UCLA

Department of Physics & Astronomy

We were told it couldn't be done, that it was far too ambitious . . .

Annual Report 2006- 2007

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Department of Physics & Astronomy
2006-2007

University of California, Los Angeles

Message from the Chair:

Ferdinand Coroniti, Chair

For the Department of Physics & Astronomy, Fall arrives with the hope and promise of the new academic year. 2007-08 will be an exciting and somewhat hectic year as we undergo the Eight Year Review by the Academic Senate and undertake searches for new faculty. UCLA has a new Chancellor, Gene Block, and, last Fall, the Division of Physical Sciences in the College acquired a new Interim Dean, our own Professor Joseph Rudnick.

With the improved financial condition of the college, last year the department conducted four faculty searches. The department is especially pleased that extragalactic astronomers Steven Furlanetto, a theorist, and Alice Shapley, an observer, will be joining the department in January, 2008. Outstanding candidates in condensed matter theory and in theoretical particle physics have faculty position offers. This year the department plans to conduct searches in experimental condensed matter physics, computational plasma physics, and quantum-atomic-optical physics. In addition, Dean Rudnick has invited physics and astronomy to develop a proposal for a major new research initiative with the goal increasing significantly the stature of the department.

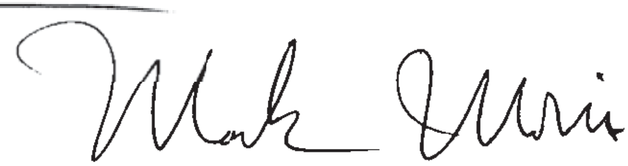
The feature article in this year's Annual Report is on the Infrared Laboratory. Founded in 1990 by Professors Ian McLean and Eric Becklin, and enhanced with the appointment of Professor James Larkin in 1996, the IR Lab was the key link that led to the consolidation of the Division of Astronomy and the Department of Physics.

Exciting developments abound throughout the department's research program, and space permits mention of only a few. Professor Robert Cousins is now deployed to the Large Hadron Collider (LHC) at CERN as thedeputy spokesperson for the Compact Muon Solenoid (CMS) experiment, one of the two major (about 2000 physicists) LHC detectors…Professor Arisaka has invented new high time (millisecond) and space (nanometer) resolution camera based on ICMOS technology and particle physics fast readout techniques; combining the camera with a confocal microscope, he and Professor Dolores Bozovic have now imaged the kilohertz vibrations of the cilia in the inner ear under mechanical stimulation…Professor David Saltzberg spent a couple of months on the Antarctic ice sheet with the balloon-borne ANITA (Antarctic Neutrino Impulse Telescope Array) experiment to search for ultra high-energy cosmic neutrinos…Professors René Ong and Vladimer Vassiliev participated in the acquisition of first light by the VERITAS observatory…Professors Pellegrini and Jamie Rosenzweig participated in the design and construction of the Stanford Linac Coherent Light Source (LCLS) that will turn-on early next year…Professor George Gruner was invited by Scientific American (May, 2007) to discuss his research on networks of carbon nanotubes and the possibility of new carbon nanotube electronic devices.

Turning to curricular matters, the quantity and especially the quality of applicants to the department's graduate programs continued to increase, and this year there was dramatic rise in the number of acceptances by the top ranked candidates. The number of undergraduate majors reached the high water mark of 259, with 33 students choosing the new biophysics major. The department confers the third largest number of astronomy and the sixth largest number of physics bachelor degrees in the country, making UCLA a very significant presence in the nation's education of young physical scientists. Finally, the younger faculty are energetically introducing modern teaching methodologies (clickers and interactive concept questions) into the lower division courses and computational techniques into the upper division curriculum.

At the 2007 departmental commencement celebration, we were honored to have Ben L. Holmes as the featured speaker. After an interesting and charming review of his educational experiences as a physics major and his subsequent career in industry, Ben conveyed to the new graduates the words of wisdom " to make a contribution … strive to be the best at whatever you choose to do." In its teaching and research programs, the department aspires to follow Ben's wise admonition. The department is deeply appreciative of his and his wife Carol's strong support, and of the continued interest and support of all of our alumni and friends. Your past generosity has made invaluable contributions to the educational "quality of life" in the department, and together we can continue to build a truly excellent Physics and Astronomy program at UCLA.

Mark Morris, Vice-Chair



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The Infrared Lab at UCLA

W.M. Keck Observatory Mauna Kea, Hawaii high above the clouds

The days of peering up at the stars through a telescope are long gone—the human eye just isn't sensitive enough anymore. Electronic imaging devices have replaced the human eye, maximizing the power of visible light and giving us awe-inspiring views of the universe, as well as sophisticated data about its past, present and future. But visible light itself is no longer the best way to "see" all that is going on. Infrared camera technology, pioneered by UCLA astrophysicists Eric E. Becklin, Ian S. McLean and others, has taken over from visible light and is now used throughout the world to explore space. Says McLean, "To their credit, astronomers pay a lot of attention to new technology and as soon as something appears that might be useful we try to adapt it right away. The drive to look beyond our own solar system is so powerful."

Developed by the military for use in heat-seeking weapons systems in the 1960s, infrared technology was quickly adopted by astronomers because it enabled them to see farther and more clearly. Whereas a visible light telescope, like the Hubble, captures dramatic pictures, an infrared-equipped telescope, like the one at the W.M. Keck Observatory, can "see" farther into the galaxy to more obscure regions and answer the questions: "What is that object?" "How far away is it?" "How heavy?" "How hot?" "How old?" As well, infrared light can reach far beyond our galaxy to explore deeper into space. In fact the visible light from the most distant galaxies in the universe becomes infrared light on its way to Earth, due to the expansion of the universe.

NIRSPEC was and still is the most successful instrument project that the Keck has ever had.

It has only been over the last 20 years that telescopes have been designed and equipped to collect infrared light. Astrophysicists believe that they have still not touched on all of the possibilities. The technology is difficult and expensive—not as easy to develop as visible light instruments. One of the problems is the heat that is emitted by the infrared light of normal objects in the universe, such as telescopes. For this reason, telescopes are always situated on high mountain tops where the air is thin and cold. To remove its own heat, the infrared package—including the camera and spectrometer—is loaded into a vacuum chamber and cooled to liquid nitrogen cryogenic temperature before it is installed in the telescope. Says McLean, "The experiment you just designed and built is now in an environment that might as well be outer space. It is a vacuum so cold you couldn't put your hands inside to make a simple repair. Because of the (vacuum cryogenic) technology, infrared astrophysics is an expensive country club to join. But it is our specialty at UCLA. We try to make the instruments both

powerful and reliable."

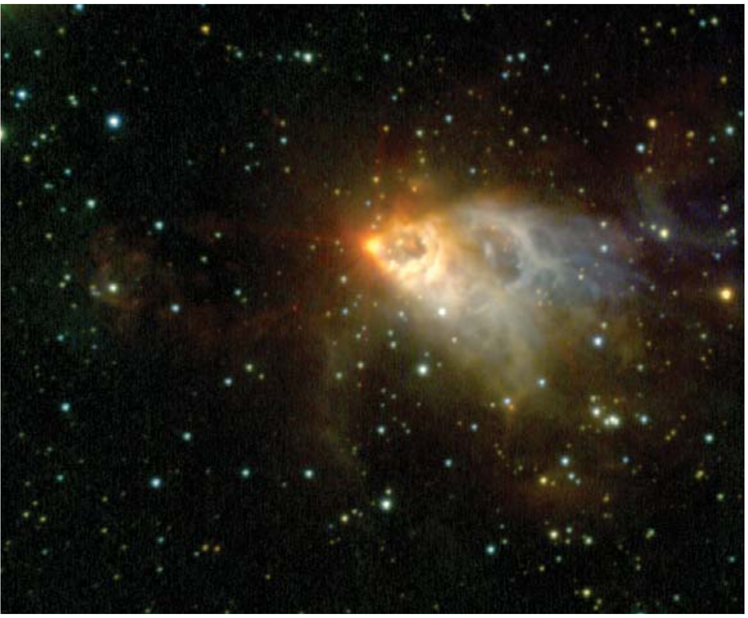
Eighteen years ago when Becklin and McLean decided to leave their respective institutions and come to UCLA to collaborate, they had to start from scratch. One of the first instruments they built in the newly established Infrared Lab was a digital camera that took pictures in two infrared colors simultaneously, which was twice as efficient as any other camera at the time. It was built in 1993 and delivered to the 3-meter telescope at Lick Observatory, operated by UC Santa Cruz. That instrumentation is still functioning today. The project's success established the nascent UCLA infrared instrumentation program.

NIRSPEC

However, Becklin and McLean realized they could do better. So they went on to build the first high resolution cryogenic cross dispersed echelle spectrometer for the Keck Observatory, called NIRSPEC (for Near Infra-Red Spectrometer). McLean led the project, working with Becklin and with James R. Graham from U.C. Berkeley. McLean reminisces:

That broke the mold. No one had ever built an instrument like it before. We were told it couldn't be done, that it was far too ambitious. But it was delivered in March 1999 and worked perfectly at first-light, which is when it's actually attached to the telescope and you get starlight through it for the first time. It was and still is the most successful instrument project that the Keck has ever had. It was built essentially on time and on budget. I liked that experiment and part of the reason why it worked is that I tried very hard to find this balance between having a really clever physics experiment and having a well engineered instrument. You don't get a well-engineered washing machine until you've made a million washing machines and then you get Maytag, but we got to build this only once.

The twin 10-meter telescopes of the Keck Observatory belong to the University of California and the California Institute of Technology (Caltech) jointly. They are currently the largest telescopes in the world. NASA has a one-sixth share of the observatory and the National Science Foundation also has access through an exchange program that funds instrument development. Situated on the summit of Mauna Kea on the island of Hawaii, the Keck telescopes



This dramatic infrared image sheds new light on the early stages of the formation of giant stars in our galaxy. This image reveals remarkable details in a nebula of gas and dust expelled from AFGL 2591. This expulsion is a common feature in the formation of stars similar in size to the Sun, but it is far less common in their massive counterparts. The resolution of this image is 0.4 arcseconds.

Ian S. McLean

- PhD from the University of Glasgow, 1974
- Senior Scientific Officer, Royal Observatory, Edinburgh, Scotland, 1980
- Principal Scientific Officer, Joint Astronomy Centre, Hilo, Hawaii, 1986
- Professor of Physics & Astronomy, UCLA, 1989

Professor McLean is currently director of the UCLA Infrared Laboratory, which he co-founded with Professor Eric Becklin in 1989. He is also an associate director of the University of California Observatories (UCO), a multi-campus research unit based at UC Santa Cruz, which provides partial support for the Infrared Lab. McLean recently stepped down from the science steering committee of the Keck Observatory after 10 years of service—the last three as chairman of the committee—and was honored with a presentation at the board of director's meeting on June 22, 2007.

McLean has been involved in astronomical instrumentation for over 30 years. Most recently, he was the principal investigator for NIRSPEC (1999) a cryogenic spectrometer for the Keck Observatory. Currently, he is principal investigator for SOFIA's FLITECAM and for the MOSFIRE project at the Keck Observatory. McLean's scientific interests include brown dwarfs; star-forming regions; the origin and evolution of carbon-based molecules; and the galactic center and galaxy formation in the high redshift universe.

Eric E. Becklin

- PhD from CalTech, 1968
- Astronomer, Institute for Astronomy, University of Hawaii, 1977
- Director, NASA Infrared Telescope Facility, 1977
- Guggenheim Fellow, Royal Observatory, Edinburgh, Scotland, 1985
- Professor of Physics & Astronomy, UCLA, 1989
- Chief Scientist, SOFIA, 1997
- Professor Emeritus at UCLA, 2005

Professor Becklin's current major efforts are the study of brown dwarfs (the missing link between stars and planets); the detection of dust rings around stars that are related to planet formation; the dynamics and composition of the center of our galaxy; and the nature of luminous infrared galaxies. This research uses UCLA instrumentation developed in collaboration with Ian McLean, as well as facility instrumentation at the University of California's Lick and Keck observatories.

Becklin is currently chief scientist and director designate of the Stratospheric Observatory for Infrared Astronomy (SOFIA). This ambitious project, which involves a modified Boeing 747-SP equipped with a 2.5m infrared telescope, will observe objects in space at infrared wavelengths that are blocked from ground-based facilities by the atmosphere. As part of this project, Becklin is working with McLean on an infrared test camera, FLITECAM, which will be used to test the optical and infrared properties of SOFIA.

NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA) is silhouetted against the sky as it soars on its second check flight near Waco, Texas on May 10, 2007. Credit: NASA Photo by: Jim Ross

have provided the scientific community with invaluable data throughout the last decade.

Building instruments for observatories is an unconventional endeavor. McLean explains, "We get funding to develop the instruments, but we make them facility-class, so we actually hand them over and then everybody gets to use them." There is a degree of altruism in doing this kind of work because astrophysicists who spend years designing and building this instrumentation are not highly compensated in comparison with many other scientific fields. There is no profit motive involved.

Infrared technology has enabled advances in many fields of astrophysics. The discovery of brown dwarfs and the measurement of the mass of the black hole at the center of the Milky Way are examples. Another important and surprising discovery is that the universe is expanding at an accelerating rate. (The expansion itself was determined 80 years ago by Edwin Hubble.) Normal scientific reasoning would suggest just the opposite, that the build-up of matter in the universe would cause it to slow down. This issue and what it might mean in a few billion years has become a major research frontier.

MOSFIRE

The latest generation instrument for the Keck Observatory, MOSFIRE (Multi-Object Spectrometer for Infra-Red Exploration), has just passed its critical design review. McLean points out, "The technology has improved since we installed NIRSPEC, which has a one megapixel digital camera for the infrared. Now we can go to four megapixels." McLean is the principal investigator on MOSFIRE, working with a $12 million budget. It should be ready for installation in early 2010. It will be one of the most powerful instruments in the world. Says McLean, "You take a picture, select up to 46 stars or galaxies and then get the infrared spectra of those 46 objects simultaneously. Not one at a time, but all 46 together. The NIRSPEC can only do one at a time. That is an enormous leap forward in efficiency."

The next 12 months is the construction phase where what was on paper will be turned into real hardware. Being modular, the hardware pieces can be tested independently and then assembled in what is called the integration phase. When it is ready for installation at the Keck Observatory, the instrument will weigh two tons.

GEMINI Planet Imager

Situated in the Chilean Andes, the Gemini Observatory is the product of a seven-nation collaboration—including the United States. Focusing on the 8-meter Gemini South telescope, a consortium under the leadership of Bruce A. Macintosh (formerly a doctoral student at the UCLA Infrared Lab and currently with the Lawrence Livermore National Laboratory) is building an instrument called the Gemini Planet Imager (GPI). This instrumentation will be used in conjunction with a new kind of infrared camera to search for planets around other stars. The Infrared Lab is supporting this project primarily through the efforts of James E. Larkin, who joined UCLA in 1997. Larkin delivered a unique infrared camera called OSIRIS (for OH Suppressing Infra-Red Imaging Spectrograph) to the Keck Observatory in 2005. Operating with the Keck Adaptive Optics System, this camera eliminates the turbulence caused by the Earth's atmosphere, thereby producing extremely sharp images.

Larkin has contracted to build the back-end science instrument (an integral field spectrometer with diffraction-limited imaging, low resolution spectroscopy, and a linear polarization mode) for the GPI. Scheduled for delivery in 2010, this instrumentation utilizes even more advanced adaptive optics than OSIRIS, which will render the images sharper than ever before. Says McLean, "It will be possible for the first time to see a planet directly in orbit around a nearby star. We know of at least 240 other stars, like the sun, that are relatively close to our solar system and have planets." The first such star was discovered in 1995, so in 12 years, astrophysicists have gone from not knowing of any other planetary systems outside of our own to knowing hundreds of them. These numbers dramatically increase the interest in searches for extra-terrestrial life.

SOFIA

In 1996, following his pioneering service to the UCLA astronomy program, Eric Becklin, accepted the position of chief scientist and director designate of SOFIA (Stratospheric Observatory for Infrared Astronomy). Developed under the auspices of NASA, SOFIA is taking a different approach to observing the stars. A Boeing 747SP jetliner has been modified to carry a 2.5-meter, reflector telescope optimized for infrared observations at altitudes of about 41,000 feet. Its flight capability will allow observations at infrared wavelengths that are blocked from ground-based facilities by the atmosphere, and it can go to almost any point on the Earth's surface for these observations. The telescope looks out of a large door in the side

Large Magellanic Cloud. This vibrant image from NASA's Spitzer Space Telescope shows the Large Magellanic Cloud, a satellite galaxy to our own Milky Way galaxy. Image Credit: NASA/JPL-Caltech/STScI

James E. Larkin

- PhD from CalTech, 1996
- Robert R. McCormick Postdoctoral Fellow, University of Chicago, 1995
- Professor of Physics & Astronomy, UCLA, 1997
- Alfred P. Sloan Fellow, 2000

Professor Larkin works in the areas of extragalactic astrophysics, adaptive optics (AO) and infrared instrumentation. Larkin and colleagues were the first to observe faint field galaxies with a Shack-Hartmann AO system in order to directly observe galaxy evolution. This has now developed into a large legacy program as part of the NSF Center for Adaptive Optics. Larkin is the principal investigator of OSIRIS, a new diffraction limited cryogenic spectrograph that can take more than 1,000 simultaneous spectra over a rectangular field of view. He is also a co-principal investigator on the Gemini Planet Imager to develop an advanced AO system with the capability to directly image young Jovian planets around nearby stars. His interests in planet detection have grown from work on one of the Terrestrial Planet Finder architecture teams, and membership in the ORIGINS subcommittee for NASA.

of the fuselage near the airplane's tail and carries nine instruments. The first successful flight occurred in April 2007 in Texas, and then the plane was flown to Edwards Air Force Base in California, where it is now based. Once it is completely operational, the SOFIA is expected to fly three or four nights a week over the next 20 years.

UCLA has a significant and diverse role in SOFIA development and operations. Under McLean's direction, the Infrared Lab is building FLITECAM, a first-light cryogenic infrared test experiment camera and spectrometer for SOFIA. FLITECAM has been used for scientific research on eight occasions at the University of California's 3-meter Shane telescope on Mt. Hamilton, and it was showcased at the SOFIA Mission Operations Review at the NASA Ames Research Center in early 2007.

McLean believes that future infrared research will become increasingly collaborative, with worldwide participation. The cost alone has become prohibitive for any institution, or even any one government to fund. As an example, he cites the newest project for the UC and Caltech astronomy communities—a next generation telescope much larger than those at the Keck Observatory. "It will be a collaboration with Canada to build a telescope three times larger than the one currently operating in Hawaii." Although a site has not been identified, it may possibly be situated in the Andes. The UCLA Infrared Lab expects to participate in future ventures with the same pioneering spirit that it has shown over the last decade and a half.

WHY INFRARED?

The medium swirling around the stars—the inter-stellar medium—is not a true vacuum. Hydrogen gas exists there, mixed with tiny smoke-like particles that astronomers refer to as dust. The stars are the source of this dust, with our sun contributing a million tons every second over the last four and a half billion years.

The inter-stellar dust absorbs visible light, which is what our eyes use to see. Because of this absorption, the light from many distant objects outside the solar system doesn't reach us through visible light telescopes. But telescopes equipped with infrared technology see right through the dust, slipping around the particles and probing deep inside even the most obscure regions. Astronomers are now able to see objects they never knew were there 20 years ago.

Ultimately, what we want to do with infrared technology is find planetary systems that are similar to the one in which we live. However stars and planets take a long time to form, typically 10 to 100 million years; and it takes a lot longer than that for life to grow. Astronomers cannot possibly wait for a particular young star system to evolve before making assumptions about its potential to support life.

Explanation: Hurtling through a cosmic dust cloud a mere 400 light-years away, the lovely Pleiades or Seven Sisters star cluster is well-known in astronomical images for its striking blue reflection nebulae.

Credit: NASA, JPL-Caltech, J. Stauffer (SSC, Caltech)

On a smaller scale, scientists who are studying human beings have the same dilemma. They do not want to take the time to follow a population through its entire lifespan, but they know that little babies will grow up to be children, who will become teenagers and eventually adults. So scientists look at many families at different stages of life and gain the information they need about the potential of one human being. That is what astronomers are doing with the stars. Using infrared, they are analyzing many different star systems: young, old, and various stages in between. In this way, they can understand the potential of one star. This is what infrared technology is accomplishing. In a matter of years, it has exponentially increased our knowledge about space and in so doing, given us a history of our world, as well as clues about our galactic future.

An investment in knowledge

pays the best interest . . .

Benjamin Franklin

DONORS 2006 - 2007

The Star Projector in UCLA 's planetarium has been upgraded, repaired and polished, thanks to the generous donation by the Nicholas Foundation last year. After a brief hiatus, the Planetarium's doors were once again opened this past fall. Astronomy, elementary and high school students, along with the general public, visited the updated venue and all roundly acclaimed this spectacular star show. One visitor remarked "…I'm thrilled for the special opportunity to view these many recent and wondrous discoveries of this exciting world of astronomy."

Planetarium shows are offered every Wednesday evening during the academic year at 7 pm on the roof of the Mathematics Building. You are most welcome to visit and spend a night among the stars.

Donors 2006-2007

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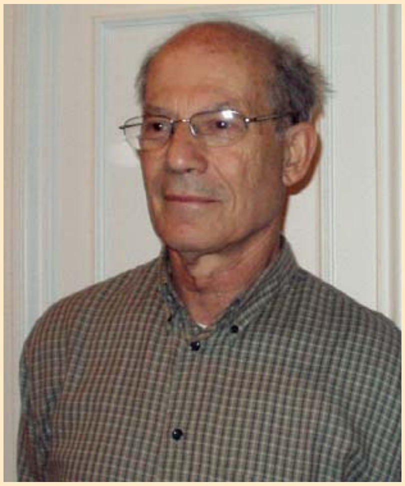
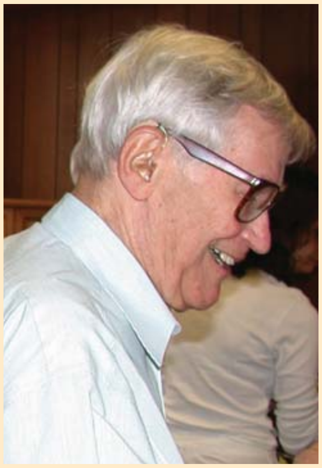
Alum gives back to physics



Guy Weyl, PhD 1969
Theoretical Plasma Physics

Guy Weyl received his Ph. D degree in 1969 in (theoretical) Plasma Physics under Professor Burton Fried. He later joined the Avco Everett Reasearch Laboratory where he specialized in laser-material interactions. He says that the five years spent in the physics department of UCLA were among the happiest years of his life. He was awarded a Hertz Foundation fellowship which was significantly more generous than other fellowships available at the time and which enabled him to comfortably support his wife and 2 children who were born then. He felt it only natural to give back to UCLA by helping create the ***Physics and Astronomy Alumni Fellowship*** and funding the first fellow. "Hopefully, other Physics and Astronomy alumni will contribute to this fund and allow the fellowships to continue."



David Saxon

The David Saxon Physics Graduate Fellowship Fund was recently established to honor David S. Saxon, a beloved and outstanding Chair in the Department of Physics. His impressive resume reflected a myriad of many responsible positions he held in academic circles over his long career. Ongoing contributions to this Fund make it possible for future and deserving students to pursue their own dreams and also carry on the legacy of a major scholar and outstanding leader, David Saxon.

Arthur E. Levine and Lauren B. Leichtman

Lauren and Arthur
Lauren B. Leichtman & Arthur E. Levine Family Foundation.

Arthur and Lauren have been loyal supporters of this department through the Lauren B. Leichtman & Arthur E. Levine Family Foundation. Their generous donations have funded a multitude of meaningful projects such as: Graduate student support, dinners hosted to encourage Recruiting Professors to UCLA and a wide array of research efforts. They provided the department with an opportunity to invite Claire Max, Director of Center for Adaptive Optics from UC Santa Cruz, to visit the UCLA campus during her sabbatical. In addition, they have also pledged a generous gift to establish the Lauren B. Leichtman & Arthur E. Levine Astrophysics Endowed Chair. Andrea Ghez remarks that "Arthur and Lauren's unwaivering support has allowed me to do so much more than I could have otherwise. This has been essential in a research field that is highly competitive."

Jerry Magnin's close association with Arthur E. Levine has stimulated his interest in our department and he now enthusiastically supports and encourages the outstanding research being done, adding – "...it is exciting and wonderful that we have such world class scientists at UCLA..." His financial contribution helps this department to expand and explore the ongoing and challenging areas of research.

Jerry is President of Bruin Pharma. Bruin Pharma has licensed a number of compounds to improve the function of HDL cholesterol which were developed by Alan Fogelman at UCLA's Department of Medicine and his colleagues .

CAREER DAY 2007

April 11, 2007 marked the calendar for another successful Career Day. This yearly event sponsored by the UCLA Physics & Astronomy Alumni Alliance (PAAL) is held for graduates earning their BS, MS, or PhD. The department schedules this informative meeting early in the spring to allow the upcoming graduates adequate time to consider options and better understand the wide range of employment opportunities available to them once they enter the job market. As in the past years, renowned speakers from the academic and public sectors gathered to present a wide array of pertinent information about their personal journeys and professional experiences.

Panelists field questions at this year's career day

The program was designed to have each individual speaker give his/her presentation. Followed by an open session giving the students ample time to ask questions and make comments that were of particular interest to them. Students paid rapt attention as the professionals shared their backgrounds. This informal and free exchange of questions, answers and ideas gave another opportunity to our audience. The session opened the door for our graduates and provided a view that will help them shape their dreams and plan their future. UCLA Alumni Speakers were:

Nzhde Agazaryan, Health Sciences Assistant Professor, UCLA, School of Medicine; Bob Baker, Mathematics Instructor, University High School, President of PAAL; Cheng-Wei Cheng, Senior IT – Architect, IBM Corporation; Darius G. Gagne, Principal & Co-Founder of Quantum Wealth Management; Perry Lanaro, Director of Financial Systems, Universal Motion Pictures; David Morse, Intellectual Property attorney Connoly Bove Lodge & Hutz LLP; Ritesh Narang, Systems Engineer, Vista Research, Inc.; John G. Taborn, Graduate Counselor Supervisor, UCLA Career Center; John Vaszari, Program Manager & Senior Engineer, L-3 Communications, Electron Technologies; Clara Yoon, Research Analyst(Scientific Programmer, Areté Associates).

2006-2007 PAAL Outstanding Graduates

Erin Hicks

Makan Mohageg

Commencement Day, June 16, 2007

Graduates from the UCLA Department of Physics & Astronomy gathered at Schoenberg Hall to celebrate their graduation.

Traditional opening ceremonies were followed by the keynote speaker, Ben L. Holmes, who holds a BSc in Applied Physics earned at UCLA in 1959. Ben addressed the students with sincerity and laudatory praise, sharing his background and interspersing his remarks with priceless words of wisdom….

"…to make a contribution…strive to be the best at whatever you choose to do…."

The audience of families and friends enthusiastically applauded the speaker's poignant and warm words of advice to the new graduates. The program flowed into the traditional awarding of honors as Graduates and Undergraduates, in turn, filed to the stage to receive their honors.

This year's class reflected not only the growing number of graduates from the Department, but also the unusually large Astrophysics Class. Another milestone for the Department was established as the first BioPhysics class was among those being graduated.

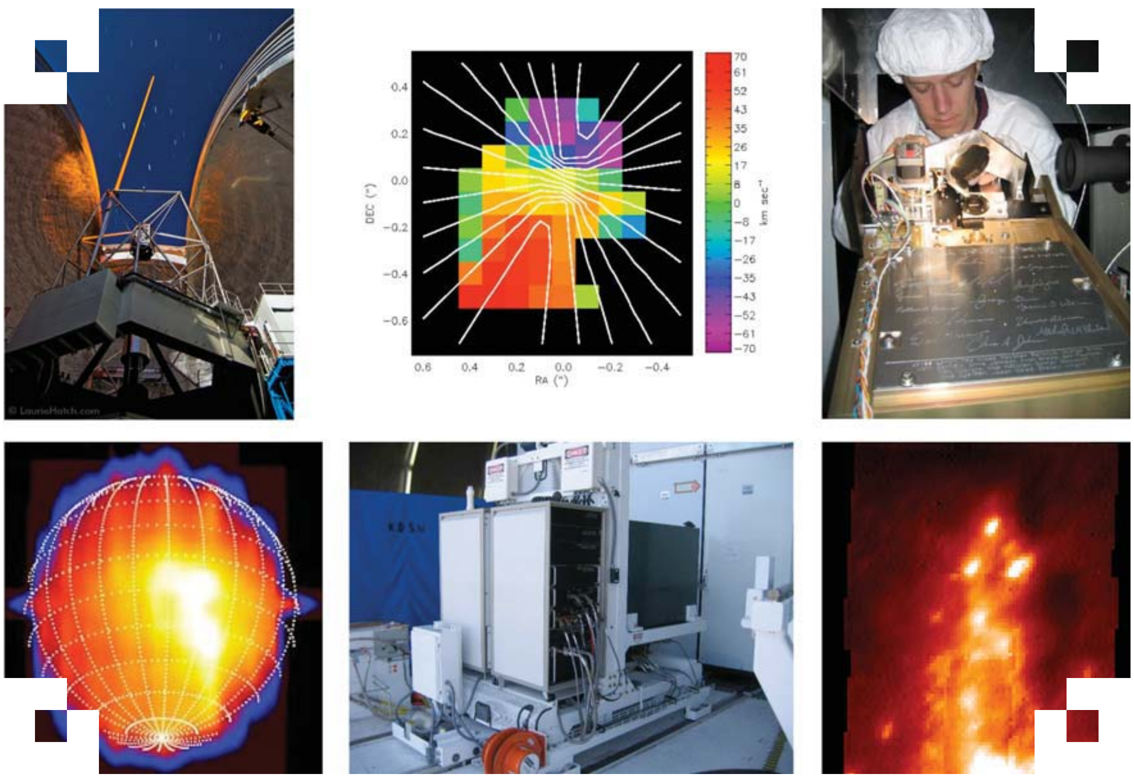
Ferdinand Coroniti put the finishing touches on the afternoon by Announcing Awards and Department Honors.

The graduates then hurriedly moved on to various festivities with their family and friends to complete this extraordinary graduation day…June 16, 2007 …with Ben Holmes' words ringing in their ears…

"…make a contribution…strive to be the best…"

If we knew what it was we were doing, it would not be called research, would it? . . .

Albert Einstein



The OSIRIS spectrograph (bottom middle) works exclusively with the Keck Adaptive Optics System. With the aid of an artificial laser guide star (upper left) the system is able to undo the blurring of the atmosphere and take images roughly 20 times sharper than with traditional telescopes. This has allowed **James Larkin** (upper right) and his team to make observations of a wide range of objects in the Universe. In the upper middle panel is a velocity map of a distant galaxy which may be one of the first observations of a disk galaxy like our own Milky Way in formation. At the lower left is a surface map of Saturn's moon Titan, and the image on the right shows individual star forming regions in a nearby galaxy called M82. In all of these observations over a thousand spectra are taken and combined to form the presented images. Panel produced by Shelley Wright.

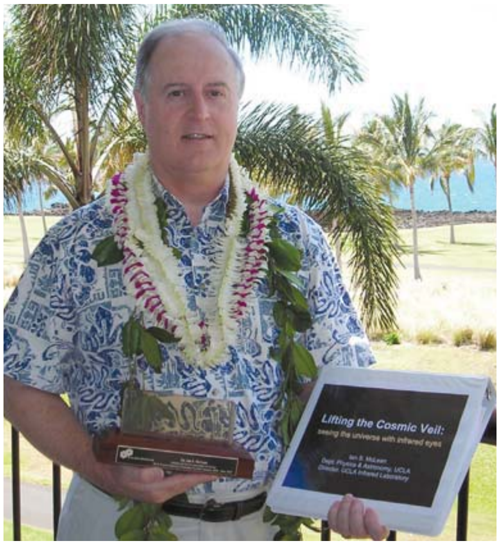
Astronomy

The past 12 months have been a busy and successful time for the UCLA Infrared Laboratory. The faciities in Knudsen Hall were expanded and refurbished, and new laboratory space in the Physics and Astronomy Building (PAB) was equipped with a Clean Room. **Ian McLean** and **James Larkin,** principal investigators in the IR Lab have major contracts for the W. M. Keck Observatory, the Gemini International Observatories, NASA and the Thirty Meter Telescope project.

Multi-Object Spectrometer for Infra-Red Exploration (MOSFIRE) is scheduled for delivery at the end of 2009. McLean is the Principal Investigator (PI) on this project which is a collaboration among Caltech, UCLA, UCSC and the WMKO, and funded partially from the NSF and a private donation by Gordon and Betty Moore.

McLean is also the PI of First Light Test Camera (FLITECAM) the first-light infrared test experiment camera for NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA.) This cryogenic infrared camera and spectrometer is complete and nearing delivery to the SOFIA aircraft which earlier this year had its first successful flights and is now at the Dryden Flight Research Center on the Edwards Airforce Base in California.

McLean continued to use the The Near Infrared Spectrograph (NIRSpec) instrument that he delivered to the Keck Observatory from UCLA in 1999. In April 2007, McLean and his collaborators on the NIRSpec Brown Dwarf Spectroscopic survey published a major new research paper in this long-term survey of brown dwarfs. A public archive has been developed to make the results of these surveys widely available. UCLA graduate student **Emily Rice** is comparing NIRSPEC spectra with model atmospheres generated in collaboration with former UCLA post-doctoral researcher **Travis Barman.**



June 20, 2007 Professor Ian McLean was honored by the W.M. Keck Observatory Board of Directors and colleagues on the Keck Observatory Science Steering Committee (SSC) for almost 10 years of service to the SSC and the Observatory.

The completed FLITECAM instrument for SOFIA (blue cylinder on white handling cart) is shown in the new IR Lab in the basement of PAB. Racks and displays in the background are part of the deliverable system.

UCLA graduate student **Erin Smith** recently won a prestigious NASA HQ graduate student research fellowship award. There is a 90% rejection rate for this award. Erin is now writing her thesis based on FLITECAM data taken at the Lick Obervatory.

2007-2008 - Professor McLean will be on sabbatical leave at the Royal Observatory in Edinburgh, Scotland where he will be working on a new edition of his book entitled "Electronic Imaging in Astronomy" first published in 1997.

Mark Morris's research remains largely focused on the center of the Galaxy. Morris and graduate student **Jon Mauerhan**, are studying the formation of massive stars in the central 300 light years of the Galaxy, in a quest to determine whether those stars form predominantly in massive clusters that subsequently evaporate, or whether they form in relative isolation. The answer is important for understanding the mechanism for star formation in this unusual and hostile environment. Nowhere is the environment more hostile to star formation than in the immediate vicinity of the central black hole, and yet massive stars have formed there in abundance. Morris and collaborators (former UCLA grad student Fred Baganoff and recent post-doc **Mike Muno)** continue to observe the Galactic center with the Chandra X-ray Observatory. This year, they found a variable, fluorescent x-ray source near the Galactic center which suggests that, sometime in the past several hundred years, there was a tremendous and relatively brief flash of x-rays. This discovery provides a powerful probe of the gas and dust in the central zone of the Galaxy

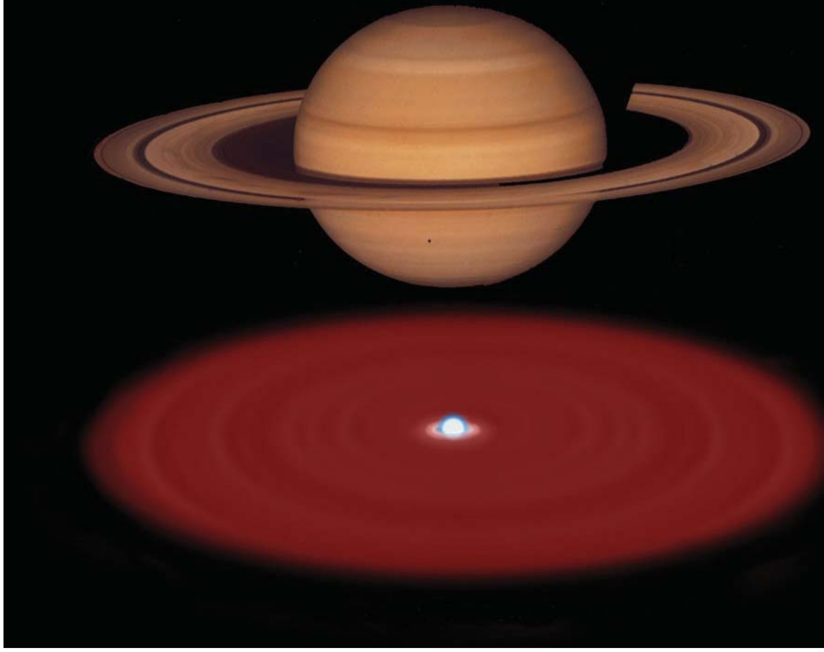
Morris is also continuing study of how red giants undergo the rapid transition to become planetary nebulae. With JPL colleague R. Sahai, Morris used the Hubble Space Telescope to capture images of many of these objects in the process of undergoing the transition.

During 2006-2007**, Michael Jura's** research has been focused on using the Spitzer Space Telescope to study the infrared emission from white dwarfs. The arguments are now very strong that some of these stars are surrounded by dust rings similar to those orbiting Saturn. Accretion from these dust rings are measured and thus determine the composition of the parent body which at least in some cases, resembles the composition of the Earth.

Jura has also been involved in developing a new course with Matt Kahn, an economist in the Institute of the Envirnoment. The course will be taught for the first time in Fall, 2007 on Energy in the Modern Economy.

For the last two years, astronomers have suspected that a nearby white dwarf star called GD 362 was "snacking" on a shredded asteroid. Now, an analysis of chemical "crumbs" in the star's atmosphere conducted by NASA's Spitzer Space Telescope has confirmed this suspicion.

Read more at: *http://www.spitzer.caltech.edu/Media/happenings/20070313/*



An artist concept of GD 362, showing the relative sizes of its debris disk and the planet Saturn.
Courtesy of Gemini Observatory/AURA/Jon Lomberg

"This is a really fascinating system, that could offer clues to what our solar system may look like in approximately five billion years when our Sun becomes a white dwarf," said Dr. Michael Jura, of the University of California at Los Angeles (UCLA).

Brad Hansen and colleagues from Columbia, MIT and Central Florida published the first detection of day/night temperature differences on an extrasolar planet. Using the Spitzer Space Telescope, they showed that the observed brightness of the innermost planet orbiting the star upsilon Andromedae varies as it goes around the star, which proves that the planet is hotter on the side facing the star than it is on the side facing away.

Using the Hubble Space Telescope, Brad Hansen, along with **Mike Rich**, **David Reitzel** and colleagues from British Columbia, Rice University and the University of Washington, measured the age of the globular cluster NGC 6397 with substantially greater accuracy than has been done before. This object is one of the oldest objects in the Milky Way, and is between 11 and 12 billion years old. The measurement suggests that much of the assembly of the Milky Way galaxy took place about two billion years after the Big Bang.

Using the Keck Telescopes, Brad Hansen, along with Mike Rich, David Reitzel and colleagues from British Columbia and UC Santa Cruz, measured the masses of several young white dwarfs in the open star cluster NGC 6791. The resulting low values of the measured masses supports a hypothesis this group advanced two years ago to explain some puzzling features of the stellar population in this cluster. **Ben Zuckerman,** along with Brad Hansen, Mike Jura, graduate student **Carl Melis** and Detlev Koester of Kiel University, recently measured the chemical composition of an extrasolar asteroid. The asteroid in question was tidally disrupted and accreted onto the atmosphere of a white dwarf star. Measuring the spectrum of the white dwarf with the Keck Telescope, Zuckerman and colleagues were able to detect the spectral lines of more than a dozen elements and measure their strengths. The results suggest that the composition of the unfortunate asteroid bears strong similarities to that of the earth-moon system.

COBE, the COsmic Background Explorer, did the research that was awarded the Nobel Prize in Physics in 2006. **Edward (Ned) Wright** went to Stockholm along with 15 of the 18 surviving science team members. The Wide-field Infrared Survey Explorer (WISE) passed its critcal design review held at UCLA in June 2007, and is scheduled for launch in November 2009.

Laser Guide Star Adaptive Optics (LGS-AO) has had a large impact on several aspects of the **Andrea Ghez** group's studies of the black hole at the Galactic Center (GC) and its environs. With the recent advent of (LGS-AO) at the Keck Observatory, the first 10 meter class telescope to have such a system, has revolutionized what can be done at the highest angular resolution achievable (see figure over).

First, it has improved our ability to measure the galaxy's central gravitational potential. Specifically, through improved positional and radial velocity measurements of a star through almost a complete orbit, accurate estimates of the black hole's mass (4-5 million times the mass of the Sun) and distance have been made. One of the key science cases for future adaptive optics systems at Keck, as well as future large ground-based telescopes, is to probe an unexplored regime of general relativity..

Another aspect of LGS-AO's scientific impact on our studies of the GC is the discovery of new young stars in the vicinity of the central black hole as well the measurement of the orbital motion of young stars. With large tidal forces, the central black hole makes its surrounding regions inhospitable to star formation. The LGS-AO measurements allow demonstrations that roughly show half of the young stars in this region share a common orbital plane.

Another focus of the Andrea Ghez research group's effort, which has benefitted tremendously from LGS-AO, is the formation of young and low mass stars. In particular, focus most recently was on using the orbital motion of binary stars to calibrate the Pre-Main Sequence (PMS) and low mass evolutionary models. In the last year, research discovered new binary brown dwarfs, increasing the number of known, young, very low mass binaries that can be followed dynamically by 50%, and obtained our first high precision measurement of the mass of 2Mass 0746, which is one of only three existing direct mass measurements for a brown dwarf and has a precision of 3%, which is sufficient to distinguish between the evolutionary models. NIRSPEC, built at UCLA, with LGS-AO at Keck is the only system in the world (ground or space) that can measure spatially resolved radial velocities of very low mass companions.

The laser guide star system at the W. M. Keck Observatory. This picture was taken, while we were taking data on the center of the Milky Way galaxy. The laser light stimulates sodium atoms located about 90 km up in the atmosphere to create a bright artificial star, which is used to understand and correct for distortions introduced by the atmosphere at lower altitudes.

The Galex satellite discovered an oddly misshapen shell spanning 0.5 degrees, centered on the dwarf Nova Z Cam. Deeper imaging in H-alpha and spectroscopy from Lick confirmed that the structure is an ancient nova shell (Shara et al. 2007, Nature. 446, 159). Galex also discovered a spectacular turbulent wake trailing behind the famous red variable star

In the image, the face-on spiral galaxy NGC 6946 is ablaze with colorful galactic fireworks fueled by the births and deaths of multitudes of brilliant, massive stars. Astronomers suspect that massive stellar giants have been ending their lives in supernova explosions throughout NGC 6946 in rapid-fire fashion for tens of millions of years.
Credit: Gemini Observatory /Travis Rector, University of Alaska Anchorage

Mira. An imaging campaign for 100 orbits using the ACS on HST reveals 16 new planetary transit candidates. All are "hot Jupiters" but a subset - the Ultar Short Period Planets - have periods of < 1 day and are a new class of hot Jupiters that orbit M dwarfs. Two major papers by Fulbright, McWilliam, and **Michael Rich** report on Rich's large Keck study of abundances in the bulge using HIRES. (Fulbright, McWilliam and Rich, 2006 ApJ, 646, 499; 2007 ApJ, 661, 1152). The deficit of oxygen remains a mystery since it is produced in the same burning shells as the other light elements like Mg. Rich and Livia Origlia (Bologna) continued their investigation of abundances in the inner bulge. Rich, UCLA postdoc **David Reitzel,** UCLA graduate student **Christian Howard,** and Professor H. Zhao (University St. Andrews) have mapped the Galactic bulge's line of sight velocity distribution and rotation curve at b=-4 deg. This is the largest study ever done, now over 4000 M giants. The rotation curve of the bulge/bar is now seen not to be a solid body, and aspects agree with self consistent theoretical models of the rapidly rotating Galactic bar.

The 2006 Aaronson Award from the University of Arizona was awarded to Andrea Ghez. The Lectureship and accompanying cash prize is awarded on a regular basis to an individual or group who by their passion for research and dedication to excellence, has produced a body of work in the past ten years in observational astronomy which has resulted in a significant deepening of our understanding of the universe.

Extra Galactic Astronomy

Jean Turner, in collaboration with Don Backer (UC Berkeley) and Jim Moran (Harvard), edited the volume, *"Revealing the Molecular Universe: One Antenna is Never Enough,"* proceedings of the conference to honor William J. Welch held in Berkeley in 2005.

Turner continued her work on molecular gas and its relation to star formation in galaxies. She and former UCLA graduate student **Lucian (Pat) Crosthwaite** (Northrop-Grumman) published a study of carbon monoxide (CO) emission in the peculiar spiral galaxy, NGC 6946, as part of their program of deep, high fidelity CO imaging of nearby galaxies. CO is a good tracer of molecular gas mass, and these are some of the most sensitive CO images of galaxies to date. Turner and Crosthwaite found that CO emission is present throughout the central disk of NGC 6946, including regions between the spiral arms. Their work showed that the widely-accepted Schmidt law is not a good descriptor of the relationship of molecular gas to star formation in this galaxy. Instead, the star formation rate appears to be directly proportional to the amount of neutral gas, which implies a constant star formation efficiency.

Astroparticle Physics

UCLA has a strong group led by **Rene Ong** and **Vladimir Vassiliev** who are carrying out research in the area of Very High Energy (VHE) gamma-ray astrophysics -the study of photons of energies above 100 GeV coming from powerful cosmic accelerators. This group has a major involvement in the Very Energetic Radiation Imaging Telescope Array System (VERITAS). The construction of VERITAS was completed in late 2007 and the operation of the full array of four 12 m diameter telescopes started in spring 2007. Early data from VERITAS, operating first with two telescopes and then with three telescopes, look very promising. VERITAS can detect the Crab Nebula, the standard candle in VHE astronomy, under a minute of operation (over an hour of operation was required with the previous generation of telescopes). Moreover, early results in addition to the Crab include the discovery of the supernova remnant IC 443 and the microquasar LSI +61 303 and the detection of a number of extragalactic sources: the radio galaxy M87 in the Virgo cluster and several active galactic nuclei. VERITAS has started a five year observing program that will complement observations made by the Gamma-ray Large Area Space Telescope (GLAST), to be launched by NASA in early 2008.

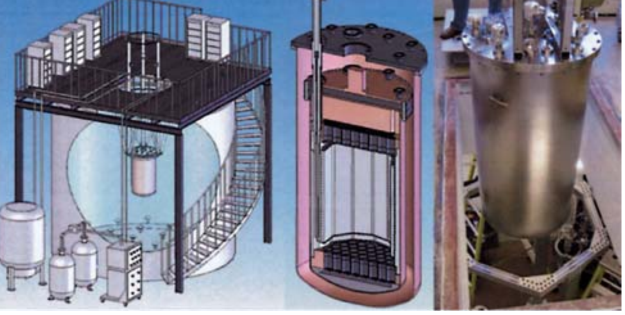
The UCLA VERITAS group includes postdoctoral associates **Stephan Fegan** and **Amanda Weinstein,** graduate students **Timothy Arlen, Ozlem Celik, Ken Chow,** and **Matthew Wood.** For the last three years, a student associated with UCLA's successful and highly competitive Research Experience for Undergraduates (REU) program has worked on VERITAS related activities; these students were **Thomas Fishman** (2005), **William Gignac** (2006) and **Jennifer Helsby** (2007).

REU student Jennifer Helsby standing next to one of the VERITAS telescopes in Arizona.

Another important milestone that occurred in the last year was the completion of the Solar Tower Atmospheric Cherenkov Effect Experiment (STACEE). STACEE used 64 large heliostat mirrors at a solar research facility at Sandia National Labs to detect astrophysical gamma-ray sources at energies lower than previous instruments. STACEE operated successfully for a five year period starting in early 2002. The experiment took its last data in June 2007 and it was decomissioned during summer 2007. Analysis of STACEE data continues, carried out by Ong, research physicist **Jeff Zweerink** and graduate student **Alex Jarvis.**

A new focus of the VHE astrophysics group is the development of a major gamma-ray observatory with sensitivity an order of magnitude better than VERITAS. This observatory, currently called the Advance Gamma Imaging System (AGIS) and potentially costing ~$100M, will likely consist of 50-100 atmospheric Cherenkov telescopes covering an area of 1 km^2. UCLA is playing a major role in the development of AGIS, leading the design of a novel wide-field telescope system. Start-up funding for AGIS has come from the UCLA Department of Physics, and a proposal for research and development support has been submitted to the National Science Foundation and the Department of Energy.

A First Light Celebration was held in April 2007 at the VERITAS site at the basecamp of the Whipple Observatory on Mt. Hopkins in southern Arizona.



Overview of the LUX detector system. Shown left to right are the 6 m Ø water tank with Cherenkov-light muon veto, Cutaway view of the LUX detector, and detector with stainless rather than low backgroud Cu, cans, under cryogenic tests at Case in July 2007

The idea of the two-phase liquid Xenon detector for dark matter was developed at UCLA and Pisa in 1997. It is therefore appropriate that the first collaborative meeting for the Large Underground Xenon detector (LUX) was held at UCLA in January 2007 and organized by the **David Cline group**. This will be the largest detector in the world and the first detector to go into the DUSEL Underground Laboratories at Homestake, South Dakota. **Hanguo Wang** is the UCLA spokesperson for LUX. The key internal detector that will be constructed in the UCLA Dark Matter Laboratory will be under the supervision of David Cline and colleagues. They also continue the search for dark matter with the ZEPLIN II detector at the Boulby UK lab, discussed in previous UCLA reports. Approval for twenty more months of research has recently been received.

The ICARUS neutrino detector at the Gran Sasso Lab at CERN will collect data from the CERN neutrino beam, located 732 km from our detector, at the end of 2007. This is a very powerful technique for future neutrino experiments.

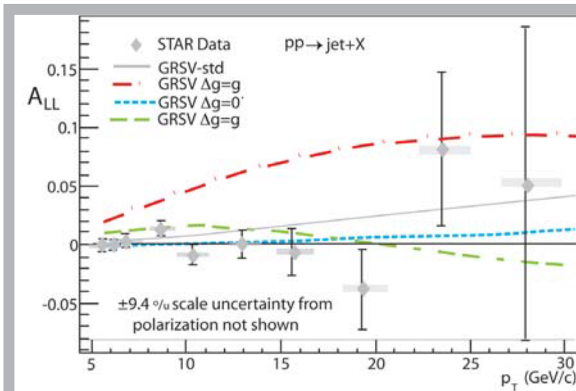
In continuing investigation of primordial black holes, very short burst gamma ray bursts are being studied. This year three new papers were published and many talks given. The GLAST gamma ray detector, set to be launched into space in 2008, will be important for this research.

Physics

Nuclear Physics

The Nuclear Physics Group (**Huan Huang-Charles Whitten**) has research programs on Relativistic Heavy Ion Collisions and Spin Physics. They are currently focusing on the STAR experiment at RHIC for the heavy ion and spin physics program. Experimental measurements at RHIC have indicated that in central Au+Au collisions high energy density matter has been formed in the early stage of the collision where the dominant degrees of freedom are partonic. Their research effort aims at investigating the properties of the dense matter created in those collisions. In particular, the recent results indicate that heavy quarks, both the charm and the bottom quarks, lose a significant amount of energy while traversing the dense partonic matter. The magnitude of the heavy quark energy loss is compatible to that of light quarks, which is in contradiction with previous theoretical expectations. Measurements of heavy quark energy loss at RHIC have stimulated exciting theoretical developments on parton energy loss mechanisms.

The UCLA spin physics program centers on the study of the spin structure of the proton using polarized proton-proton collisions at RHIC. Experimental focus is on the measurement of inclusive jet and di-jet production where quark and gluon scatterings are considered the major underlying physical processes described by perturbative Quantum Chromo-Dynamics (pQCD) calculations. A major scientific goal of the spin physics program at RHIC is to determine the spin carried by the gluons in the proton. We have completed a first generation of ALL measurements at RHIC which provide an experimental constraint on theoretical calculations for the gluon spin structure function of the proton. Recent measurement of Longitudinal double spin asymmetry (A_LL) shown in the figure is a significant improvement over previous STAR results published in *Physical Review Letters 97 (2006) 252001.*



Caption – Longitudinal double-spin asymmetry, ALL, for inclusive jet production as a function of jet transverse momentum from polarized p+p collisions at 200 GeV center-of-mass energy. The error bars are statistical only. The grey boxes indicate the systematic uncertainties of the measured points. The curves are predictions for Next-Leading-Order parton jets from B. Jager et al, Physical Review D 70 (2004) 034010. The curve GRSV-std represents the best fit to deep inelastic scattering data and gives a gluon contribution of about 50% of the proton spin. The curves GRSV Δg = (-g, 0, g) correspond to - , zero and + contributions from gluons to the proton spin.

Future experimental effort will measure quark-gluon Compton scattering, producing a jet and a high energy photon. The photon will be measured by electromagnetic calorimeters and the jet by a combination of electromagnetic calorimeters and a time-projection chamber. The Compton process will cover a broad kinematic range and provide a more stringent constraint on the gluon spin structure function. The ongoing STAR detector upgrade projects in which the UCLA group plays a major role will significantly improve the STAR capability for heavy ion and spin physics program in the coming years; and the RHIC accelerator complex continues to improve its operation for higher luminosity and beam polarization.

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 **Sasha Starostin** and **Serguei Prakhov,** a new researcher is in the hiring stage. **Jason Brudvik** who received his PhD in June is working on a follow up of his thesis work, which is a beautiful test of chiral perturbation theory. Graduate student **John Goetz i**s getting ready to take the experimental data for his thesis, which is a search for doubly strange nucleons using the improved CLAS detector at Jefferson Laboratory. **Indara Suarez** graduated last spring. She is a participant in UCLA's Research Experience for Undergraduates (REU). She spent part of the summer at the University of Mainz where the group is spearheading a collaboration of some 12 Universities in research on multi-meson photoproduction.

The group pursues two experimental programs. One is centered about a special detector, the Crystal Ball multiphoton spectrometer that has an acceptance of almost 4 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 eta and eta-prime decays. This tests C, CP, time reversal isospin invariance, and flavor and chiral symmetry as well. Study also includes the photoproduction of selected neutral mesons to probe the structure of the proton.

John Goetz, graduate student, and Serguei Prakhov stand in front of computer array at UCLA.

The second program uses the large CLAS detector, which measures charged particles. This device is located in the 4 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, probing the quark-quark correlations inside the proton.

Condensed Matter Physics

One of the two major research activities in the **W.G. Clark** group during 2006-07 was to develop a new method to measure Radio Frequency Induced Flux Lattice Annealing (RIFLA) in a high temperature superconductor using the pulsed NMR instrumentation. Preparation was made to prepare a strained flux lattice by rotating the superconductor at low temperature in a magnetic field. This leaves the flux lattice pinned to imperfections in a non-equilibrium state. The application of rf pulses of the kind used for NMR jiggles the flux lattice and anneals it to a lower free energy configuration, with a stronger pinning force. This lowers the rf inductance of the NMR coil surrounding the sample, and increases the resonant frequency of the NMR probe. By tracking this change with a series of annealing pulses, the flux lattice annealing as a function of the number, amplitude, duration, etc. of the annealing pulses was obtained. This provides important basic knowledge of the RIFLA process which may be useful for improving the performance of superconducting materials.

Research carried out by **Stuart Brown's** group includes an effort using nuclear magnetic resonance to study correlated electrons in solids. Materials where the electronic motion is largely constrained to one or two dimensions, or where the electronic density is low, correlations can lead to emergent behavior: new electronic phases of matter. Remarkably, superconductivity–which requires an attraction between pairs of electrons–is sometimes the ground state for highly correlated systems. The classes of electronic materials for which correlations are important and lead to new physics, include high temperature superconductors, and organic superconductors.

Brown's student, **Jun Shinagawa,** completed his PhD work in 2007, in which NMR was used to show that there were two distinct superconducting phases for a class of organic superconductors. Although substantial progress in characterizing the properties of these phases, there is still a lot that remains unkown. Other activities include the study of magnetic-field induced transitions in frustrated quantum magnets (student **Steve Suh**) and the development of a scanning tunnelling microscope with unique capabilities (student **Jeff Wright**, with colleague **Karoly Holczer**).

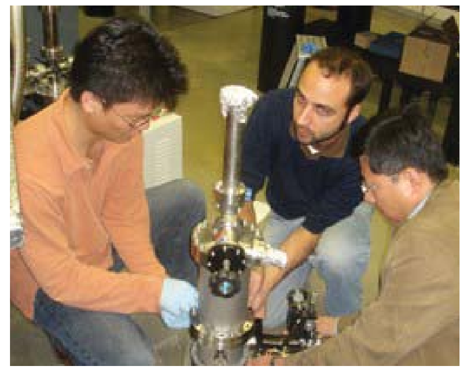
The **Thomas Mason group's** recent development of mass-production methods for making dispersions of lithographically designed colloidal particles, or 'LithoParticles', was featured on the cover of the Journal of Physical Chemistry C and twice in Nature. The first Colloidal Alphabet Soup consisting of all twenty-six capital letters of the modern English-Latin alphabet have been designed and developed. These microscale polymeric letters undergo significant Brownian motion and illustrate the power of the synthetic approach to create a wide diversity of shapes. This approach can be extended to the nanoscale to make monodisperse submicron particles that have precise shapes. LithoParticle dispersions received an award by R&D Magazine as one of the top 25 developments in the micro/nano area in 2007. The breakup of viscous threads into discrete swirls by a viscous "swirling instability" as the threads propagate off-center in microchannels have been demonstrated. Work on instabilities of viscous threads in microfluidic channels, was presented as a poster at the APS Division of Fluid Dynamics Meeting, and has received the AIP/APS Gallery of Fluid Motion Award for the second year in a row. Former UCLA postdoc, **Thomas Cubaud**, who led the work on microfluidic instabilities, has moved to SUNY-Stony Brook after obtaining a faculty position as an assistant professor in mechanical engineering. Finally, the review article on nanoemulsions, published in the Journal of Physics: Condensed Matter in late 2006, has been recognized as one of the top papers of 2006 by the Institute of Physics (IoP) based on download demand.

Sudip Chakravarty has recently worked on two main areas of physics. The first is the concept of the von Neumann entanglement entropy, which is a useful measure to characterize a quantum phase transition. The non-analyticity of this entropy at disorder-dominated quantum phase transitions is striking. The collaboration involved students **Angela Kopp** and **Xun Jia,** and Professor Ilya Gruzberg from the University of Chicago and his student Arvind R. Subramaniam. High temperature superconductivity remains a strong focus of activity. The extreme variability of observables across the phase diagram of the cuprate high temperature superconductors has remained a profound mystery, with no convincing explanation of the superconducting dome. While much attention has been paid to the underdoped regime of the hole-doped cuprates, little attention has been paid to the overdoped regime. Experiments are revealing that the phenomenology of the overdoped regime is just as puzzling. This work was in collaboration with student **Angela Kopp** and postdoc **Amit Ghosal** and was published in the proceedings of the *National Academy of Sciences.*

Chakravarty is equally excited about the remarkable quantum oscillation experiments in the underdoped high temperature superconductors performed by L. Taillefer (University of Sherbrooke, Canada) and his coworkers, which was published in *Nature* recently. Chakravarty (in collaboration with Professor Hae-Young Kee, University of Toronto) explains the experimental results with the theory that the pseudogap is a state with a hidden order. The success of the analysis underscores the importance of breaking of translational symmetry, not Mott insulation, as we have been assuming during the past two decades. This work is submitted for publication and is available at the *http://arxiv.org/abs/0710.0608*. Chakravarty continues to pursue research on the newly discovered material: Graphene. A three year grant from the National Science Foundation was funded to help Chakravarty continue his studies.

Biophysics

John Miao, with postdocs and students **Changyong Song, Huaidong Jiang, Adrian Mancuso, Ben Fahimian, Edwin Lee, Rui Xu, Jose Rodriguez, Bago Amirbekian, Kevin Raines** and **Donald Chang,** continue to develop novel image methods and to pursue applications in nanoscience and biology; by using 3rd generation synchrotron x-rays, quantitative 3D imaging of a heat-treated GaN particle with a voxel resolution of $17 \times 17 \times 17$ nm^3. The platelet structure of GaN and the formation of small islands on the surface of the platelets, were observed and successfully captured the internal GaN-Ga_2O_3 core shell structure in three dimensions [Miao *et al., Phys. Rev. Lett.* **97**, 215503 (2006)]. In collaboration with Murnane-Kapteyn group at the University of Colorado at Boulder, the first experimental demonstration of lensless imaging using coherent high harmonic soft-x-ray beams [Sandberg *et al., Phys. Rev. Lett.*, in press (2007)] were reported. This work demonstrates a practical tabletop lensless microscope that promises to find applications in materials science, nanoscience and biology. Miao was invited to write a review article for *Annu. Rev. Phys. Chem.*, on the basis of pioneering contributions to the x-ray diffraction imaging field (or called lensless imaging.) On another front, in collaboration with the Crump Institute at UCLA and other cryo-electron microscopy groups, Miao's group has demonstrated that 30% of dose reduction may be achieved in computerized tomography (CT) and cryo-electron tomography by using the equal slope reconstruction algorithm, which was originally proposed by Miao and collaborators in 2005. A patent entitled "Iterative Methods for Dose Reduction and Image Enhancement in Tomography" has just been filed.

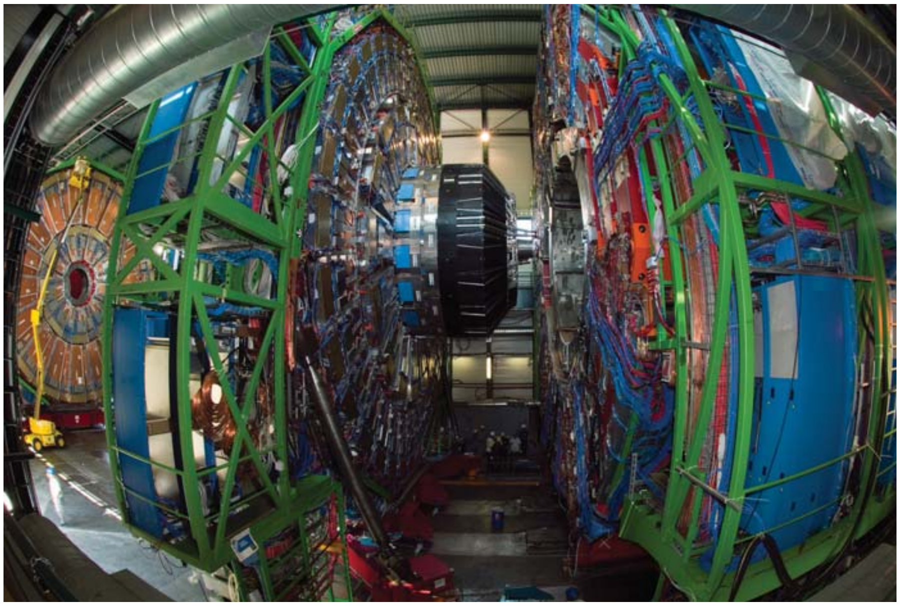


Drs. Changyong Song, Adrian Mancuso and Huaidong Jiang (from left to right) were setting up a 4K × 4K CCD detector for a coherent X-ray diffraction imaging experiment at the Advanced Photon Source in Chicago

Research in the biophyics group led by **Giovanni Zocchi** is contributing to the emerging field of mechanochemistry. Specifically, development continues on the approach for the mechanical control of chemical reactions. Coupling a controllable molecular spring to an enzyme and thus externally controlling the enzyme's conformation and activity. On the technical side, different coupling strategies for the molecular spring are being explored. On the scientific side, new molecules were used to perform a quantitative study of the induced fit mechanism in the enzyme Guanylate Kinase.

On another front, work continues on the single-molecule studies of conformational dynamics of DNA.

Robert Cousins - *deputy spokesperson of CMS*
CDF - Jay Hauser, David Saltzberg, Rainer Wallny
CMS - Katsushi Arisaka, David Cline, Robert Cousins, Jay Hauser, and Rainer Wallny



A wide-angle photograph of the CMS detector being assembled for the first time above ground at CERN. During 2007 the various parts of this massive detector are being lowered to 100 meters underground and gas, high voltage, and cabling systems are being installed.

UCLA Experimental Elementary Particles (EEP) physicists attempt to find out what are the basic constituents of nature (particles, strings?) and what are the interactions between them. In particular, they investigate the phenomena of the exceedingly small, which is accessed (because of quantum mechanics and the Heisenberg uncertainty principle) by the highest energy accelerators. As an example of what has been found, UCLA physicists participated in the discovery of the top quark in 1995. What they are looking for is the theory known as the Standard Model which explains all known basic phenomena of strong, electromagnetic, and weak interactions; however, it lacks the centerpiece known as the Higgs boson particle.

At the Fermi National Accelerator Laboratory ("Fermilab") near Chicago, protons are routinely collided with antiprotons with nearly two trillion electron-volts of energy in the Tevatron accelerator. Starting the middle of next year at the CERN laboratory near Geneva, Switzerland, beams of protons will be brought into collision in the LHC accelerator with seven times as much energy. The Higgs particle is extremely difficult to find at the Tevatron, but because of the higher energy it is expected to be well within the reach of the LHC experiments. Besides the Higgs particle, these experiments have good chances of discovering the dark matter of the universe (predicted by theories of "supersymmetry"), or to shed light on "Grand Unified Theories" by discovering heavier versions of W or Z boson particles, as well as other possibilities.

The UCLA physicists currently participate in this quest through their work on the Collider Detector at Fermilab (CDF) experiment near Chicago and on the Compact Muon Solenoid (CMS) experiment at CERN near Geneva, Switzerland. CDF has recently tripled their accumulated data sample, allowing for in-depth studies of top quarks as well as searches for other particles predicted but not yet observed. Meanwhile, after many years of building hardware for the CMS experiment, especially the muon particle detection system, the UCLA group is commissioning the detector and putting the final touches on software in preparation for first operation with colliding beams next year. **Robert Cousins** is the deputy spokesperson of the CMS experiment and is serving as the highest ranking American in the management of any of the LHC experiments. UCLA physicists working on CDF this year are **Jay Hauser, David Saltzberg,** and **Rainer Wallny**; three postdoctoral researchers, and three graduate students. This group on CDF has produced a number of physics papers in the past year. Hauser's graduate students **Brian Mohr** and **Alon Attal** recently received their PhDs.

In the past year, the UCLA team on CDF has moved into leadership roles in every aspect of studies of the top quark. Postdoc **Charles Plager** has become head of the CDF top quark properties analysis group; postdoc **Bernd Stelzer** is head of the single top quark production analysis group; postdoc **Florencia Canelli** served as head of the top quark mass analysis group and has since moved into her second year of a prestigious Wilson Fellowship at Fermilab.

Jay Hauser with PhD recipients Brian Mohr and Alon Attal. Mohr used sophisticated statistical techniques to measure the mass of the top quark particle more precisely than any previous measurement. Atal searched for spectacular "multi-lepton" events, and placed limits on a theory known as "R-parity violating supersymmetry." Both results were published as Physical Review Letter articles.

Hints to the mass of the elusive Higgs particle have been found by precise measurements of the top quark mass and the W boson mass. The most precise measurement of the top quark mass comes from an analysis conducted by Rainer Wallny and postdoc Florencia Canelli in collaboration with Jay Hauser and graduate student Brian Mohr. The result showed that the top quark mass is a little smaller than previously measured. This favors a Higgs boson mass that is actually less than the observed limit, causing a potential problem for the Standard Model that can be alleviated by the hypothetical Supersymmetry theory that will be probed by the LHC experiments.

As a result of his work on CDF over the past several years, Wallny was recently awarded the competitive Outstanding Junior Investigator grant from the U.S. Department of Energy to support his research.

The top quarks at the Tevatron thus far have all been found in pairs. An electroweak process is predicted to produce a small number of top quarks singly. A UCLA analysis in progress by Wallny, postdoc Bernd Stelzer, and graduate student **Peter Dong,** is closing in on the first well-substantiated observation of production of this rare process. Once found, the measurement of the numbers of top quarks produced should also yield a measurement to better than 10% accuracy of the unmeasured coupling of a top quark to a bottom quark and the W boson.

Wallny and Dong have installed a novel beam loss detection system that uses artificial diamond detectors inside of CDF. The exceptional radiation hardness of diamond detectors render them ideal for such beam monitoring applications. The CDF beam monitoring system Wallny built the largest of its kind inspiring similar systems for the LHC experiments. The system's success during the past year is now certified to make beam abort decisions in the day-to-day operations to protect the CDF detector from beam accidents.

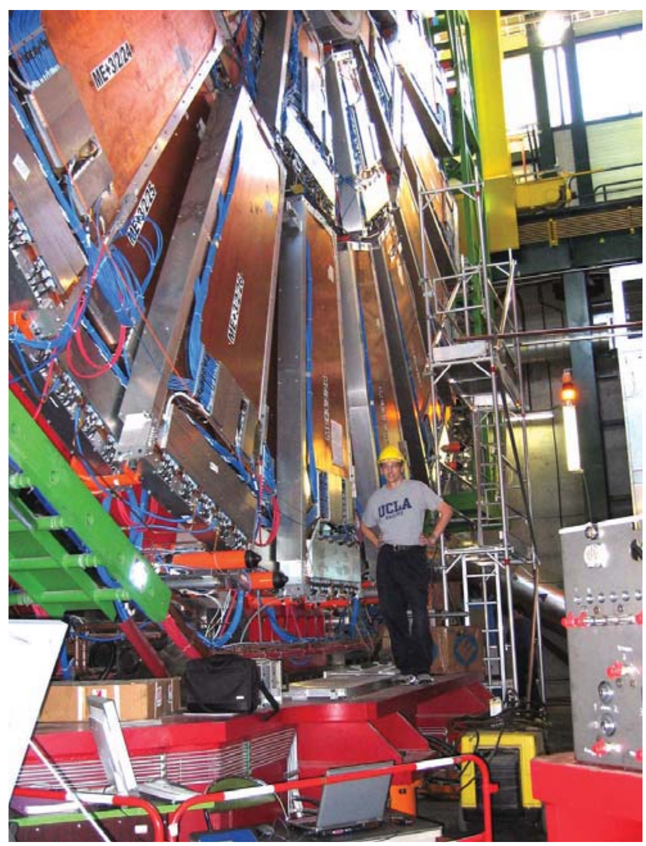
Charles Plager and David Saltzberg are using CDF's large dataset to look for rare decay channels for the top quark. These decays, called "flavor changing neutral currents," are highly suppressed in the current theory. However, anticipated extensions such as supersymmetry could enhance the rate of these decays by nine orders of magnitude. A positive signal would point the way to new particles and symmetries even before the LHC turns on.

The UCLA physicists working on CMS this year are **Katsushi Arisaka, David Cline,** Bob Cousins, Jay Hauser, and Rainer Wallny; six research physicists and postdoctoral researchers; two graduate students; and two electronics engineers. UCLA professors took various paths toward their work on CMS and joined it at various times, beginning with David Cline who helped initiate CMS in 1989. The group has taken on a broad range of commitments within a coherent focus on muon particle detection. Muons will be the key to much of the physics potential of CMS, whether it be the Higgs boson, supersymmetry, Zí bosons, top and bottom quark physics, or other new physics involving leptons.

During the past year much of this group has been at CERN, commissioning the muon detection system and preparing the associated electronics, software, and simulation in anticipation of the first colliding beams in 2008. They have also studied in detail several aspects of the discovery physics potential at the LHC.

During fall 2006, the parts of the CMS detector came together for the first time and took cosmic ray muon data while running with its massive 4.0 Tesla magnet. The muon system was a central part of that activity, involving postdoctoral researchers **Valerie Andreev, Misha Ignatenko, Greg Rakness,** and **Slava Valuev** in various ways. Graduate students **David Matlock** and **Jordan Tucker** improved the geometrical description of the detector in the simulation, and developed software tools that showed that we collected the cosmic ray muon particles efficiently.

After the cosmic ray test in late 2006, parts of the CMS detector have been lowered 100 meters underground



Jay Hauser stands in front of muon detector chambers that have been commissioned by the UCLA group. The complete detector contains 468 chambers. Hauser and his team have built major parts of the electronics used for selecting muon particles and measuring their trajectories.

and have been progressively outfitted with gas, high voltage, and readout cabling systems. Misha Ignatenko has been testing the chambers as they are outfitted, while Valeri Andreev has been responsible for operations of the high voltage and gas systems. Greg Rakness has been commissioning the muon selection and readout electronics, and Slava Valuev has been writing software that simulates the precise operation of the electronics.

In anticipation of possible discoveries to be made, **Jason Mumford and, Jordan Tucker** have been working with Slava Valuev to investigate a heavier type of Z boson particle known as the Z' through its decays to pairs of muons.

David Saltzberg's group (including gradate students **Stephen Hoover** and **Abby Goodhue** and postdoc **Amy Connolly**) successfully flew their ANITA payload in December 2006 - January 2007 which looked down at the Antarctic ice for ultra-high energy neutrino interactions. Shown here is the launch of the payload by NASA's Columbia Scientific Ballooning Facility near McMurdo Antarctica, a base run by the National Science Foundation. The payload spent a month at 120,000 feet collecting data. Results of the neutrino search should be made available later this year.

Stephen Hoover preparing the UCLA high-voltage pulser system and monitoring man-made radio interference.

Theoretical Elementary Particles

Even relativistic quantum field theories, such as Quantum ChromoDynamics (QCD), can be described by the Schrodinger equation, which is usually applied to non-relativistic systems such as the hydrogen atom. The advantage of the Schrodinger equation for many applications is that it reduces the dimensionality of the field theory from four (our usual three space plus one time) to three, making it possible to compare known three-dimensional calculations to what we need in four dimensions. **John Cornwall** has carried out part of this program and finds that certain three-dimensional results in QCD can be directly translated into four dimensions, with results in good agreement with what we observe in four dimensions. In particular, the three-dimensional calculation of a dynamical mass turns into a calculation of the coupling constant in four-dimensional QCD at low momentum transfer, whose value is inferred from various experiments. This work is published in Physical Review D.

Christian Fronsdal has started a new line of investigation; at least it is new to him. The plan is to study stellar-structures from a new perspective, insisting on a formulation of all the dynamics in terms of a variational principle, with a subsidiary aim of throwing some light on what can be understood as an astrophysical black hole. As it turns out, this is a radical departure from the standard approach. A preliminary investigation of polytropes has shown that, when better boundary conditions are applied to the problem, the white dwarfs are limited in mass; however, this is not because of stability considerations (Chandrasekhar) but because the dynamics limits the mass of static configurations, a change of interpretation with profound epistemological consequences. Another radical innovation is that the new theory has a conserved current, probably to be identified with baryon number. Fronsdal's work is aimed at including the electromagnetic field and the photon gas, always within a dynamical framework dominated by a variational principle. This line of investigation unavoidably leads to the need to develop other fields of physics, for example, the description of mixtures of charged gases.

Alex Kusenko, together with M. Lowenstein (NASA) and P. Biermann (Max Planck Inst., Bonn), are using Suzaku X-ray telescope to search for dark matter in the form of sterile neutrinos. The first observations already took place, and the data are being analyzed. The nature of dark matter remains unknown, but

artists rendering of Suzaku x-ray telescope there are astrophysical hints suggesting that it could be made up of sterile neutrinos. Indeed, the same particles could be emitted from a supernova with a large enough anisotropy to give the emerging neutron star a large "kick." This would explain the long-standing puzzle of why the pulsars have very large velocities.

Eric D'Hoker was elected Honorary Trustee of the Aspen Center for Physics in recognition for his work as President and Treasurer of the Center.

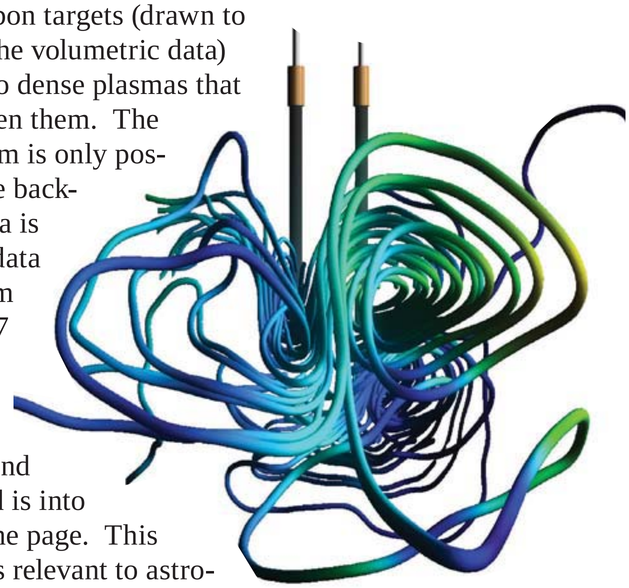
Eric D'Hoker and D.H. Phong (Mathematics, Columbia University) made a breakthrough in the understanding of the cohomology of chiral superstring amplitudes to two-loop order. They showed that the chiral amplitudes are given in terms of holomorphic blocks, and used this result to show the absence of unphysical singularities in superstring scattering amplitudes.

Eric D'Hoker, **Michael Gutperle** and graduate student **John Estes** developed new methods for obtaining solutions with 16 supersymmetries to the Type IIB supergravity field equations. They applied these methods and derived entire infinite families of exact solutions whose AdS/CFT duals are supersymmetric Yang-Mills theories either with a planar interface, or with a Wilson line inserted.

Plasma Physics

Walter Gekelman is the director of the Basic Plasma Science Facility, (BaPSF; www.plasma.physics.ucla.edu/bapsf) which is a national user facility. Plasma scientists and graduate students from institutions worldwide come to UCLA to do experiments on the Large Plasma Device (LAPD), a one-of-a kind research tool. In the past year, 28 plasma physicists, external to our local group have participated in research at UCLA. The local group consists of Walter Gekelman and **George Morales,** five research scientists (**James Maggs, Steve Vincena, David Leneman, Shreekrisna Tripathi,** and **Patrick Pribyl**), and three engineers/technicians (**Zoltan Lucky, Marvin Drandell** and **Mio Nakamoto**). The group currently has six graduate students (**Andrew Collette, Brett Jacobs, Alex Gigliotti, Chris Cooper, Eric Lawrence** and **Stephanie Stattel)**. The subjects studied by the UCLA group include: a) the interaction of dense colliding plasmas in a background magnetoplasma, b) the properties of Alfvén waves and their interaction with plasma structures and flows, c) the transport of heat across strong magnetic fields, d) the interaction of waves with hot electron rings, e) magnetic flux ropes, f) generation of solitary structures in turbulence, g) the measurement of ion distribution functions in a plasma processing tool, h) Alfvén wave masers, and i) rotating plasmas.

The data acquired in many of the experiments is fully three-dimensional. It is acquired at tens of thousands of spatial positions and thousands of time steps with resolution as small as 200 ps/step. The figure here shows the current system generated 400 ns after two laser beams strike the carbon targets (drawn to scale within the volumetric data) and create two dense plasmas that collide between them. The current system is only possible when the background plasma is present. The data is viewed from a position 2.47 meters from the plane of the targets. The background magnetic field is into the plane of the page. This experiment is relevant to astrophysical processes such as the collision of jets.



Troy Carter has continued work on nonlinear processes, turbulence and transport in magnetized plasmas. His work makes use of magnetic confinement fusion research facilities such as the DIII-D tokamak (General Atomics) and the National Spherical Torus Experiment (Princeton), and the Madison Symmetric Torus (U. Wisconsin) as well as the Basic Plasma Science Facility at UCLA. Graduate student **Brian Brugman** recently completed his thesis work on the first study of nonlinear interactions between Alfv´en waves in a laboratory plasma. Work on nonlinear properties of these important plasma waves is continued by graduate student **David Auerbach,** who is focusing on plasma heating and turbulence generated by counter-propagating wave interactions. Graduate student **Anne White**, working with **Tony Peebles, Lothar Schmitz** and Carter, has made measurements of electron temperature fluctuations in the core of the DIII-D tokamak. The measurements, made using a correlation electron cyclotron emission radiometer, show a suprising level of temperature fluctuations in low-confinement mode ("L-mode") plasmas and reveal a sharp drop in fluctuation amplitude associated with the transition to high-confinement mode (or "H-mode"). Anne White will present her findings in an invited talk at the upcoming APS Division of Plasma Physics meeting. Carter and Jim Maggs continue their work on suppression of turbulent transport by bias-driven rotation in the Large Plasma Device. Graduate student **Travis Yates,** working with **David Brower, Weixing Ding,** and Carter, is investigating magnetic fluctuations and turbulence driven by tearing modes in the MST reversed field pinch experiment at the University of Wisconsin. The measurements, made using far-infrared polarimetry, have revealed broadband magnetic fluctuations in this device, allowing for the possibility of studying the turbulent cascade of Alfvén waves in a high temperature laboratory plasma.

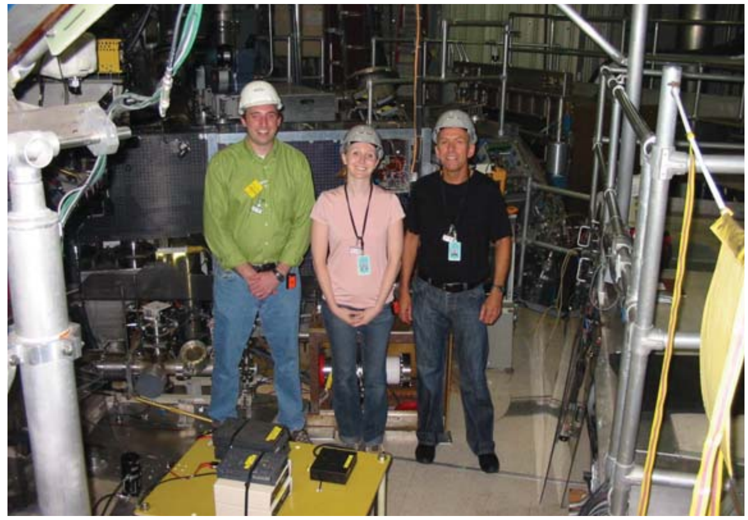
David LaFonteese completed a PhD dissertation under the supervision of **George Morales.** The research was performed in the Electric Tokamak (ET) device operated at UCLA under the direction of **Dr. Robert Taylor.** This novel investigation, both computational and experimental, explored a concept analogous to a medical MRI to diagnose the properties of a toroidally-confined thermonuclear fusion device.

The concept is based on the propagation properties of fast Alfvén waves through a plasma in which the magnetic field varies with position. The technical details have been published in *The Physics of Plasmas 14, 052510 (2007).*

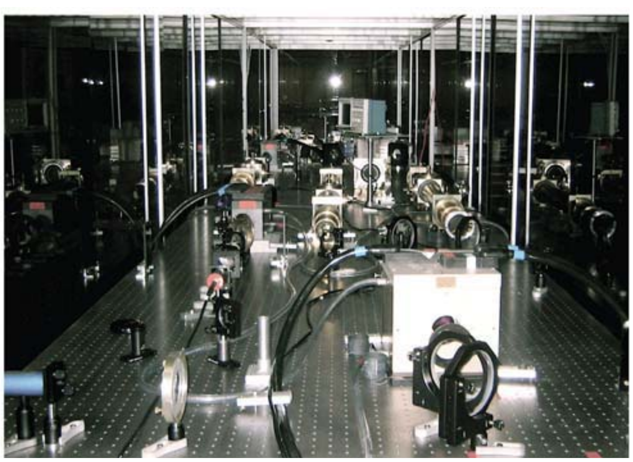
George Morales facilitated the linking of UCLA to the "Erasmus Mundus" project funded by the European Union. The purpose of this project is to train students in plasma fusion science in preparation for the manpower needs expected when the ITER project comes into operation in France in about ten years.

Walter Gekelman, George Morales and **James Maggs** have become partners with the University of Maryland, and also Stanford, in a MURI project that recently was funded for a period of five years. The research addresses fundamental physics issues on radiation belt dynamics and remediation.

Christoph Niemann and the high-energy density plasma physics (HEDP) group works jointly with the National Ignition Facility (NIF) at the Lawrence Livermore National Laboratory (LLNL) to study extreme states of matter relevant to laser fusion and laboratory astrophysics. NIF, the world's largest laser, is nearing completion at LLNL and will start target experiments early next year. The first ignition attempt is scheduled for 2010. The group is part of the ignition campaign and is actively involved in NIF diagnostics development and commissioning. In experiments on midscale laser facilities, development continues on high-brightness x-ray backlighters for NIF and has recently demonstrated record x-ray yields. The group has also been selected as one of three university groups to lead the first science experiments on NIF. Currently experiments to investigate energy transfer in overlapping NIF beams are being developed. A high-energy laser system with NIF-relevant laser intensities (>1014W/cm2) has been commissioned at UCLA. The laser can also be fired into the neighboring Large Plasma Device to drive astrophysical shock waves, such as those encountered in e.g. supernova explosions or coronal mass ejections. First experiments have demonstrated that the laser blow-off can drive large amplitude plasma waves that propagate at near Alfvénic velocities. These experiments could eventually help to shed some light on the origin of cosmic rays.



Troy Carter, Anne White, and Lothar Schmitz stand by the correlation electron cyclotron emission radiometer diagnostic on the DIII-D tokamak at General Atomics in San Diego, CA.



The new high-energy glass laser system at UCLA

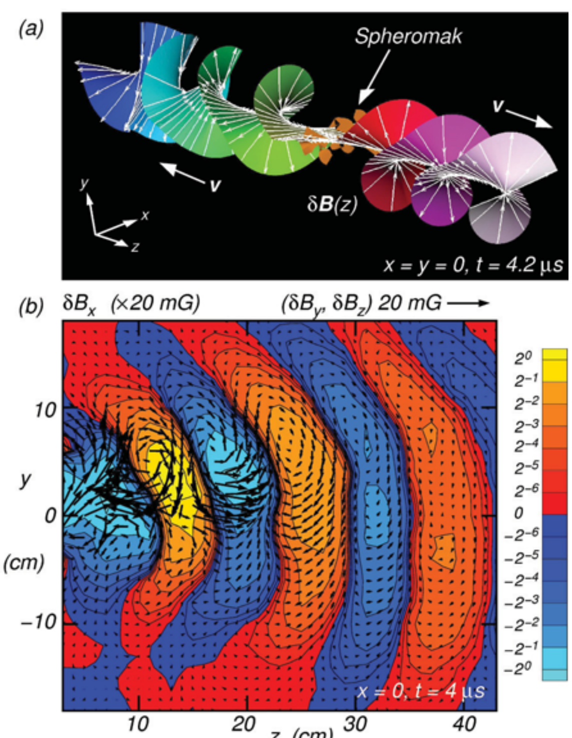
The Computer Simulations of Plasma Group under the leadership of **Warren B. Mori,** and Adjunct Professors **Viktor Decyk,** and **Phil Pritchett** continue to do pioneering work in high-performance computing of complex plasma phenomena. The group consists of four junior researchers and six PhD students. Its research remains focused on the use of fully parallelized particle based simulation models to study magnetically confined plasmas, 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 including OSIRIS, UPIC Framework, Recon3D, and QuickPIC.

Recent highlights include two of its recent graduates, **Chenkgun Huang** and **Wei Lu**, receiving best thesis awards. Chengkun Huang, received the prestigious 2007 Nicholas Metropolis Award. The citation reads, "For his innovative work in plasma physics that led to the development of the QuickPIC code that has revolutionized the simulation of plasma based accelerators." This is the best the-

Thomas Mason (Soft Condensed Matter) along with T. Cubaud, were awarded the 2007 Gallery of Fluid Motion Award (American Physical Society DFD).

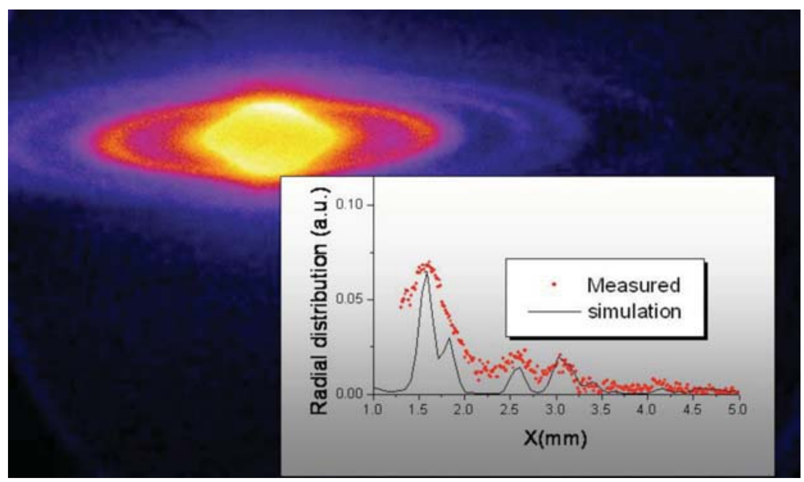
sis prize given by the Division of Computational Physics within the American Physical Society. A description of the code QuickPIC was published this past year [Huang et al., J. Comp. Phys. Vol. 217, pp. 278 (2006)]. Wei Lu received the 2007 John Dawson Thesis Prize. This is the best thesis award given in the area of plasma-based acceleration.It is given bi-annually at the Laser and Plasma Accelerators Workshop which is sponsored by the International Committee for Future Accelerators (ICFA). The title of his thesis was, "Nonlinear Plasma Wakefield Theory and Optimum Scaling for Laser Wakefield Acceleration in the Blowout Regime." Details of his scaling laws were published in Physical Review STAB [vol. 10, pp. 061301 (2007)]. Both are currently a post-doctoral researcher in the group. In one recent publication, Blumenfeld et al. [Nature vol. 445, pp. 741 2007], the group's code QuickPIC was used by a graduate student in the group, M. Zhou, to model a plasma wakefield experiment in which the energy of some electrons in the 42 GeV electron beam at the Stanford Linear Accelerator were doubled in less than 1 meter. Figures from the group's codes were used in a News Feature article in Nature titled, "The Plasma Revolution" *[Nature vol. 229 pp. 133 2007].*

Experimental research into the non-linear interaction between a very large magnetic perturbation and a plasma conducted by the plasma group of **Reiner Stenzel** and **Manuel Urrutia** continues to yield surprising results. They have found that, as the magnetic configuration imposed by a coil antenna switches from opposing to increasing the ambient field in a plasma column, a freely moving spheromak is launched. The spheromak is accompanied by strong electron heating which, in turn, produces an instability in the plasma that drives a linear wave at a frequency unrelated to the coil oscillation. The electron heating is not only in the bulk of the plasma (from 2 eV to 18 eV), but also includes the formation of energetic tails (>22 eV). This wave is, of course, also a whistler as demonstrated in (a),where its right-handed polarization is displayed through a hodograph-like display of the magnetic vector on axis, but its topology is very different from that of the wave packet induced by the coil. Examination of the topology reveals that the phase fronts resemble those of plane waves but, upon closer examination, indicate that the source current is a non-symmetric azimuthal current distribution, i.e., a lumpy current flowing in the θ-direction. To visualize this in a simple diagram, we display in a $y-z$ plane (b) contours of δB_x showing the wave phase fronts, as well as the projection of the vector field, (δB_y, δB_z), showing loops linked with δB_x.



Accelerator Beam Physics

The Pegasus Laboratory -- a small accelerator physics laboratory located in the sub-basement of Knudsen Hall--has been recently re-commissioned as an advanced photoinjector by **Pietro Musumeci** and coworkers. Boosted by the addition of a new state-of-the-art 35 fs laser system and equipped with very fine resolution temporal diagnostics, the laboratory aims at the production of ultra-short (sub-100 fs) relativistic electron bunches. The main goal of this research is to create beams suitable for relativistic electron diffraction. At relativistic energies the beam space charge forces are strongly reduced allowing the possibility of packing 10-100 millions electrons in a 100 fs long bunch (a 3-4 order of magnitude increase in electron number compared with what is possible using non-relativistic electron sources in conventional electron diffraction set-ups). Because the probe beam is so fast and so intense, one can use a synchronized pump laser beam to excite an ultrafast process (even an irreversible one, like a melting phase transformation) and with this technique observe the evolution in time of the crystal structure at unprecedented time scales.



Electron diffraction rings recorded using the 100 fs long (rms) beam out of the Pegasus photoinjector after scattering off a 200 nm thick Al target.

New Faculty

Yaroslav Tserkovnyak's, area of research, broadly defined, is mesoscopic physics, with a special focus on spintronics. Spintronics (a neologism for "spin-based electronics") is an emergent technology that exploits the spin state of the electrons rather than their charge state. What sets this new faculty member apart from any researchers in this device motivated area is his deep understanding, interest, and application of fundamental physics.

He completed his secondary education at Ukrainian Physics and Mathematics Lyceum in Kyiv in 1996. Yaroslav later enrolled in full-time university programs at National Bogomolets Medical University, General Medicine Faculty and National Shevchenko University, Physics Faculty, in Kyiv. Transferring to the University of British Columbia, Physics Department, Vancouver, Canada, he completed the BSc program in 1999. Further studies continued at Harvard University in Cambridge, Massachusetts where he was awarded his AM (2001) and PhD (2003) in physics.

Petro Musumeci Pietro Musumeci recently joined our faculty as an expert in beam physics, photoinjectors, radiation from particle beams, next generation light sources, ultra-fast laser techniques and advance accelerators.

Currently, he is the SPARC photoinjector commissioning coordinator, PLASMON-X and seeding at SPARC experiments study and design. In addition to his quite Herculean task as SPARC commission head, he has proved be a natural teacher and has developed other interests.

He won the Award "Enrico Persico" Academic Nazionale dei Lincei at age 21. He was graduated in 1998 from Laurea in Fisica cum Laude from the University of Rome "La Sapienza." He received his Master of Science in Physics at UCLA in 1999. He worked as a Teaching Assistant @ USPAS Particle Accelerator School in 2002. His PhD studies at UCLA commenced in 1999 and were completed in 2004. His post-doc studies were at INFN sez. Roma in 2004-2005 while teaching classes at the Physics Department of University of Rome "La Sapienza."

Faculty Retirements

Eric Becklin received his PhD from CalTech in 1968. He was next appointed Astronomer for the Institute for Astronomy, University of Hawaii in 1977. He became Director, NASA Infrared Telescope Facility in 1977. In 1985, he spent time as a Guggenheim Fellow, at the Royal Observatory in Edinburgh, Scotland. He joined the department in 1989, and in1997 went on to SOFIA where he, even though retired, continues as Chief Scientist and Director Designate. His major current efforts are the study of brown dwarfs(the missing link between stars and planets); the detection of dust rings around stars that are related to planet formations; the dynamics and composition of the center of our galaxy; and the nature of luminous infrared galaxies. He has been Professor Emeritus at UCLA since 2005.

Peter E. Schlein received his PhD at Northwestern University and pursued his postdoctoral studies at the University of Chicago, Johns Hopkins University and at UCLA. He joined UCLA in 1962 as an Assistant Professor, advancing to Professor in 1968. He is an experimental high energy physicist. His research is in areas widely regarded as constituting the frontier of our knowledge of the ultimate structure of matter and energy. Peter has persistently and successfully swam against the tide in his area of research, leading experimental efforts that employ only a few scientists. External referees opined that he is among the best and most celebrated member of his profession.

FACULTY 2006-2007

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Maha Ashour-Abdalla
Zvi Bern
Stuart Brown –
Vice Chair of Resources
Robijn Bruinsma
Charles Buchanan –
Vice Chair of Academic Affairs
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Steven Cowley
Eric D'Hoker
Sergio Ferrara
Christian Fronsdal
Walter Gekelman
Graciela Gelmini
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Kàroly Holczer
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Hong-Wen Jiang
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Assistant Professor

Dolores Bozovic
Troy Carter
Michael Gutperle
Jianwei Miao
Pietro Musumeci
Christoph Niemann
B. Chris Regan
Yaroslav Tserkovnyak
Vladimir Vassiliev
Rainer Wallny

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Nina Byers
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Mirek Plavec
William E. Slater
Alfred Wong
Chun Wa Wong
Eugene Wong
Byron T. Wright
Benjamin Zuckerman

Researcher

Viktor Decyk
Samim Erhan
Jean Noel Le Boeuf – *retired* 06/07
Anthony Lin
James Maggs
Neil Morley
William Peebles
Philip Pritchett
R. Michael Rich
Steven Trentalange
J. Manuel Urrutia
Mahmoud Youssef

Associate Researcher

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

Assisstant Researcher

Shahrira Abachi
Luca Bertello
Carmen Constantin
Yasuo Fukui
Sarah Gallagher
Pierre Gourdain
Mikhail Ignatenko
Alexey Iskakov
David Leneman
Nandini Mukherjee
Sven Reiche
Glenn Rosenthal
Shoko Sakai
Alexsandr Starostin
John Tonge
Frank Tsung
Tripathi Shreekrishna
Jeffrey Zweerink

EDUCATION & HIGHLIGHTS

"If a man

neglects education,

he walks lame to the

end of his life.". . .

Plato

REU (Research Experience for Undergraduates) 2007

Francoise Queval, Academic coordinator with the 2007 REU students

Summer 2007 saw the 5th annual Research Experience for Undergraduates (REU program) in the Department of Physics and Astronomy. Thirteen students came from across the country to engage in real frontier level research with a UCLA faculty member for a period of 10 weeks. Each of the participants was matched with a faculty mentor according to the student's stated interests. The projects spanned the various fields represented in the department, such as plasma physics, condensed matter physics, cosmic ray physics, high energy physics, astrophysics, and biophysics. The program includes other academic and social activities, all in an effort to maximize the research experience and the amount of learning, as well as create a sense of community for the students. Overall, the objective of the REU program is to immerse and acquaint students with the totality of the research experience and have them participate in cutting-edge science in order to incite them to undertake graduate studies in physics or a related science field. This program is UCLA's way of playing an important role on the national scene by recruiting bright young minds to pursue science careers. This is critical since the educational institutions in the United States do not meet the country's demand for scientists and/or engineers.

Outreach...

Every year hundreds of elementary and middle school girls look forward to attending the **Sally Ride Science Festival.** Founded by Dr. Sally Ride, most notably known as the first female astronaut to enter space, this festival aims to promote science to young girls and inspire them to pursue their interests. Everyone can look forward to a fun-filled day with workshops, food and music. However, perhaps the best part of the festival is the participation of science clubs from universities all throughout Southern California. Last year the Biotech Society of UCLA participated in this festival on March 24, 2007. Donald Chang (biophysics), Jose Rodriguez, and Xochitl Williams - Garcia went to Caltech. They were going to teach these students how a microscope worked. Using foil, water, and Willy Wonka Nerds candy, they demonstrated how an image could be magnified from the curvature of the water in the foil. "Now put a drop of water in the hole you just punched in the foil…what do you see?" says Rodriguez to the students. The young students exclaim "It looks bigger!" "You've just made your own miniature microscope!" cheers Rodriguez. The Biotech Society booth stayed busy all day with young people learning how a microscope functions. This year the Sally Ride Science Festival will take place at Cal State LA on October 13, 2007, and the Biotech Society will once again help promote science to young students.

As in previous years, the UCLA Plasma Science and Technology Institute has sponsored participation in several outreach events. Dr. J. Manuel Urrutia has again coordinated UCLA's presence in the annual **Chavez Memorial March-Celebra la Ciencia Fair** (March 25, 2007**).** Charles Whitten and Reiner Stenzel and research faculty Phillip Prittchet joined graduate students Humberto Torreblanca and Jay Fahlen to man the booth. As always, the hands-on approach is an excellent way to illustrate to children and their parents the wonders of physics. A partnership with UCLA's **Early Academic Outreach Program (EAOP)** led to a very successful presentation on September 26, 2007, to more than 80 students from Sun Valley Middle School and their parents. The presentation was part of a program facilitated by Families In Schools, a non-profit dedicated to increasing the participation of parents in the education of their children. According to them, 82% of the parents who attended our presentation "strongly agreed" that the presentation had been "interesting and informational." Due to this high level of interest, EAOP is committed to increasing the department's involvement in these type of activities.

F I N K E L S T E I N   S Y M P O S I U M

The Department of Physics and Astronomy presented a symposium on May 2, 2007, to honor Robert Finkelstein's 90th birthday (April 14, 2006) and to also celebrate his many contributions to physics and the important role he has played in the department.

The afternoon opened with Ernest Abers, introducing Dean Joseph Runick. Joe's heartfelt remarks were followed by Robert Pecci, Vice-Chancellor of Research and Ferdinand Coroniti, Chair of Physics and Astronomy, who added their paeans to our honoree.

The formal program followed with UCLA's Christian Fronsdale's paper on "Black Holes and Models of Real Stars," Mal Ruderman (Columbia University) addressed "Neutron stars, Inside and Outside," Alberto Sirlin (New York University) spoke about "Estimates of the Higgs Boson Mass in the Standard Model and Other Important Applications of Electroweak Corrections," and Jan Smith (Amsterdam) closed the afternoon discussing "The anomaly and the Lattice." The Symposium was not only successful in academic achievement, but equally gratifying in the generous show of appreciation by all who enthusiastically participated in this fitting tribute to one of sciences most beloved and accomplished physicist, Robert Finkelstein.

Robert Finkelstein and friends

F e l l o w s h i p s . . .

GAANN Fellowship Recipients

The Department of Education grant proposal for Graduate Assistance in Areas of National Need (GAANN) fellowship has been awarded to ten incoming students. The recipients for the academic year 2007-08 are:

Daniel Aharoni, Brandon Buckley, Tristan Dennen, Brett Friedman, John Koulakis, Adam Kullberg, Josh Moody, Brendan O'shea, Derek Schaeffer, Scott Sullivan. Selection criteria for this fellowship is competitive and based on financial-need and academic ranking. Recipients of this fellowship are encouraged to seek out research opportunities earlier in the PhD program and are 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 PhD candidates during their final year of graduate school, providing support which 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: Erika Artukovic, Anne White, Shelley Wright

W. Gilbert Clark provided technical guidance to Debra Strick, graduate student in the Biomedical Engineering Interdepartmental Program on her project "Intracranial Microcoil for Magnetic Resonance Imaging." His activity was to show her how to design and construct small radio frequency NMR coils for insertion into the human brain for imaging very small, specific regions.

Sergio Ferrara recipient 2006 Dannie Heineman Prize for Mathematical Physics

"For constructing supergravity, the first supersymmetric extension of Einstein's theory of general relativity, and for their central role in its subsequent development."

Sergio was born in Rome, Italy, on May 2, 1945; he graduated from the University of Rome in 1968. Since then he has worked as a CNEN and INFN researcher at the Frascati National Laboratories; as a CNRS Visiting Scientist at the Laboratoire de Physique Theorique, Ecole Normale Superieure, Paris, and at the Theoretical Studies Division at CERN, Geneva. In 1980 he was made a full professor of theoretical physics in Italy. He became a staff member of the Theory Division at CERN in 1981 and a Professor of Physics at the University of California, Los Angeles, in 1985. Since 1986 he has been a senior staff member of the Physics Department at CERN.

Sergio Ferrara

GRADUATES 2006-2007

B.S. Astrophysics

Samuel Barber
Margarita Cecena
Jerome Fang, *Charles Geoffrey Hilton* Award
David Giordani
Jennifer Goodman
Richard Hart
Lauren Holzbauer
Megan Mugerditchian
Kanury Kanishka Rao
Christopher Rodriguez
Chalence Safranek-Shrader
Matthew Sanchez
Daniel Sugano
Tim Kham Tran
Bade Uzgil

B.S. Physics

Thien Quang Chu
Jose Contreras
Christian Contreras-Campana
Emmanuel Contreras-Campana
James Cozzens
Megan Ellis
Miguel Estrada
Antonio Fierro
Gregory Foster
Jennifer Gallegos
Martin Griswold, *E.Lee Kinsey Senior Award*
Kourosh Ghaderi
Akane Hashimoto
Hsin-Cheng Hsiao
Leonard Charles Jarrott
Kyle Jewhurst
Rina Kakimi
Arjun Khosa
Onnie Luk
Emin Menachekanian
Eric Mlinar
Nejdeh Nersessian
Samuel Patera
Alfonse Pham
Galen Reed
Marcos Ruelas
Cyrus Rustomji
Adam Secousse
Christopher Smith
Anton Stepanov
Anthony Tylenda
Sonny Vo
Davy Xu
Timothy Yang
Kosuke Yasui
Yu-Chen Yen
Guanhua Zhou

B.A. Physics

Physics BA
Kristine Baghdasaryan
Eric Dan
Jason Hsing-Chieh Yin

B.S. Biophysics

Amirbekian, Bagrat
Kevin Dagostino
Ardalan Davarifar
Tobias Falzone
Shilpi Ghosh
Michael Piccione
Tharani Prasad
Jose Rodriguez
Quy Tran

DOCTORAL DEGREES AWARDED

Astronomy
Erin Hicks
Matthew Barczys
Seth Hornstein

Astrophysics
Peter Plavchan

Biophysics
Jeungphill Hanne
Fan Zhang
Yan Zeng

Experimental Plazma Physics
Nathaniel Hicks
Brian Brugman

Experimental Condensed Matter
Jun Shinagawa

High Energy Experiment
Alon Attal
Brian Mohr *(AY05-06 Dissertation Year Fellowship Recipient)*

Nuclear Experiment
Jason Brudvik

Theoretical Elementary Physics
Adrian Soldatenko
Jason Schissel

Theoretical Plasma Physics
David LaFonteese

Theoretical Condensed Matter Physics
David Hecht
Makan Mohageg
Gavin Scott
Liangbing Hu

Abelmann-Rudnick Scholars 2007-08

Maryam Khatonabadi
&
Michael Winters

UCLA Physics and Astronomy Department
2005 - 2006
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For more information on the Department see our website:
<http://home.physics.ucla.edu>

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