimens. The cascade particles are particularly well suited to study the quark structure of the proton, and probing the quark-quark correlations inside the proton.



Members of the group (from upper-left, clockwise), John Goetz, Bernard Nefkens, Indara Suarez, Aleksandr Starostin, and Serguei Prakhov. In the background is the frontpage of the Physical Review Letters issue where the first Crystal Ball article from MAMI was published (*Incoherent Neutral Pion Photoproduction on 12C: Phys. Rev. Lett. 100 (2008) 132301*).

Condensed Matter Physics

UCLA researchers discovered that unspooling a simple roll of Scotch tape produces X-rays – strong enough to produce clear images of their fingers. Physicist, **Seth Putterman,** lead author of the study "We're marveling at Mother Nature," commented that although researchers suspected that the process might produce X-rays, they were astounded by their intensity and duration. Putterman's students **Carlos G. Camara, Juan V. Scobar** and **Jonathan Hird** constructed a device to study this phenomenon. The discovery could eventually lead to compact X-ray sources that could be used for treating cancer, among other things, according to a study recently published in the journal Nature.



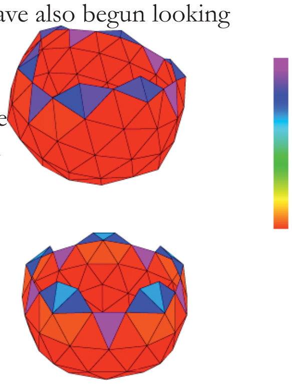
Gary Williams' group has made the first measurements of superfluidity in thin helium films coating carbon nanotubes. They have observed third sound waves propagating down the tubes, which are thickness waves of the helium that also involve temperature oscillations. This work has been carried out by graduate student **Emin Menachekanian;** undergraduates **Sonny Vo, Hossie Fard, Anshul Kogar, Guanyu Zhu;** and REU student **Lara Mitchell.**

Another experiment carried out in the Williams lab involves studies of the luminescence from laser-induced bubbles in liquids. Work by former graduate student **Dr. Han-Ching Chu Czarnecki,** undergraduate **Sonny Vo**, and high school student **Tim Hsieh** found a new precursor luminescence pulse from the laser-induced bubbles in NaCl solutions. In another project, graduate student **Erin Englert** and REU student **Allison McCarn** studied luminescence from bubbles in water-glycerol mixtures, finding that the duration of the luminescence pulse increased by nearly a factor of two as the glycerol concentration was increased, a result of the increasing viscosity of the solution.

W. Gil Clark et al using pulsed nuclear magnetic resonance (NMR), measured and analyzed the static and dynamic properties of ^{77}Se in the organic conductor λ-(BETS)$_2$FeCl$_4$ to investigate its unusual low temperature phases, including field-induced superconductivity (FISC). It was extremely challenging. The ^{77}Se magnetic moment and the natural abundance are small, and the single crystal sample mass was only 6 micrograms. By using a tiny NMR coil and typically 10,000 averages, good measurements were obtained, and the Jaccarino-Peter mechanism proposed for the FISC phase was verified. The results are published in *Guoqing Wu, W. G. Clark, S. E. Brown, J. S. Brooks, A. Kobayashi, and H. Kobayashi, Phys. Rev. B 76, 132510 (2007).*

Joseph Rudnick and **Robijn Bruinsma** are working with **Alex Morozov**, a postdoctoral researcher, on the assembly of viruses. The focus of their study is the way in which assembly proceeds over time and its ultimate outcome in terms of completed, infectious viruses and partially assembled fragments. They have just completed an investigation of a mathematical model for that process that they dub the Assembly Line Model. This representation reproduces some of the more striking observations of viral assembly, including its apparent consistency with the Law of Mass Action, which is appropriate to a reversible chemical reaction rather than the apparently irreversible process of virus assembly.

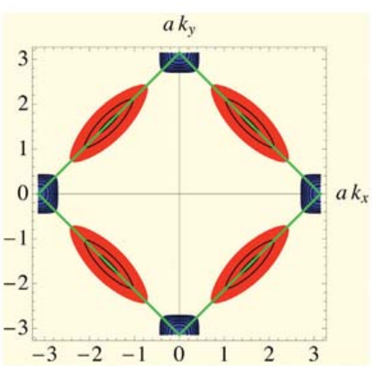
Bruinsma, Rudnick and Morozov have also begun looking into the energetics governing viral assembly, making use of a variant of the finite element method to assess the mechanical energies and forces associated with fully and partially assembled viral capsids. See the figure of two partially assembled T=3 viral protein shells, or capsids. The "rainbow" indicates the color coding of local energies, red for lowest, violet for highest.



Theoretical Condensed Matter Physics

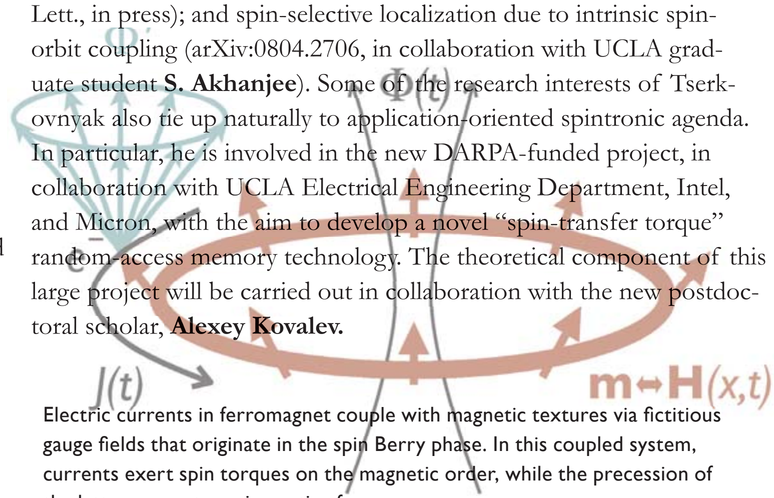
The past year has seen a remarkable development in high temperature superconductors. A number of exquisite experiments published in major journals, such as Nature and Physical Review Letters, have detected quantum oscillations (de Haas-van Alphen effect, for example) signifying small Fermi pockets in underdoped high temperature superconductors. Over the past two decades this was thought to be almost impossible. What separates these experiments from others are the high quality samples and a very high precision, low temperature, and high magnetic field measurements of the order of 60 Tesla. Implications could be far reaching. **Sudip Chakravarty,** along with collaborator Hae-Young Kee at the University of Toronto and UCLA students **Pallab Goswami**, **Xun Jia,** and **Ivailo Dimov, (**Pallab Goswami and Ivailo Dimov, received their Ph.Ds in the past year) have developed a theory involving Fermi surface reconstruction due to a hidden order to explain these results. Two papers were published, one in the Proceedings of the National Academy of Sci-ences *[S. Chakravarty and H.-Y. Kee, Proc. Natl. Acad Sci. USA,105, 8835 (2008)*] and the other in Science [*S. Chakravarty, Science, 319, 735 (2008)].*

Chakravarty has also been working on interesting effects in graphene, in particular on the novel dissipative quantum Hall effect observed at $\nu=0$. This work was carried out in collaboration with students Pallab Goswami and Xun Jia and was published in the Physical Review Letters [*X. Jia, P. Goswami, S. Chakravarty, Phys. Rev. Lett.101,036805 (2008)].* Collaboration with graduate student, **David Schwab,** has resulted in publication in Physical Review Letter *[P. Goswami, D. Schwab, S. Chakravarty, Phys. Rev. Lett. 100, 015703 (2008)]* involving a conceptual question about quantum phase transition and disorder. This collaboration has further evolved to another paper regarding the effect of disorder on Mott insulators, available on the arXiv.



This figure shows how Fermi surface reconstruction takes place, where small blue pockets contain electrons as charge carriers and red pockets contain holes, positive charge carriers, even though these materials are nominally hole doped.

Yaroslav Tserkovnyak investigates nonequilibrium transport and dynamic phenomena in systems with magnetic order or strong spin-orbit coupling. In both cases, electron spin interacts with collective degrees of freedom such as magnetic order parameter or mechanical strain modulating spin-orbit coupling. These interactions pose an interesting coupled dynamic problem, where, on the one hand, electric flows can be used to excite magnetic or mechanical dynamics, while, on the other hand, controlling the collective dynamics with external fields opens intriguing gateways for manipulating electronic transport. Specific recent projects include development of the scattering theory of Gilbert damping in magnetic systems [*Phys. Rev. Lett. 101, 037207 (2008)*]; a study of piezospin polarization of currents in nanostructures [*"Phys. Rev. Lett." 101, 036401 (2008)*]; theory of fictitious gauge fields and effective magnetohydrodynamics of spin-textured ferromagnets [*Phys. Rev. B 77, 134407 (2008)* in collaboration with UCLA graduate student **M. Mecklenburg** and arXiv:0806.4656, in collaboration with UCLA graduate student **C. Wong**]; tunnel-barrier enhanced voltage signals generated by magnetic dynamics [*Phys. Rev. Lett. 100, 067602 (2008) and Phys. Rev. B 78, 020401(R) (2008)]*; proximity-effect assisted absorption of spin currents in superconductors (Europhys. Lett., in press); and spin-selective localization due to intrinsic spin-orbit coupling (arXiv:0804.2706, in collaboration with UCLA graduate student **S. Akhanjee**). Some of the research interests of Tserkovnyak also tie up naturally to application-oriented spintronic agenda. In particular, he is involved in the new DARPA-funded project, in collaboration with UCLA Electrical Engineering Department, Intel, and Micron, with the aim to develop a novel "spin-transfer torque" random-access memory technology. The theoretical component of this large project will be carried out in collaboration with the new postdoctoral scholar, **Alexey Kovalev.**



Electric currents in ferromagnet couple with magnetic textures via fictitious gauge fields that originate in the spin Berry phase. In this coupled system, currents exert spin torques on the magnetic order, while the precession of the latter generates spin-motive forces.

Biophysics

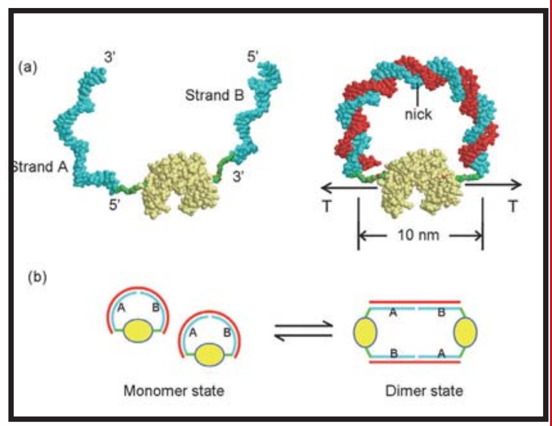
Jian Wei (John) Miao and group continue to conduct cutting-edge research in biophysics and nanoscience. For the first time they have applied coherent X-ray diffraction microscopy to nondestructive imaging of mineral crystals inside biological composite materials at the nanometer scale resolution, and identified mineral crystals in collagen fibrils at different stages of mineralization. Based on the experimental results and biomineralization analyses, a dynamic mechanism to account for the nucleation and growth of mineral crystals in the collagen matrix has been proposed [*Jiang et al., PRL 100, 038103 (2008).*] By exploiting the abrupt change in the scattering cross-section near electronic resonances, the group carried out the first experimental demonstration of resonant X-ray diffraction micro-scopy for element specific imaging of buried structures. They performed nondestructive and quantitative imaging of buried Bi structures inside a Si crystal by directly phasing coherent X-ray diffraction patterns acquired below and above the Bi M5 edge [*Song et al., PRL 100, 025504 (2008).*] For the first time, they recorded and reconstructed coherent X-ray diffraction patterns from single, unstained viruses. By separating the diffraction pattern of the virus particles from that of their surroundings, they performed quantitative and high-contrast imaging of a single virion. The structure of the viral capsid inside a virion was visualized. This work is directly transferable to the use of X-ray free electron lasers, and represents an experimental milestone toward the X-ray imaging of single large macromolecules [*Song et al., PRL, in press (2008).*]

Miao Group

Thomas Mason and postdoc **Kun Zhao** have developed a method of mass-producing colloidal assemblies of lithographic particles using roughness controlled depletion attractions. By custom-tailoring the nanoscale roughness on different surfaces of microscale particles, dispersing the particles in a liquid, and adding a smaller nanoscale depletion agent, they have created a thermodynamic self-assembled phase of dimers, a desired colloidal assembly. This approach provides a controlled route for building microscale devices out of customized particles [*Phys. Rev. Lett. 99268301(2007).*] Postdoc **Jung-Ren Huang** and Mason have explored shear-induced unjamming, ordering, and rejamming of deformable droplets in concentrated microscale emulsions using a new light scattering technique, Shear Oscillation Light Scattering (SOLS). By modeling the phase-dependent light scattering pattern, they deduce the deformation and average positional structure of the droplets in the concentrated emulsion [*Europhys. Lett. 83 28004 (2008).*] Recently graduated from UCLA, **James N. Wilking** examined the positions and orientations of complex lithographic colloids in a single beam gradient optical trap [*Europhys. Lett. 81 58005 (2008)*] and also devised a method of nonlinear rotational micro-rheology of complex fluids [*Phys. Rev. E Rapid Comm. 77 055101 (2008).*] Another UCLA graduate, **Connie B. Chang** created a methodology to encapsidate nanoemulsion droplets using plant virus protein and studied the structural disorder of the protein on the droplet surfaces using transmission electron microscopy [*ACS Nano 2 281-286 (2008).*]

Research in the biophysics group led by **Giovanni Zocchi** is focused on mechano-chemistry, specifically the mechanical control of enzymatic reactions. By coupling a molecular spring to the enzyme they have control of the enzyme's conformation and activity. There is an interesting interplay of elastic and binding energy in these new molecules; for example, this year we explored a system where the elastic energy of the molecular spring drives a polymerization process. This allows precise measurements of the elastic energy of the molecule.

We believe the approach of controlling proteins through the molecular spring is general; accordingly, this year the Zocchi group has initiated experiments to demonstrate mechanical control of gene transcription and ion channels. Finally, some time has been spent writing two review papers based on the work, one on DNA melting and one on the molecular springs approach. They will appear in 2009.



Elastic energy driven polymerization. The figure shows a two-arms protein-DNA chimera (top) built with two different DNA 30mers (blue) covalently attached to mutated Cys residues on the surface of an enzyme (yellow); hybridization with a complementary DNA strand (red) forms a 60 bp DNA molecular spring with a nick in the middle. Bottom: due to the nick in the molecular spring, monomers can relax the elastic energy by forming dimers.

Atomic, Molecular, and Optical Physics

A newly arrived faculty member at UCLA, **Eric Hudson's** research focuses on the study of quantum information and metrology, as well as tests of the foundations of fundamental physics. Towards these goals Hudson is developing and implementing methods for trapping ultracold polar molecular ions.These trapped molecular ions, whose quantum states can be precisely engineered, will provide a "clean" experimental system for the study of cold ion chemistry, precision measurement of molecular transitions, and the implementation of a scalable, quantum computation architecture."

In addition to the molecular ion cooling and trapping experiment, a solid-state optical frequency standard, based on a low-lying transition in the 229Th nucleus is being developed. Recent data indicates that this transition has the lowest energy of any known nuclear excitation, which should make it amenable to study by laser spectroscopy. Preliminary analysis indicates that this system may achieve an improvement in precision of as much as 10^6 over current optical.

Experimental Elementary Particles

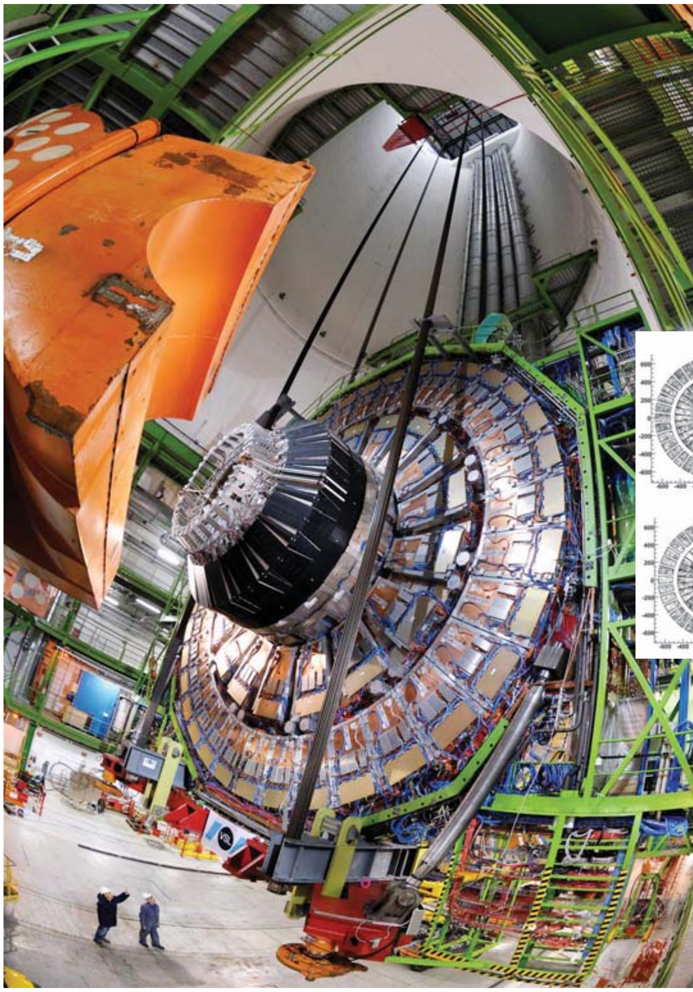


Figure 1) A cosmic ray map of the 468 chambers in the CMS muon detector. The UCLA team is responsible for commissioning this detector and has built major parts of the electronics and software used for selecting muon particles and measuring their trajectories.

The startup of the Large Hadron Collider (LHC) has been in the news lately, partly due to the possibility of producing microscopic black holes in the laboratory. (It is known that such black holes would immediately evaporate by Hawking radiation and are thus harmless.) Protons were circulated in the LHC tunnel for the first time in September 2008, although colliding beams will have to wait until 2009 due to an LHC magnet incident.

The UCLA physicists working on LHC have concentrated their work on the huge Compact Muon Solenoid (CMS) detector. Physicists in the group include: faculty **Katsushi Arisaka, David Cline, Bob Cousins, Jay Hauser, Rainer Wallny;** as well as students and postdocs **Valeri Andreev, Misha Ignatenko, Chad Jarvis, Charles Plager, Greg Rakness, Jordan Tucker, Slava Valuev, Xiaofeng Yang.** They have largely focused on muon particle detection and measurement. Muons will be the key to much of the physics potential of the LHC, including particles, Z' bosons, and many other possibilities.

During the past year, the CMS detector was put together and installed underground at the LHC. Figure 1 above shows the muon detectors on one of the 1000-ton pieces of CMS that were lowered 100 meters underground. The UCLA team leads the effort to prepare the endcap muon system for data-taking, and has been using cosmic ray muon particles to test the detectors. Figure 2) below, is a map of detected cosmic ray muons, showing that almost all of this muon detector is operating properly. During the injections of the first protons delivered by the LHC, this muon detector captured events in which protons in the LHC beam struck magnets or collimators upstream, producing "beam halo" muons such as the one in Figure 3) at bottom of page.

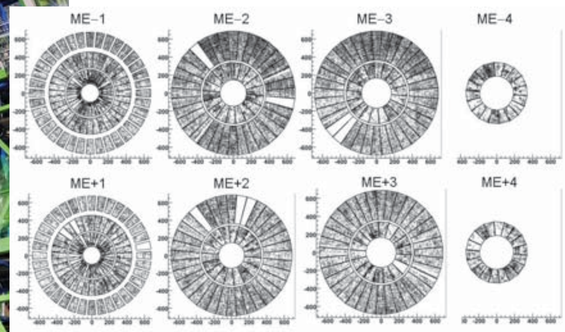


Figure 2) A cosmic ray map of the 468 chambers in the CMS muon detector. The UCLA team is responsible for commissioning this detector and has built major parts of the electronics and software used for selecting muon particles and measuring their trajectories.

Meanwhile, in anticipation of possible future discoveries, the CMS team has performed analyses of simulated CMS data to investigate aspects of several types of hypothetical particles such as heavier types of W and Z boson particles known as W' and Z', and to investigate using heavy b-quarks as signals for new physics.

Cousins began the second year of a three year term in the leadership of the 2000 scientist CMS collaboration as deputy spokesperson, the highest position currently held by a U.S. physicist working at the LHC. Meanwhile, Hauser has taken on responsibility for the construction of upgrades to the U.S.-built muon detector that will be necessary in the next decade when the LHC accelerator will be upgraded.

The UCLA CMS team is eagerly looking forward to a rich harvest of data taken during the first beam-beam LHC collisions in the coming year.

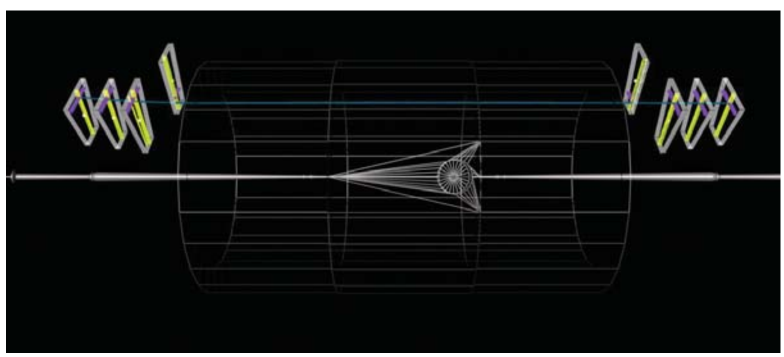


Figure 3) One of the very first LHC particle events contains a muon particle that was captured by UCLA-built electronics. A proton interaction far upstream of the CMS detector produced a muon particle that entered CMS from the right, passing through four stations of muon detectors on each side before exiting the detector to the left.

While the LHC finishes construction, the UCLA team is reaping the best data yet from the world's highest energy collider, the Fermilab Tevatron, using the Collider Detector at Fermilab (CDF) they helped build. **Rainer Wallny,** UCLA doctoral student **Peter Dong** and UCLA post-doc **Bernd Stelzer** used modern statistical techniques to extract a signal for top quarks produced by a rare electroweak process. Their observed event rate provided the final element of the full matrix of quark couplings remaining to be measured. Stelzer has moved on to a professorship at Canada's Simon Fraser University. **David Saltzberg** and UCLA post-doc **Charles Plager** continue their searches for a variety of unexpected decays of the top quark, most recently placing the world's first constraint on its potential invisible decays. Jay Hauser and UCLA PhD student **Alon Attal** published the world's most sensitive search for a kind of supersymmetry that would yield spectacular events, i.e., containing four or more high momentum electrons or muons. Attal moved on to become a leader of CDF detector operations.

Wallny and Dong commissioned a new detector made of diamonds in the innermost regions of the CDF detector. The diamonds now monitor the radiation hazard of the beam, thereby protecting CDF's delicate trackers during this period of its highest luminosity running. Diamonds improve the old technology in being especially hard against radiation damage, yet small enough to place in critical locations.

Peter Dong (left) received his Ph.D. in June 2008 for work with the world's highest energy particle collisions using the CDF experiment. He is shown here with his advisor, Rainer Wallny.

Theoretical Elementary Particles

UCLA graduate student **Kalliopi Petraki** has published some exciting new results relating the properties of dark matter on small scales to the way dark-matter particles are produced in the early universe. Kallia has presented her results at three international conferences, one in Europe and one in the U.S.

Alex Kusenko has pursued the intriguing possibility that a sterile neutrino with mass of several keV can explain the pulsar velocities, and that the same particle can be the long sought-after dark-matter particle. The search for this elusive particle, using the designated observations of dark-matter in Dwarf Spheroidals by Suzaku and Chandra X-ray telescopes began in 2007.

In collaboration with A. Mazumdar, Kusenko has also pointed out a new way to search for supersymmetry using the existing and future detectors of gravitational waves.

Per Kraus has worked on understanding how quantum gravity effects can smooth out singular solutions in general relativity and its extensions. Also, with collaborators, UCLA postdoc **Josh Davis** and UCLA grad student **Akhil Shah** have initiated an exploration of how string theory ideas can be applied to the quantum Hall effect.

Eric D'Hoker and **Michael Gutperle,** in collaboration with graduate students **John Estes** and **Darya Krym**, have extended and perfected their methods for systematically constructing supergravity solutions with extended supersymmetry. Applied to M-theory, they succeeded in mapping out entire families of solutions, and obtaining those in exact form. The power and generality of their approach derives from connecting the solutions to a problem of integrable systems that they solved completely. These results are also interesting mathematically, as the symmetry of these M-theory solutions is given by the unique exceptional Lie superalgebra with a continuous free parameter.

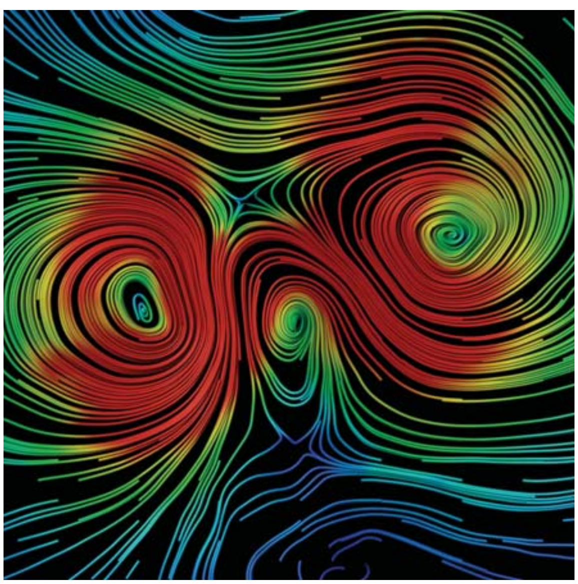
In further collaboration with Paul Sorba (Annecy, France), D'Hoker, Estes, Gutperle, and Krym established a general correspondence between supergravity solutions with extended supersymmetry subject to certain asymptotics, and certain Lie superalgebras, which has allowed them to derive a general classification of such solutions. These results also offer new mathematical insight into the structure of the moduli spaces of such solutions, and may perhaps, be related to generalizations of Donaldson theory.

John Estes obtained his PhD in Spring 2008, and is now a postdoctoralfellow, jointly at Ecole Polytechnique and Ecole Normale Superieure in Paris, France.

Plasma Physics

Walter Gekelman presented the annual Alfvén Lecture at the Royal Institute of Technology in Stockholm, Sweden. This lecture, open to the general public, was in honor of what would have been Nobel-prize-winning physcist Hannes Alfvén's 100th birthday, and was attended by surviving members of the laureate's family. Walter Gekelman is the director of UCLA's Basic Plasma Science Facility (BaPSF) – the only national user facility for basic plasma research. In the last year, 26 scientists and students were external users of the facility. The facility's local group comprises: two faculty Walter Gekelman and George Morales; three research scientists **James Maggs, Stephen Vincena, Shreekrishna Tripathi**; and four engineers/technicians **Zoltan Lucky, Patrick Pribyl, Marvin Drandell, Mio Nakamoto**. The group also has six graduate students: **Andrew Collette, Brett Jacobs, Alex, Gigliotti, Chris Cooper, Eric Lawrence, Stephanie Stattel**. Current research topics being investigated include: the remediation of radiation belt particles using plasma waves; modeling ionospheric density cavity formation by Alfvén waves; the properties of Alfvén waves in high-beta plasmas; the interaction of current flux ropes; laser-induced fluorescence measurements in a commercial plasma etching device; and the basic physics of cross-field transport and heat conduction in magnetized plasmas.

The group continues to explore new ways to visualize multi-dimensional datasets (see image). This is a representation of the measured magnetic field lines produced during the interaction of two laser-produced plasmas; energetic particles are produced and flow as electric currents within an ambient plasma, giving rise to the displayed magnetic structures shown at one instant of time. Understanding the three-dimensional complexities of such systems in the lab aids in interpreting data from solar flux tubes, to galactic jets, to the earth's magneto-tail.

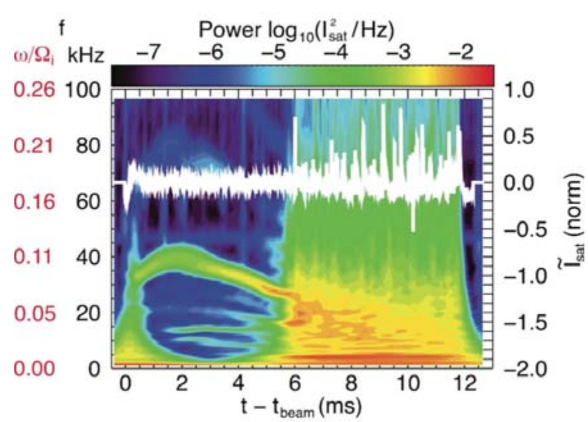


This image of the data was selected as the cover image for the American Physical Society, Division of Plasma Physics book, The Plasma Universe, to be published in late-fall of 2008.

George Morales, **Troy Carter,** and **James Maggs**, along with graduate students **David Pace** and **Meixuan Shi**, have achieved noteworthy results in the study of heat transport in magnetized plasmas. Experiments performed in the Basic Plasma Science Facility (BaPSF) at UCLA have created a microscopic temperature filament that permits the detailed investigation of the transition from coherent oscillations to a turbulent regime characterized by a broadband spectrum that exhibits an exponential frequency dependence. The origin of this spectrum has been traced to the nonlinear generation of solitary pulses having a unique Lorentzian shape. In a separate complementary experiment at BaPSF, this group also found that macroscopic "density blobs" embedded in steady-state turbulence exhibit an exponential frequency spectrum. The similarity of the results in the two different experiments strongly suggests a universal feature of pressure-driven turbulence in magnetized plasmas that results in non-diffusive cross-field transport. This finding may explain the origin of previous observations of an exponential spectrum in helical confinement devices, research tokamaks and arc-plasmas. It may also contribute to the understanding of "blob" phenomena and anomalous transport in edge plasmas which are presently topics of extensive research by the worldwide fusion community. The findings have been recently published [*Phys. Rev. Letters 101, 085001 (2008)*] and will be reported in an invited talk by David Pace at the forthcoming annual meeting of the Division of Plasma Physics of the American Physical Society.

Another significant discovery made with the controlled temperature filament was the identification of spontaneously generated thermal waves (or diffusion waves) in a magnetized plasma. The resulting signals are analogous to a thermal wave maser. These results suggest that specially designed, oscillatory electron beam sources could use this phenomenon to explore anomalous transport behavior in magnetized plasmas. It is possible that similar oscillations may be encountered in natural environments leading to filamentary structures, as is the case in the solar corona. These findings have been recently published [*Phys. Rev. Letters. 101, 035003 (2008)*].

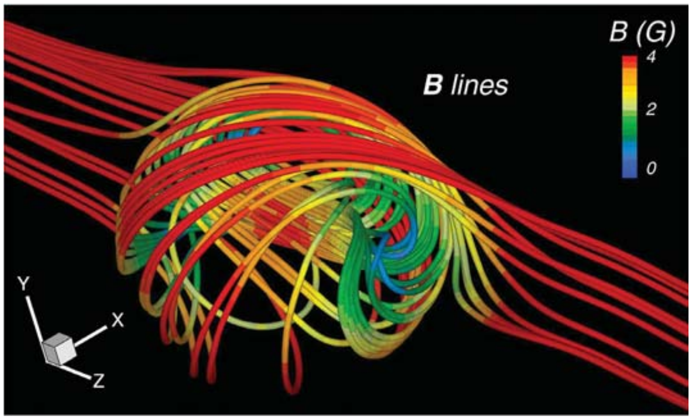
Through the Plasma Science and Technology Institute (PSTI), UCLA has become an international partner in the Erasmus Mundus program sponsored by the European Union. The purpose of this program is to train plasma scientists and fusion engineers in anticipation of the manpower needs of the ITER project presently under construction in Cadarache, France. During the Spring Quarter of 2008 Koen Kemmel, a student from Belgium, participated in laser-plasma experiments conducted in BaPSF under the guidance of Walter Gekelman. The results were used by Kemmel to complete a M.S. thesis awarded by the University of Ghent.



Transition to broadband turbulence and generation of Lorentzian pulses

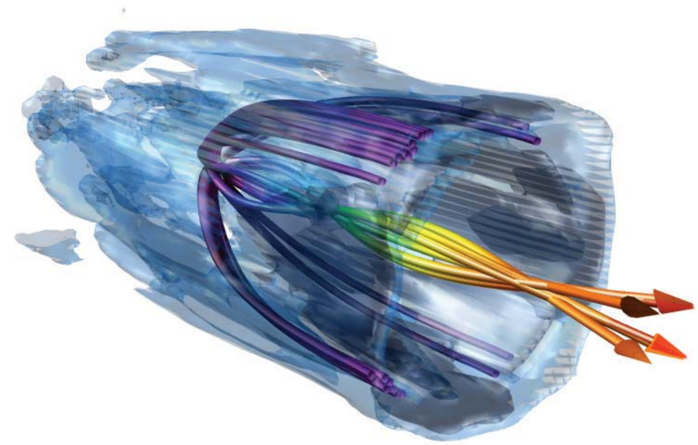
Christoph Niemann and the high-energy density plasma physics (HEDP) group conduct research on laser-plasma interactions and extreme states of matter, relevant to laser fusion and laboratory astrophysics. The group works jointly with the National Ignition Facility (NIF) and has strong ties to the Lawrence Livermore National Laboratory (LLNL). NIF, the world's largest laser under construction at LLNL, will be completed early next year and is scheduled to demonstrate controlled thermonuclear ignition in 2010. The local group has a strong presence at LLNL and is actively involved in diagnostics development for NIF. In addition, the group conducts plasma physics experiments on midscale laser facilities around the world. Graduate student **Nathan Kugland** holds an LLNL Lawrence Fellowship and has been the primary investigator for several experimental laser campaigns at the LLNL Jupiter facility. Kugland works with assistant researcher **Carmen Constantin** and focuses on using K-alpha x-ray emission as a tracer to diagnose hot electron transport in plasmas. Kugland also collaborates on x-ray scattering experiments on shock-compressed matter at the Rutherford Appleton Laboratory (UK). Constantin has performed collaborative experiments at the Helen laser (UK) that develops ultra bright picosecond sources of thermal radiation from small hohlraums for studying dense plasmas. Graduate student **Erik Everson** supports collaborative experiments at the Los Alamos Trident laser on highly nonlinear, kinetic plasma-waves. Constantin, working with graduate students Everson, and **Derek Schaeffer**, also continued local experiments on laser-produced shocks and exploding plasmas in the Large Plasma Device. An upgrade of the local glass laser system, supported by LLNL, has enabled recent experiments on super Alfvénic flows that compressed the ambient magnetic field by more than 50%.

Reiner Stenzel and **Manuel Uruttia** have continued to study nonlinear whistler modes in plasmas. They have created waves which reverse the ambient magnetic field and create three-dimensional, propagating vortices. Inside the vortices, the electrons gain energy and produce instabilities. The result is that the vortex radiates like a moving antenna. These unusual properties have created a lot of interest and results appeared on the front cover of a Physical Review Letter. The work is continuing and we are presently studying the formation of magnetic bubbles in plasmas.



Magnetic field lines of a whistler spheromak. It has the topology of a spheromak but propagates as a highly nonlinear whistler wave packet. Its magnetic helicity depends on direction of propagation relative to B0. The field lines are constructed from probe measurements in a laboratory plasma resolved in 3-D space and time.

The Computer Simulations of Plasma Group under the leadership of **Warren B. Mori**, and Adjunct Professors **Viktor Decyk,** and **Philip Pritchett** continue to do pioneering work in high-performance computing of complex plasma phenomena. The group consists of four junior researchers and six PhD students. The research remains focused on the use of fully parallelized particle based simulation models to study laser and beam plasma interactions, space plasmas, Alfvenic plasmas, and high-energy density science. The group specializes in particle-in-cell (PIC) techniques and continues to develop and maintain over five separate state-of-the-art PIC simulation codes, OSIRIS, PARSEC, Recon3D, QuickPIC, and the UPIC Framework. These codes are used throughout the world and are run on as many as 10,000 processors on some of the worlds fastest computers.



Conceptual design of three-dimensional simulations with the full temporal and spatial scale of ongoing plasma based accelerator experiments.

The group was the recipient of highly competitive INCITE Awards that provides access to the largest computers managed by the Department of Energy (DOE). The group is also affiliated with DOE Scientific Discovery through an Advanced Computing (SciDAC) grant. The grant is titled "Community Petascale Project for Accelerator Science and Simulation" (COMPASS). They have also received a grant from DOE Fusion Science Center (FSC) on "Extreme states of matter and fast ignition physics."

Besides studying basic high-energy density plasma science, the group is also engaged in carrying out three-dimensional simulations with the full temporal and spatial scale of both ongoing plasma based accelerator experiments, as well as conceptual designs of such accelerators that are well beyond the reach and cost of existing experiments. In one of these experiments, electrons in the front of a 42 GeV SLAC excited a plasma wave wakefield on which electrons in the tail of the beam had their energy doubled to 84 GeV in only .8 meters.

The group also produces outstanding students. One recent graduate, **Chengkun Huang** received the 2007 Nicholas Metropolis Award. This is the best thesis prize given by the Division of Computational Physics within the American Physical Society. Another recent graduate, **Wei Lu** received the 2007 John Dawson Thesis Prize.

Accelerator Beam Physics

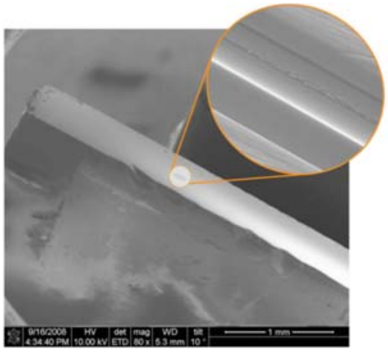
The last year was marked by progress and recognition for the UCLA Particle Beam Physics Laboratory Program (**James Rosenzweig**, director). The PBPL program is dedicated to research in advanced accelerators for high energy physics frontier applications, and to next generation light sources for probes of matter at the atomic time and length scales. In particular, the PBPL has been at the frontier of research into free-electron lasers (FEL), which will extend coherent sources into the angstrom range. In recognition of contributions to the FEL field, from the physics of the electron beam to proof-of-principle experiments in high gain FELs, Rosenzweig was awarded, along with collaborator Ilan Ben-zvi (Stonybrook/BNL) the 2007 International Free-electron Laser Prize.

In the past year, Rosenzweig's program has been extended to emphasize production of attosecond FEL pulses, and observation of crystal-like structures in the cold, intense beams used in FELs. While X-ray FELs, such as the LCLS (originally proposed and spear-headed by **Claudio Pellegrini** of UCLA Physics), promise to revolutionize measurements of the ultra-fast and ultra-small; they are very expensive, costing many $100M's. As an elegant alternative which can produce narrow band ultra-fast X-rays is also based on psec electronbeams, and is termed inverse Compton scattering. In the last few months, initial ICS experiments at BNL have shown a path towards advanced imaging measurements.

On the advanced accelerator side, PBPL has published first striking results on ultra-high gradient acceleration using wakefields in dielectric fiber structures. Over 4 GV/m acceleration fields were observed without breakdown in psec wake pulses. This exceeds present state-of-the-art by nearly two orders of magnitude, paving the way for high energy linear colliders at the 100 m length scale, instead of the presently envisioned 10 km.

The Micro Accelerator Platform (MAP), an ongoing project within the Particle Beam Physics Laboratory, seeks to create "particle accelerator on a chip." With applications in medicine, industry and research, the MAP promises to bring relativist electrons and their attendant x-rays into new environments and uses. Unlike conventional accelerators, the MAP is based on dielectric materials, is powered by a laser, and measures less than a millimeter in all dimensions. This multifaceted project, led by Associate Researcher **Gil Travish** in collaboration with Professor **Rodney Yoder** of Manhattanville College (and formerly a Postdoc at UCLA), has recently progressed from the conceptual stage to laboratory prototyping. Undergraduate students **Ninel Vartanian** and **Esperanza Arab** conducted the fabrication and testing work during their summer CARE program, and continue to work in the laboratory.

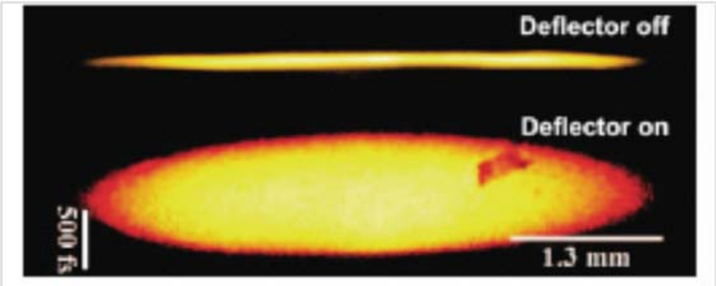
More recently, a breakthrough on electron emission from pyroelectric crystals has been made (see Figure on bottom left). Crystal based particle sources are to be used in the MAP in order to avoid the need for external high voltage supplies. This new class of particle sources is being developed with exchange student, **Urd Hørberg Lacroix.** The test structures and particle sources have been fabricated on campus using a focused ion beam machine, operated by **Noah Bodzin** and **Sergey Prikhodko**. UCLA has applied for an international patent on this work.



A tiny (1μm x 100 μm) slot is cut on the face of a pyroelectric crystal. The shape, show in detail in the insert, creates a continuous beam of electrons, driven by the fields produced within the crystal.

The Pegasus photoinjector laboratory led by **Pietro Musumeci** is pushing the barrier of ultrashort electron beam physics across the 100 fs boundary. In the quest for using such beams for dynamically resolve structural changes at atomic scale with 100 fs time resolution by ultrafast electron diffraction, the laboratory is implementing various advanced diagnostic tools to monitor the beam at such short time scales.

Graduate student **Cheyne Scoby** has implemented an electro-optic sampling technique which cross-correlates the electron beam electromagnetic field with a 40 fs ultrafast infrared laser pulse to obtain information on the relative time of arrival of the bunches with < 200 fs precision. Graduate student **Josh Moody** has developed a longitudinal phase space measurement technique with a record resolution of 50 fs x 1 keV. By using this diagnostic tool, the correlations between the beam energy distribution and the longitudinal position along the bunch can be unveiled.



Ellipsoida beam image as measred by the rf streak camera.

In addition to the ultrafast beam theme, the laboratory has been involved in fundamental beam research. They were able to successfully create a nearly ideal uniformly filled ellipsoidal beam distribution and demonstrate the operation of the rf photoinjector in the novel so called 'blow-out' regime. For 40 years, uniformly filled ellipsoidal beam distributions have been studied theoretically, as they hold the promise of generating self-fields linear in the coordinate offset in all three directions. The scheme to actually produce such distribution in a laboratory takes advantage of the self-reorganization of the electrons driven by the strong space charge force that takes place when a very short laser pulse illuminates the cathode. The ellipsoidal beam distribution was directly measured using an rf streak camera as shown in the figure above.

ALICE E. SHAPLEY

Dr. Shapley received her AB in Astronomy & Astrophysics from Harvard-Radcliffe in 1997 and her Ph.D. from Caltech. She then moved as a Miller Postdoctoral Fellow to UC Berkeley. Since 2005, she has been an Assistant Professor in the Department of Astrophysical Sciences at Princeton University where she was well recognized with awards of both a Packard Fellowship and Sloan Fellowship in 2006.

Dr. Shapley is best known for her work understanding the astrophysical properties of high red-shift (z~3) galaxies known as Lyman-break galaxies. These galaxies provide us an unprecedented look at the fundamental properties of galaxies at a time when the Universe was onl y 10% of its current age and thereby provide the first direct view of the history of galaxy formation and evolution.

Most of her publications to date make extensive use of data from the world's large telescopes, especially the biggest, the Keck telescopes. With special access to Keck, UCLA has hired one of the leaders in the field of Astronomy.

STEVEN R. FURLANETTO

While only five years out from his Ph.D., Steve has already had quite a distinguished career path. He received his B.A. in Physics in 1998 from Carleton College. He moved on to the University of Cambridge, UK, with a Winston S. Churchill Fellowship, and received a Certificate of Advanced Study in Mathematics in 1999 where he was graduated with distinction. He received his A.M. in Astronomy in 2001 and his Ph.D. in Astronomy in 2003 from Harvard University. He was a Lee A. DuBridge Prize Fellow in Theoretical Physics and Astrophysics at California Institute of Technology before joining Yale University in 2006 where he was an Assistant Professor of Physics.

Dr. Furlanetto is best known for his research on the epoch of 'reionization,' which is the part in the history of the universe when we believe the first galaxies and stars began to form. This important phase of cosmic evolution is, as yet, poorly understood.

ERIC HUDSON

Dr. Hudson joined the department this fall. In addition to his twice-demonstrated ability to successfully build a laboratory essentially from scratch, the Department's Search Committee was particularly impressed and excited about Dr. Hudson's future research program that is detailed in the Research Highlights of this Annual Report.

He received his B.S. in Physics and Mathematics from Morehead State University, his M.S. and Ph.D. in Physics from the University of Colorado, and was the Yale University AMO Prize Postdoctoral Fellow. Among his numerous awards are the Graduate Fellowship from the University of Colorado at Boulder and the Presidential Scholar Scholarship from Morehead State University.

Dr. Hudson will work in the area of Atomic, Molecular, and Optical (AMO) Physics with a focus on quantum information and quantum metrology. His hiring is part of a new departmental initiative to establish a research program in AMO Physics.

FACULTY

Professors

Katsushi Arisaka
Maha Ashour-Abdalla
Zvi Bern
Stuart Brown –
  Vice Chair of Resources
Robijn Bruinsma
Charles Buchanan –
  Vice Chair of Academic Affairs
Sudip Chakravarty
David Cline
Ferdinand V. Coroniti –
  Chair of Physics and Astronomy
Robert Cousins
Steven Cowley
Eric D'Hoker
Sergio Ferrara
Christian Fronsdal
Walter Gekelman
Graciela Gelmini
Andrea Ghez
George Grüner
Jay Hauser
Kàroly Holczer
Huan Huang
Hong-Wen Jiang
Michael Jura
Steve Kivelson (Adj. Prof.)
Alexander Kusenko
James Larkin
Matthew Malkan
Ian McLean
George J. Morales
Warren Mori
Mark Morris –
  Vice Chair of Astronomy and Astrophysics
Bernard M. K. Nefkens
William Newman
Rene Ong
C. Kumar N. Patel
Roberto Peccei –
  Vice Chancellor for Research
Claudio Pellegrini
Seth J. Putterman
James Rosenzweig
Joseph A. Rudnick –
  Interim Dean of Physical Sciences
David Saltzberg
Reiner Stenzel
Terry Tomboulis
Jean Turner
Roger Ulrich
Charles A. Whitten
Gary A. Williams
Edward Wright

Associate Professors

Michael Gutperle
Brad Hansen
Per Kraus
Thomas Mason
Jianwei Miao
Alice Shapley
Giovanni Zocchi

Assistant Professors

Dolores Bozovic
Troy Carter
Steven Furlanetto
Pietro Musumeci
Christoph Niemann
B. Chris Regan
Yaroslav Tserkovnyak
Vladimir Vassiliev
Rainer Wallny

Professors Emeriti

Ernest S. Abers
Eric Becklin
Rubin Braunstein
Nina Byers
Marvin Chester
Gilbert W. Clark
John M. Cornwall
Robert Finkelstein
Roy Haddock
George Igo
Leon Knopoff
Steven Moszkowski
Richard Norton
Mirek Plavec
William E. Slater
Alfred Wong
Chun Wa Wong
Eugene Wong
Byron T. Wright
Benjamin Zuckerman

Researcher

Viktor Decyk
Samim Erhan
Anthony Lin
James Maggs
William Peebles
Philip Pritchett
R. Michael Rich
Steven Trentalange
J. Manuel Urrutia

Associate Researcher

Vahe Ghazikhanian
Sven Reiche
Terry Rhodes
Lothar Schmitz
Gil Travish
Stephen Vincena
Hanguo Wang

Assisstant Researcher

Shahriar Abachi
Luca Bertello
Carmen Constantin
Neal Crocker
Xiaoping Ding
Yasuo Fukui
Sarah Gallagher
Pierre Gourdain
Mikhail Ignatenko
Alexey Iskakov
David Leneman
Nandini Mukherjee
David Reitzel
Glenn Rosenthal
Shoko Sakai
Alexsandr Starostin
John Tonge
Frank Tsung
Shreekrishna Tripathi
Jeffrey Zweerink

Mirek Plavec

Professor Mirek Plavec, world-famous astronomer, died peacefully in his sleep at his home in Pacific Palisades on January 23, 2008.

He received his Ph.D. in astronomy from Charles University in Prague and worked in his homeland for thirteen years. He left his native Czechoslovakia after the Russian invasion in 1968 and, with his family, migrated to the United States and UCLA where he continued his research and taught astronomy for over 25 years. He was the Department's nominee for the Distinguished Teaching Award in 1973-74 and 1984-85.

Over the years, he achieved prominence in the world of astronomy and received numerous awards for his scientific research. One asteroid bears his name and, in 2006, the 240th symposium of the International Astronomical Union was dedicated in his honor.

A professor emeritus at UCLA; he also authored books and articles on astronomy. Among his books on astronomy are "Stars, Comets and Meteors," "Radio-astronomy," "History of Astronomy" and co-authored "Close Binary Stars: Observations and Interpretations."

Dr. Plavec is survived by his wife, Zdenka, his daughter, Dr. Helena Kirkpatrick, his son, Jirka, and four grandchildren. A memorial was held in March 29th, 2008 at the Cal State University-Northridge Planetarium to honor his life and work.

Peter Schlein

Peter Schlein, passed away on Tuesday, February 26th in Paris. He died of sudden cardiac arrest. Peter was a professor emeritus in the Department of Physics & Astronomy at UCLA. His career at UCLA began in 1962 as an assistant professor, acquiring full professor status in 1968. Peter joined CERN , the European center for high-energy accelerator physics in Geneva in the early 70's. While there, he developed new high-precision detectors establishing him as one of the best and most celebrated members of his profession. After 40 years as a Professor of Physics in experimental elementary particles, marked by extraordinary creativity and energy, Peter retired from the University in 2006, wanting to devote his time to re-discovering and recording music composed by his father, Irving Schlein.

Peter's passing is a great loss to CMS, UCLA, and to our field in general.

Some memories from Peter's family ……

"…he was a devoted family man. He was proud of his wife, Lisa, his children, Oren and Illana, and their spouses, Jo and Paul. In recent years, one of Peter's latest discoveries was his grandchildren. Alex and Julian, and Kate and Ari were the new wonders in his life. He thought they were beautiful and clever. They inspired him daily and he never ceased to talk about about how much they meant to him. Peter looked forward to the joy of welcoming his soon-to-be born fifth grandchild, Karina Petra. We will miss him sorely...Lisa, Oren and Ilana Schlein"

"As a human being, he was sensitive and caring…" Bruce Winstein

Teaching Techniques for the 21st Century

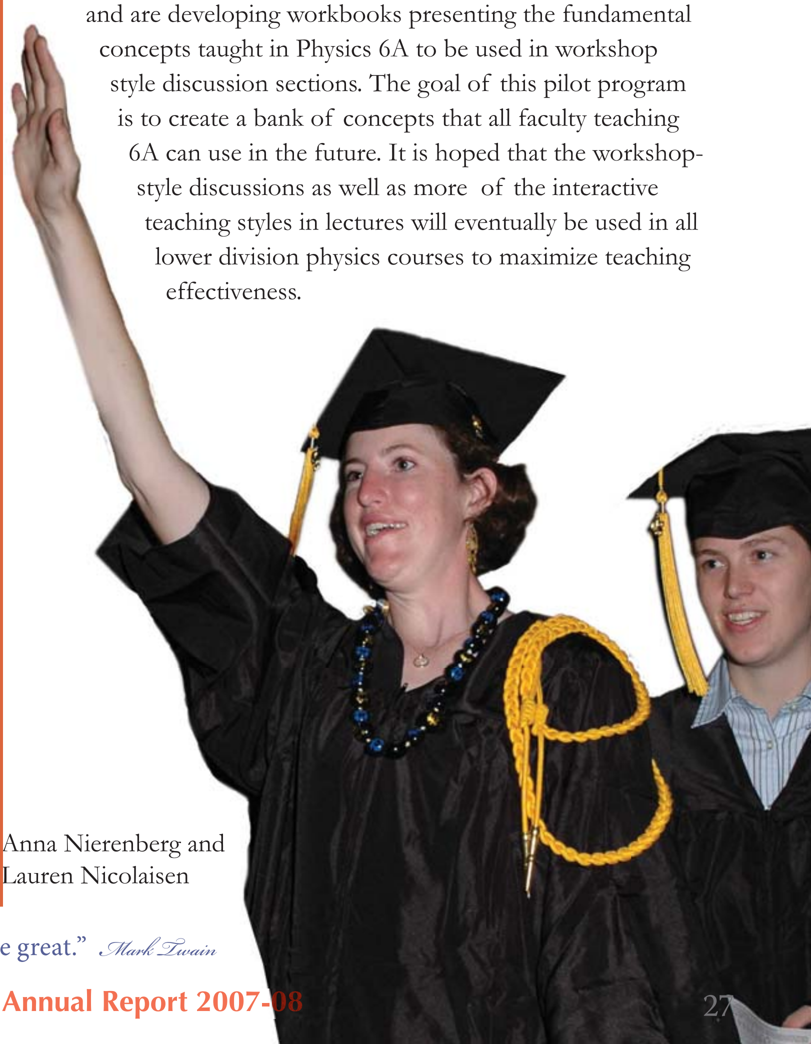
The physics department has created a Committee on Modern Teaching Techniques chaired by Professor Troy Carter. Over the past 2 decades physics education research has emerged as an important endeavor and has focused on student understanding of science concepts. The physics community has taken the lead in trying to provide an effective and relevant science education for all students. The great strength of physics is that a few fundamental concepts can explain a vast range of phenomena. From that research, modern pedagogical approaches and associated techniques have been derived and seem to fall into three categories:

1. Peer instruction or similar concept-focused, interactive styles used during lectures.

2. Online homework with a feedback/tutorial mechanism (students get immediate feedback on their response to the homework).

3. Workshop-style discussion where student groups of 4 discuss problems interactively with TA's guiding their problem-solving discussions.

The committee is charged with the evaluation of these modern pedagogical approaches and focuses on the appropriateness of these approaches in the curriculum with minimal disruptive impact on our teaching program. This spring, Professors Carter and Rainer Wallny have integrated workshop-style discussions and are developing workbooks presenting the fundamental concepts taught in Physics 6A to be used in workshop style discussion sections. The goal of this pilot program is to create a bank of concepts that all faculty teaching 6A can use in the future. It is hoped that the workshop-style discussions as well as more of the interactive teaching styles in lectures will eventually be used in all lower division physics courses to maximize teaching effectiveness.



Anna Nierenberg and Lauren Nicolaisen

"Really great people make you feel that you, too, can become great." *Mark Twain*

Program for Excellence in Education and Research in the Sciences (PEERS)...

The Program for Excellence in Education and Research in the Sciences (PEERS), began in Fall 2003. It is directed by Charles Buchanan, and is flourishing.

Each year PEERS begins with 70-90 freshmen in Physical and Life Sciences who enter UCLA with good records of academic achievement, but with more than average "life challenges." They are students with a potential to develop at UCLA and to emerge as outstanding scholars and researchers. Sixty-seventy percent are the first generation to go to college. PEERS opens doors for these students, who typically enter UCLA not knowing a great deal about what a strong research university can offer them other than courses.

PEERS provides a potpourri of synergistic education elements: collaborative learning workshops in introductory courses in Mathematics, Chemistry, Physics, and Life Sciences supervised by Brent Corbin; a freshman fall seminar on the transition to UCLA and college-level study skills; individualized counseling; a sophomore fall seminar on majors and careers; two or three research talks per quarter by charismatic professors; and the opportunity to get into significant undergraduate research. The students bond together into the "PEERS community" with the result that the whole seems to be greater than the sum of the parts.

The results have been extremely encouraging: 60-70% finish the two year PEERS program as science majors, with GPA's averaging 3.2-3.4. Forty-sixty percent of these students enter into undergraduate research by their sophomore year. They are genuinely contributing "members of the UCLA scientific community" by the time they graduate. Several have won prestigious national awards. Typically 30% matriculate to graduate or professional schools receiving offers from Stanford, MIT, Cal Tech, UCLA, Boston U, UC Davis, to list a few. These research and graduate results exceed studies of comparable control groups.

PEERS has proven to be successful. Judi Smith, Vice Provost for Undergraduate Education at UCLA, is now leading a process of "institutionalizing" PEERS.

Day of the Dead 3-D Teslathon

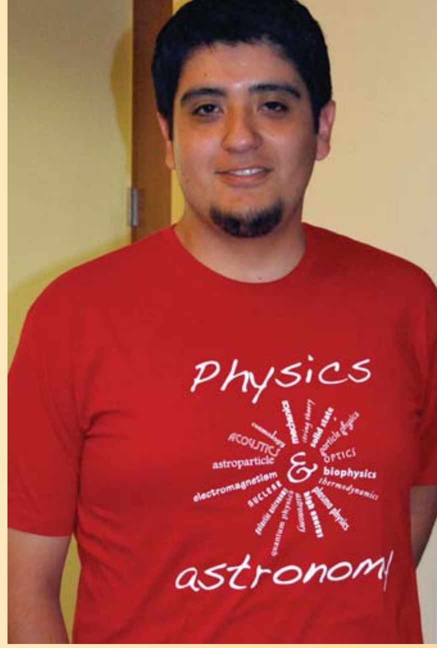
Hundreds crowded the Knudsen Outdoor Patio 2-222 to participate in the "Day of the Dead 3-D Teslathon." The evening was a brilliant and shocking display of high voltage electricity, a flame vortex and a death-defying walk over burning coals. The eclectic demonstrations and pertinent comments were peppered with enthusiastic audience responses. The energy in the room reached a fever pitch when UCLA faculty, students and a few staff walked briskly across the hot coals. The coals were heated to over 900 degrees; they were hot... hot. The bed of coals was smoothed down to make the defying walk a bit easier. The science behind this exhibit was explained after the demonstration.

A few minor casualties were recorded but the reviews at the end of the night were overwhelmingly positive and many wished for an encore.

The receptive audience was wide, diverse and truly heterogeneous; young and old; professors to cub scouts; grad students to fifth graders reveled in awe and wonder at this wonderful visual delight and happening. Martin Simon with his support group from the UCLA Physics department created this wondrous event and spectacular evening. Let's hope for a repeat performance.

Hsin-Yi (Jenny) Shih received the Charles Geoffrey Hilton Award which goes to the top graduating senior in Astrophysics.

Contact Mary Jo Robertson at mjrobert@physics.ucla.edu for T-shirt



Jorge Gomez modeling the new Physics & Astronomy T-shirt

Fellowships...

GAANN Fellowship Recipients

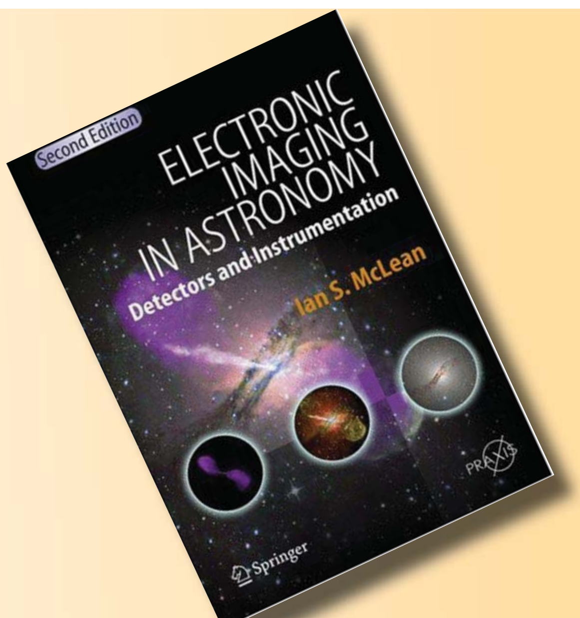
Six incoming students have been awarded the GAANN (Graduate Assistance in Areas of National Need)fellowship. Funded by a grant from the Department of Education, the 2008-2009 fund will support the following students: Anton Bondarenko; Asher Davidson; Chris Farrell; Antonio Russo; Edward White; Lauren Wozniak.

Selection for this award is competitive and based on financial-need and academic ranking. Earlier in the Ph.D. Program, recipients of this fellowship are encouraged to seek research opportunities and are also required to participate in a scientific writing course with Professor Eric D'Hoker.

Dissertation-Year Fellowship Program

The University of California's Dissertation-Year Fellowship Program provides support to outstanding Ph.D. candidates during their final year of graduate school, providing support that allows them to focus on writing their dissertation. The program is designed to identify doctoral candidates who have been educationally or economically disadvantaged or whose research or planned career direction focuses on problems relating to disadvantaged segments of society. This program assists students by providing faculty mentorship as they prepare to become postdoctoral fellows or candidates for faculty positions. This year's Fellowship Recipients chosen from the physics and astronomy department are: Quinn Konopacky, Alaina Henry, Xun Jia and Henrik Johansson.

Ian McLean spent most of his sabbatical overseas in residence at the Astronomy Technology Centre of the Royal Observatory, Edinburgh, Scotland. While a guest, his primary research and scholarly activity was the development of a second edition of his 1997 book "Electronic Imaging in Astronomy: Detectors and Instrumentation." The new book was published in June 2008 by Springer-Praxis, Berlin-Heidelberg-New York.



Physics B.S.

Daniel Arguello
Scott Carr
Christopher Cesare
Paul Cubre
Julius De Rojas
Edward Dollahan
James Dunn
Joel Frederico
Eric Goss
Michael Kanik
Maryam Khataonabadi
Velvet Klee
Matthew Levy
James Liu
Min Lu
Miles Lopes
Xu Luo
Robert Martin
Michael Miller
Lauren Nicolaisen
Anna Nierenberg
Saurabh Nijhawan
Andrew Pan
Deesha Patel
Alfonse Pham
Jacob Rothenbuhler
Aaron Senter
Kristina Serratto
Christopher Smith
Indara Suarez
Tan Tran
Christopher Tyndall
Stephanie Xenos
Yu-Chen Yen

Astrophysics B.S.

Ernest Bavarsad
Aaron Flores
Delmy Garcia
Celestine Grady
Daniel Harsono
Richard Hart
Paul Hemphill
Richard Loveless
John Nguyen
Grace Meng
Yeimy Rivera
Hsin-Yi Shih

Physics B.A.

Sike Liu
Adam Lopes
Hasti Sanandajifar
Harry Warner IV

Biophysics B.S.

Donald Chang
Rodrigo Gonzales
Jorge Gottheil
Joseph Kallini
Garrett Perrin
Joshua Reicher
Mary Alice Vijjeswarapu
Robert Vogel

Graduation Day 2008, June 14

Friends and family gathered at Schoenberg Hall to celebrate the graduation ceremony in honor of the students from the UCLA Department of Physics & Astronomy. Excitement filled the air as the Chair, Ferdinand Coroniti, graciously welcomed the guests and invited them to join the upcoming program.

The afternoon events flowed amid faculty addresses, outstanding honors and awards and reached a fever pitch when the audience rose to their feet to welcome the procession of the students in the graduating class of 2008 as they made their impressive entrance into the Hall and onto the stage.

One of the many highlights of the day was Mary Alice Vijjeswarapu, B.S., '08, singing the National Anthem. Everyone sat enraptured as they listened to her brilliant simplicity and flawless timing; her voice still resonated throughout Schoenberg as the next speakers Lauren Nicholaisen, B.S. '08 and Erin Smith, Ph.D., '08 addressed their fellow graduates.

Graduation Day festivities continued on the patio where all enjoyed a light buffet, animated conversation and emotional goodbyes to a wonderful day.

Mary Alice Vijjeswarapu, BS, '08

DOCTORAL DEGREES AWARDED

Accelerator
Robert England

Astronomy
Thayne Currie

Michael McElwain

Jon Mauerhan

Erin Smith

Shelley Wright

Astrophysics
Alex Jarvis

Louis Levenson

Biophysics
Tatiana Kuriabova

Shimul Akhanjee

Rouzbeh Gerami

Rouzbeh Ghafouri

Theoretical Condensed Matter
Ivailo Dimov

Pallab Goswami

Wei-Feng Tsai

Experimental Condensed Matter
Erika Artukovic

Emil Kirilov

David Hecht

Gerard Gaidos

Experimental Elementary Particles
Matthew Healy

Joong Yeol Lee

Peter Dong

Andrew Chien

Pedram Boghrat

Weichung Ooi

Nuclear Physics
Steven Guertin

Theoretical Elementary Particles
John Estes

RUDNICK-ABELMANN SCHOLARSHIP
2007-2008 Aviva Shackell, Steve Suh

3 juniors were recognized for outstanding academic performance and received the Rudnick-Abelmann Scholarship. The names of those students were Michael Gutierrez majoring in Physics, Nickolas McColl majoring in Physics, Aria Asghari-Sheikhy who is majoring in Biophysics.

Lauren Nicolaisen received the E.LEE KINSEY PHYSICS 2007-2008 Award for outstanding/top graduating senior in Physics.

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