



UCLA

Department of Physics & Astronomy

Accelerating a Scientific Revolution: The
Birth of the X-ray Free-Electron Laser
—*A journey from the high energy frontier to
ultra-fast x-rays, and back again*
...page 2

annual report 2009-2010

UCLA Physics and Astronomy Department
2009-2010
Chair
James Rosenzweig

Chief Administrative Officer
Will Spencer

Editor
Mary Jo Robertson

Feature Article
James Rosenzweig

Copy Editor Feature Article
Barbara Pawley

Contributing Editors
*Francoise Queval, Jenny Lee, Corinna Koehnenkamp, Diana Thatcher
and Teresa Laughlin (Donors)*

Design
Mary Jo Robertson

© 2010 by the Regents of the University of California

Requests for additional copies of the publication
UCLA Department of Physics and Astronomy
2009-2010 Annual Report may be sent to:

Office of the Chair
UCLA Department of Physics and Astronomy
430 Portola Plaza
Box 951547
Los Angeles California 90095-1547

For more information on the Department see our website:
<<http://home.physics.ucla.edu>>

Cover: The world's first hard X-ray free-electron laser started operation with a bang. First experiments at SLAC National Accelerator Laboratory's Linac Coherent Light Source stripped electrons one by one from neon atoms and nitrogen molecules, in some cases removing only the innermost electrons to create "hollow atoms." Understanding how the machine's ultra-bright X-ray pulses interact with matter will be critical for making clear, atomic-scale images of biological molecules and movies of chemical processes. (Artwork by Gregory Stewart, SLAC.)

Department of
Physics & Astronomy

*2009-2010
annual report*

Message from the Chair:

It is my honor and pleasure as Chair to present to you, the reader, the 2009-10 Annual Report of the Dept. of Physics and Astronomy. This document is an opportunity for the department to publically reflect on the progress of the past year, and to give, through the high points of our research and teaching a sense of the excitement that our program at UCLA offers. Despite some challenges associated with the state's financial difficulties, 2009-10 was a memorable year. As I was not Chair until the transition to 2010-11 commenced, I note that the excellent results of last year's academic campaign are strongly owed, as in many preceding years, to the efforts of the preceding Chair, Ferd Coroniti, who served as Chair in numerous stints for 14 years. Ferd selfless service to the department and to UCLA as a whole is greatly appreciated.

This year, as a feature article, we present a compelling story from the research group I call home, entitled "Accelerating a Scientific Revolution: The Birth of the X-ray Free-Electron Laser — A journey from the high energy frontier to ultra-fast x-rays, and back again". It recounts the story of how the UCLA effort in trying to re-invent the accelerator to address the needs of future high energy physics experiments, was central in giving birth to the brain-child of our own Prof. Claudio Pellegrini, the X-ray Free-Electron Laser (FEL). The X-ray FEL has gone, with Claudio's persistent intellectual leadership, from a theoretical vision to a reality in less than twenty years, and is now in the process of revolutionizing experimental methods from chemistry and biology, to condensed matter and high energy density physics.

As is customary, in this report we present a snapshot of the impressive variety of recent research undertaken by departmental faculty. There is much to appreciate in this area, and I highlight only a few areas here to illustrate the breadth of what you can find in UCLA physics and astronomy research.

In the astronomy division, UCLA research is enabled by unique tools, such as the Keck Telescope, which is essential to investigations of the galactic center and beyond. A novel pair of eyes at the Keck were provided by the internationally recognized UCLA Infrared Lab, which supplies state-of-the-art detectors such as NIRSPEC, as well as for many other large projects. The compelling story of the IR Lab's first twenty years is recounted in this report. The department added to the faculty the latest in infrared experts in the person of Michael Fitzgerald this year, preparing for the next generation beyond the Keck, the ambitious Thirty Meter Telescope. UCLA will be prepared to see deep into the cosmos for years to come.

On the physics side, UCLA embraces research challenges from "big science", such as experimental particle physics, to the complexity frontier of biophysics. In particle physics, UCLA has been a leading player in the large CMS detector at the Large Hadron Collider since the inception of that vast collaboration. With the experiment in full swing, the physics awaits results that promise discoveries, such as the first glimpse of the Higgs boson — helping to explain the mystery of a particle's masses — and beyond, towards supersymmetry. This showcase experiment is connected to other thriving efforts in the department, such as our first-rate elementary particle theory group, as well as the complementary approach to fundamental particles found in astroparticle physics.

In biophysics, we find the search for physics style simplicity and clarity in a biological context. Here the theme of ultra-fast imaging enters again, with John Miao exploiting the femtosecond X-ray FEL pulses to enable "lensless imaging" of nanosystems. On the functional level, recent faculty arrival Mayank Mehta has been employing fast imaging techniques developed with colleague Katsushi Arisaka (whose background starts in high energy physics) to go beyond the present boundaries of knowledge in the physics of neuroscience.

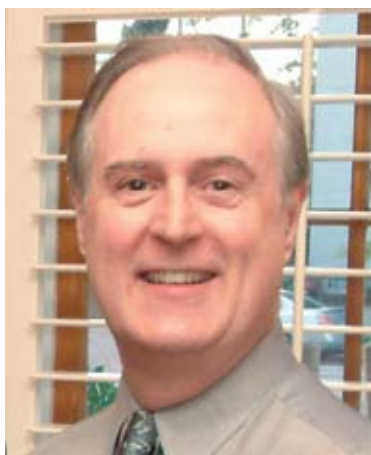
Departmental research occupies a wide scientific landscape, indeed. In addition to areas mentioned above, strong programs are proceeding in experimental hard and soft condensed matter, a new initiative in atomic-molecular-optical physics, and plasma physics. The synergy between diverse areas, already noted extends beyond departmental boundaries, with collaborations between our faculty and chemists, biologists and engineers encouraged by the UCLA California Nanosystems Institute. There are also burgeoning joint investigations between Department members and their counterparts in the world-class medical school at UCLA.

The dedicated efforts by the faculty, research staff and academic staff here are ultimately aimed at educating students, from undergraduates who are increasingly involved in research, to the high quality graduate students who are the true engine of research in the department. This report provides an update on the best of this new generation of scientists, who are the true measure of our success. In recognition of our unique blend of research areas, as well first-rate students and faculty, the recent National Research Council rankings have indicated in their new rubric that our graduate program ranks as high as 8th in the nation.

This brief welcome offers an introduction and orientation to the academic community that is our department. This community obviously extends to the alumni and valued benefactors, whose generosity is also spotlighted in this report. Whether you are interested in the UCLA Department of Physics and Astronomy as a potential colleague, student, or benefactor, or are simply curious about our educational and research activities, I invite you to explore this Annual Report, as well as the more detailed resources to be found on our website.



James (Jamie) Rosenzweig, Chair



Ian McLean, Vice Chair Astronomy

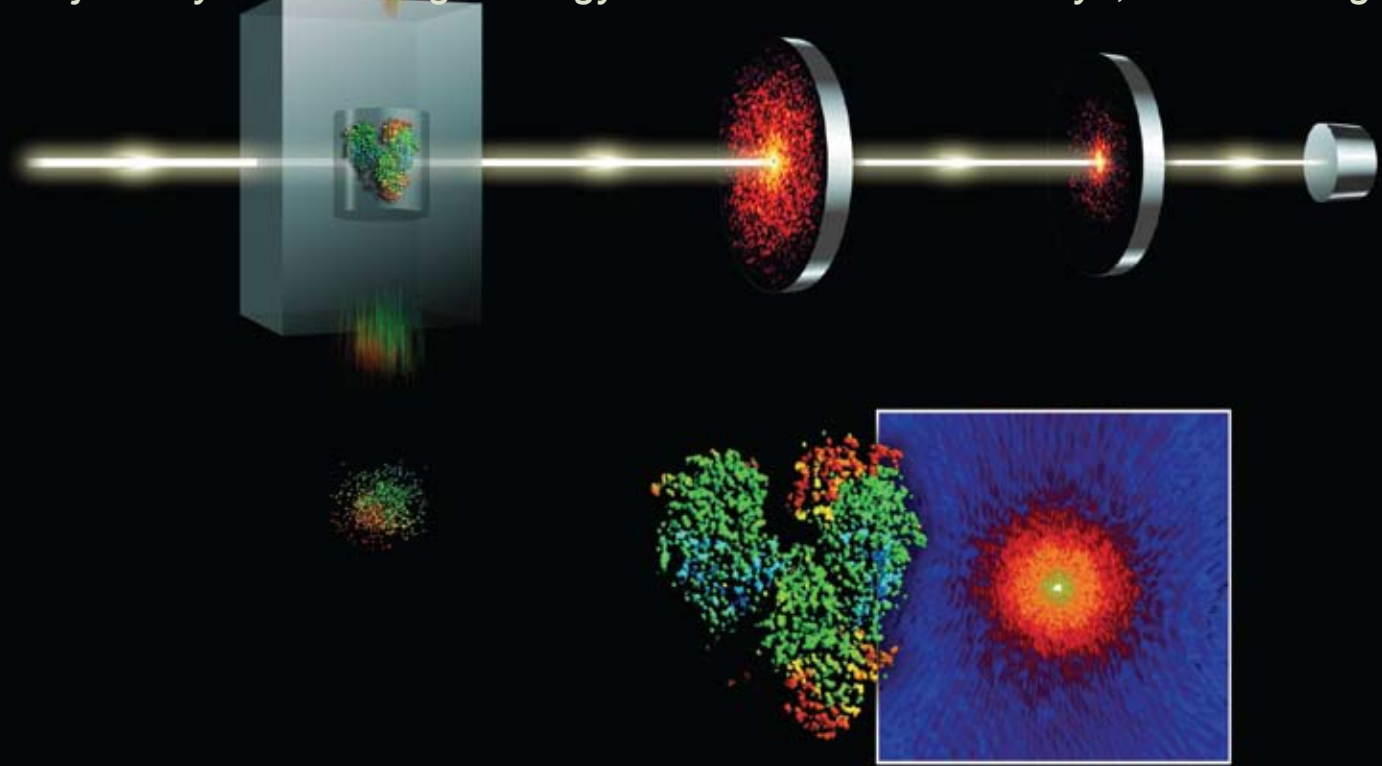
A handwritten signature in blue ink, appearing to be "J. P.", located at the bottom right of the page.

Contents:

| | |
|--|----|
| Feature Article: Accelerating a Scientific Revolution: The Birth of the X-ray Free-Electron Laser — <i>A journey from the high energy frontier to ultra-fast x-rays, and back again</i> | 2 |
| Donors: 2009-2010 | 8 |
| Highlighting our donors | 10 |
| 20th Anniversary of the Infrared Lab..... | 13 |
| Research Highlights - Astronomy & Astrophysics | 14 |
| Research Highlights - Physics | 20 |
| Faculty..... | 31 |
| Department News | 32 |
| Outreach - Education News | 34 |
| Graduation 2010 | 36 |

Accelerating a Scientific Revolution: The Birth of the X-ray Free-Electron Laser

—A journey from the high energy frontier to ultra-fast x-rays, and back again



Accelerators and the charged particle beams they produce have been central to scientific progress for nearly a century. Most importantly, they have opened the door to exploration of the high energy frontier. By colliding accelerated particles that travel near light speed, new generations of particles have been created and their most fundamental interactions—those governing natural phenomena at unbelievably short length scales—studied.

For many years, the energy of these scientific tools increased exponentially as new generations of machines and new ways of accelerating were introduced. The highest particle energy created in a laboratory stood at around 1 million electron volts (1 MeV) in the 1930s as a result of the first experimental forays inside the atomic nucleus. By the 1980s, that had grown to nearly 1 trillion electron volts—large enough to find the most elusive and heaviest of the tiny, sub-nuclear particles known as quarks.

Trouble was brewing, however. The circular “atom-smashers”, based on machines termed synchrotrons, were growing too large and expensive. The latest, the Large Hadron Collider (LHC) at CERN in Switzerland, is over 27 km around and cost billions of dollars to construct. Beyond cost and size, the synchrotron can no longer accelerate electrons to needed energies. Its strong bending magnets, which keep the particles going in a circle, provoke too much electromagnetic synchrotron radiation. For the precision high-energy experiments enabled by electrons, the accelerators should be linear, not circular.

Thus a revolution was needed, in which Claudio Pellegrini was a willing founder. He had been mulling over an idea since his student days at the University of Rome, circa 1958. The opportunity to further this and other research came when he was recruited to UCLA in 1989 from the Brookhaven National Laboratory. At UCLA, he established the UCLA Particle Beam Physics Laboratory (PBPL) with a single compelling goal: reinvent the methods to accelerate charged particles to high energy using novel techniques based on high-powered lasers, electron beams, and ionized gases—or plasmas.

What is the UCLA Particle Beam Physics Laboratory (PBPL)? *The PBPL is a multifaceted research collaboration encompassing all of the UCLA research activities into FEL. The effort comprises two laboratories as well as experiments at SLAC and other national FEL facilities.*

In 1991, Claudio formed a partnership with James Rosenzweig who was recruited to UCLA from the Argonne National Laboratory. Jamie was pioneering experiments in plasma based acceleration, aided by a Robert R. Wilson Fellow in Accelerator Physics at Fermilab. With this partnership, a program that could “push” the state-of-the-art in beam physics was born.

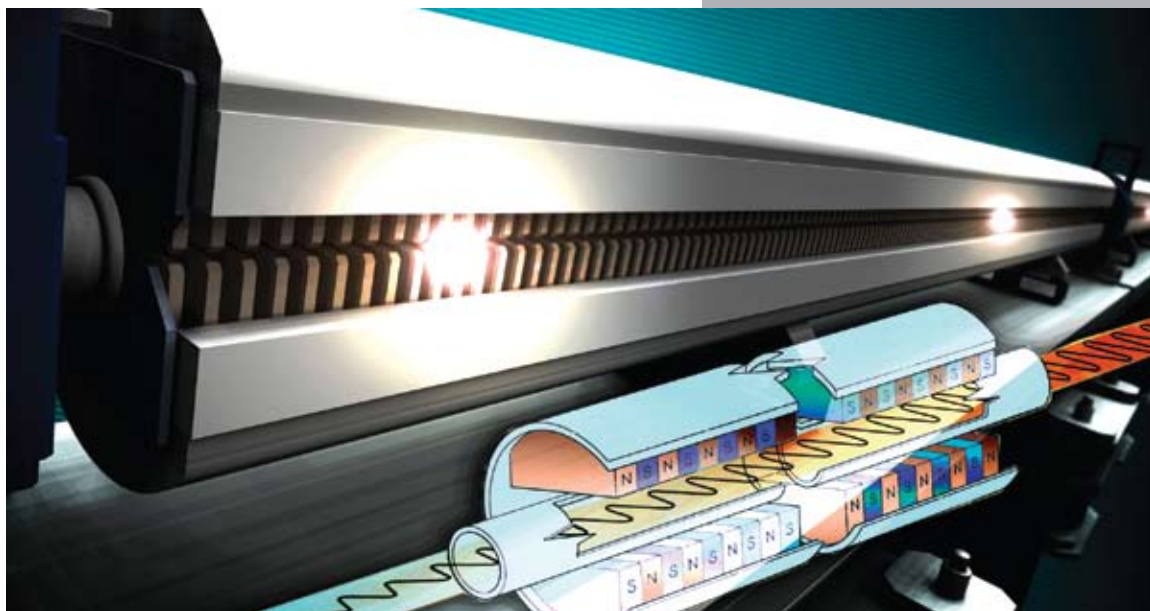
By its nature, this “push” required extreme beams (physicists use the term high brightness) of electron pulses with high density and low temperature that appear and disappear in a flash—less than a trillionth of second, or 1 picosecond. Without these qualities, colliding beams do not produce enough collisions for particle-creation experiments. These qualities also allow the beam to produce a plethora of collective effects more typical of plasmas—some desirable, some problematic, but all interesting. In particular Claudio was intensely interested in the possibility of a free-electron laser, or FEL, to create a revolutionary type of intense x-ray source.

How the X-ray FEL Works

In the FEL mechanism diagrammed here, a high brightness electron beam is repetitively deflected by alternating polarity magnets, called undulators, to make a snakelike (sinusoidal) trajectory. This periodic bending provokes spontaneous synchrotron radiation that interferes with itself to preferentially radiate one particular wavelength. As this resonant wavelength depends on the speed of the electrons relative to that of light, the wavelength produced is strongly affected by the electron energy, scaling as its inverse square. Thus, by raising the energy of the accelerator feeding the FEL, one can shorten the wavelength. Above electron energy of 1 GeV or so, this wavelength enters the X-ray spectral region.

To create a high-powered laser from the spontaneous undulator radiation, one must include a final effect, that of the radiated light wave on the beam. When the electrons experience the electric field of the wave, the energy is periodically modulated along the beam length, an effect that ultimately causes the electrons to clump into a train, called microbunches. In turn, this

clumping stimulates coherent radiation emission, which closes a feedback loop, and the radiation is increasingly enhanced as the beam propagates along the undulator. The end result of this exponentially growing disturbance is a coherent pulse of radiation that has peak power more than a million times that of the spontaneous emission.



Why x-ray light sources? *We cannot see systems built at the atomic and molecular level with optical light because the wavelengths (~ 500 nanometer, or 500 billionths of a meter) are too large. Even a large molecule, such as a protein, is simply not visible. But x-rays have wavelengths below a nanometer, to the \AA (10^{-10} m) scale, giving the enticing possibility of “seeing” atomic and molecular structures.*

After two decades of research into synchrotron light sources, physicists became dissatisfied with their limits. It was not enough to see objects with intense x-rays. They wanted to see atoms and molecules in action. In order to freeze motion on a time scale faster than typical atomic motion, the x-ray pulse should be less than 0.1 picosecond (100 femtoseconds). It turns out that optical lasers can accomplish this task. Further, lasers are coherent, i.e., all the photons (light quanta) have nearly the same wavelength and a fixed phase relationship with each other. With coherence, much more imaging information is available. One simply needs to look at holograms to understand this; the images appear to have three-dimensions. With incoherent x-rays from light sources, the images are restricted to two-dimensional shadows. However, lasers do not naturally produce the short wavelengths that are required to see atoms and molecules at the speed with which they actually move. What was needed was something that produced the characteristics of both x-rays and lasers.

The idea of a sub-picosecond pulsed x-ray laser became an elusive goal for physicists, and most turned to other avenues of research, except for Claudio. He believed that the FEL might do the trick and for two decades stubbornly worked toward this outcome.

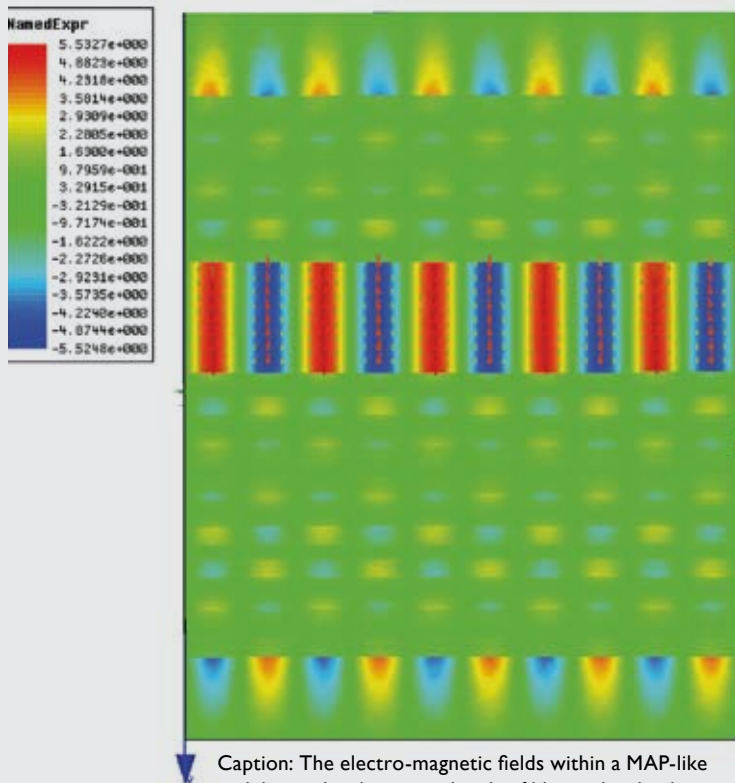
Free-electron laser on a chip?

For years it has been known that dielectric materials can support electric fields far higher than metals, before breakdown occurs. It has long been thought that it might be possible to overcoming the limitations in field gradient (energy gained by particle beam per unit length of accelerator) by moving from the commonly used microwave-powered metallic-structures to short-wavelength powered dielectric-structures.

For the past decade, an effort at the PBPL has worked to create a laser-driven, all-dielectric-structure. As conceived, the device

looks like a sandwich of dielectric materials with a narrow vacuum gap between the upper and lower halves. These slabs form the reflective boundaries of an optical resonator, with periodic coupling “slots” enabling power to enter the resonator transversely, and enforce a field profile with a strong longitudinal (accelerating) electric field. This structure offers a number of advantages including fabrication simplicity. Over the past few years, Dr. Gil Travish and his colleague Prof. Yoder (Manhattanville) have strongly pushed development of this Micro Accelerator Platform (MAP). The device will be powered by a laser, and is produced using nano-fabrication techniques familiar from microchip technology. The device affords energy gradients of ~ 1 GeV/m, allowing for relativistic beams to be produced within millimeters, and FEL-class beams within centimeters.

When fully realized, the MAP will enable production of relativistic particle beams on a micro-chip like device. Chief among the applications of such a compact source, the dream of a FEL smaller than a bread-box size stands out. Indeed recent efforts at PBPL have shown that it may be possible to produce the undulator on a chip-like device as well. This electro-magnetic undulator can be produced with “Goldilocks” periods in the 10’s of microns (just right, between the too-short period of the laser, and the too-long period of magneto-static devices). Such a 5th generation light source would allow for soft x-ray production with modest beam energies, time structures at the attosecond scale.



Caption: The electro-magnetic fields within a MAP-like undulator: the alternating bands of blue and red indicate the strong deflecting fields analogous to the “north” and “south” poles of magnets in a conventional undulator.

with



Undulator magnet constructed by UCLA and the Kurchatov Institute (Moscow), used in the first proof-of-principle of the SASE free-electron laser at the UCLA Saturnus Lab.

Self-amplified spontaneous emission (SASE) joins the effort

In the early 1990s, Claudio proposed an effect known as the self-amplified spontaneous emission (SASE) FEL to create an x-ray laser. He envisioned doing this with an existing 14 GeV linear accelerator, borrowed (as is typical of this story) from a fading high energy physics experiment at the Stanford Linear Accelerator Center (SLAC). At the time, this proposal was incredibly audacious as the SASE FEL principle was not at all proven. In recognition of his vision of the path to the x-ray FEL, along with his leading role in developing the theory of the SASE FEL, Claudio was awarded the 1999 International FEL Prize. With this vote of confidence, the stakes well understood, and the physics mission defined, Claudio and Jamie set about obtaining experimental proof of SASE FEL theory.

Experimental proof of the SASE FEL theory takes shape

The first step toward experimental proof for the SASE FEL was the construction of a new lab called Saturnus in the UCLA physics department. This effort was spearheaded by graduate student Gil Travish (now a senior research scientist in the department and a senior member of the team) working in beam physics, radiation production and accelerator technology.

To further the SASE FEL theory, a compact, high field undulator was specially designed and built in Moscow at the Kurchatov Institute. In 1998, after some years of intensive work to develop expertise in high brightness electron beam sources, the Saturnus team published the first evidence of high gain

Advanced Accelerators at UCLA

UCLA has a world-rekowned program in advanced acceleration techniques, with notable efforts in PBPL, and elsewhere in the departments of Physics and Astronomy and Electrical Engineering. To address the “need for speed”, that is to obtain of very high energy in compact distances, extremely high field accelerators are needed. UCLA is investigating methods for achieving this goal, using lasers, plasmas, and high intensity charged particle beams, in both on- and off-campus experiments.

The UCLA Neptune laboratory, a joint program between PBPL and Prof. Chan Joshi of Electrical Engineering, is the linchpin of the on-campus program. It provides a playground for this type of research, having both a state-of-the-art photoinjector that gives sub-picosecond electron beams, and an ultra-high power (>10 terawatts) long wavelength CO2 laser. This lab has hosted notable experiments in beam physics, including plasma acceleration, and inverse-free-electron laser (IFEL) acceleration — essentially running an FEL backwards to give acceleration. The world record for IFEL acceleration was set by a Neptune experiment led by Musumeci a few years back.

In order to make more dramatic progress in pushing the acceleration frontier, the PBPL employs larger facilities off-campus, at Brookhaven, SLAC, and in Frascati (Italy). Perhaps the most promising path concerns wakefield acceleration, one of Rosenzweig’s research concentrations since his Ph.D. days. In wakefield schemes, an intense, fleeting electron beam excites very high field waves in a medium; these waves can then accelerate other beams to high energy. One promising path now under study is dielectric wakefield acceleration (DWA), in which Cerenkov radiation is excited by an electron beam passing through a hollow optical fiber. Rosenzweig is now working on a design for a compact X-ray FEL based on DWA that has

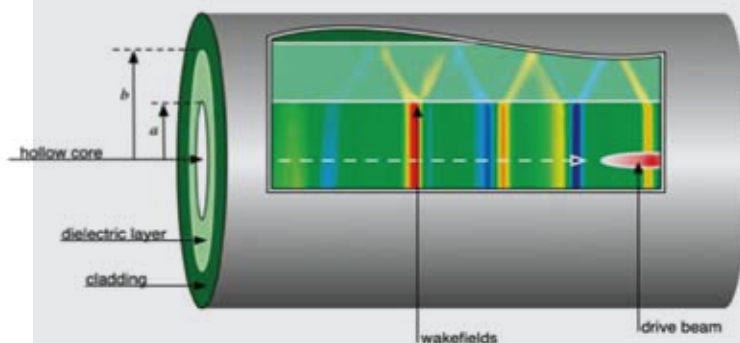


Figure 1. Schematic of the dielectric wakefield acceleration, with Cerenkov fields excited in a hollow, metal-clad optical fiber.

acceleration-fields >1 GV per meter, over an order of magnitude higher than present accelerators.

Much beyond this field level, the dielectric breaks down, creating a plasma. This

creates the true frontier scenario, plasma wakefield acceleration (PWFA), a current hot research topic. SLAC experiments by Joshi and co-workers showed acceleration fields >50 GV/m. In another synergistic twist, the PBPL group is developing experiments using the X-ray FEL-driving electron beam at the LCLS (Figure 2) to obtain another quitative leap, to over 1000 GV/m or a teravolt per meter. This implies a full linear collider’s worth of acceleration in one meter.

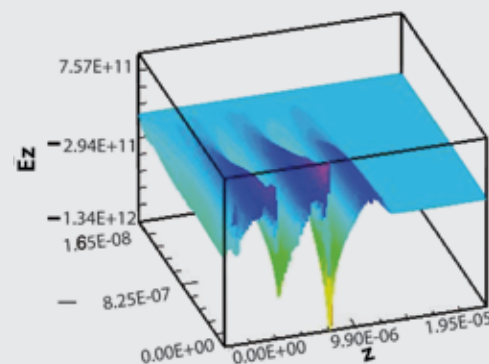


Figure 2. Simulated PWFA fields driven by LCLS injector electron beam, showing nonlinear waves exceeding 1 teravolt per meter.

(radiated energy enhancement over that given by spontaneous radiation) in a SASE FEL. The gain observed was less than an order of magnitude, however, and a clear path to an x-ray FEL was not yet assured.

To open this path completely, the Saturnus team took to the road, exploiting the higher energy beams available at national labs. The first stop was Los Alamos, where a new, longer UCLA–Kurtchatov undulator was used to demonstrate much higher gain—over 100,000. This result motivated major laboratories to commit to billion-dollar-class programs in x-ray FEL development, in particular, the Linac Coherent Light Source (LCLS) at SLAC.

The Linac Coherent Light Source (LCLS) validates x-ray FELs

The following period saw a flurry of activity, both at UCLA and at labs worldwide, all driven to achieve a deeper understanding of SASE FEL physics. In addition to collaborating with SLAC in the design of the FEL for the LCLS, the UCLA group worked on an experiment at Brookhaven called VISA. This collaboration produced a number of startling results over the course of the next seven years. Perhaps the most important had to do with methodology: UCLA was the first to use sophisticated start-to-end simulations—virtual experiments—to understand the experiments. These computational efforts followed the electrons from their birth in a high field photocathode gun, through acceleration, bending and undulating, carefully examining the subtle effects on the FEL performance. For this work, as well as the development of the physics and technology of the electron beam sources, Jamie shared (with Ilan Ben-Zvi of Brookhaven) the 2007 International FEL Prize.

All of these efforts paid off handsomely when the

A new era in science commences

Clearly, the x-ray FEL is big science now. The impact is evident by a new, brilliant view of the structure and dynamics of everyday matter obtained using the LCLS over the last year. In the near future, the x-ray FEL will realize investigations of molecular systems with length and time scales — Å and ~100 femtoseconds, respectively, which is characteristic of atomic motion.

By examining lower beam charges, the UCLA team has proposed a new direction in which even higher brightness beams with pulse duration measuring in the hundreds of attoseconds (attosecond= 10^{-18} second) are achieved. In this case, the x-rays may capture not just the overall atomic motion, but also that of the atomic electrons. This will open the door to a fundamental picture of the processes controlled by atomic electron dynamics, giving a powerful new tool to frontier fields such as femtochemistry.

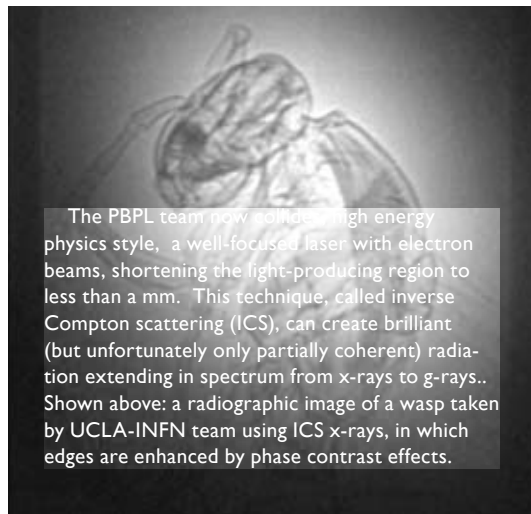
To continue the research at UCLA, the department's old Saturnus accelerator lab was re-commissioned with advanced photoinjector capability and a 35 fs laser system—and renamed PEGASUS for Photoelectron Generated Amplified Spontaneous Radiation Source. In 2007, UCLA physics doctoral student Musumeci was recruited to the beam physics faculty and is now leads the research effort at PEGASUS. He joins the effort to deliver ultra-short, low charge electron beam physics across the 100 fs boundary and develop advanced material probe techniques based on electron diffraction at that are complementary to the LCLS.

In the same way that Claudio pushed to establish the x-ray FEL at the physics frontier two decades ago, Jamie is pushing to reinvent the FEL as a smaller, leaner and more efficient technology. So, the UCLA story returns to where it began. The current work of the UCLA group may be a game-changer for science, as frontier accelerators (X-ray FELs or high energy colliders), now the province of a few national labs, cost less and fit neatly into a university building.

At 75 years of age, Claudio has decided to continue his illustrious career as UCLA professor emeritus, retiring from teaching in 2010 to pursue his iconic research full-time.

What is UCLA doing to extend and exploit the invention of the x-ray FEL? *UCLA is intent on furthering x-ray FELs by enhancing the technology and making the equipment smaller. In addition to dramatically shortening the FEL's accelerator sources, the UCLA team is contemplating a smaller particle accelerator using advanced accelerator techniques, and a smaller undulator using advanced cryogenic materials. They are even tempted to replace the undulator with a laser.*

LCLS commenced operation in 2009, stunning everyone by working even better than projected. The sentinel results ushered in the era of x-ray free-electron lasers. Next generation experiments at SLAC and DESY (Hamburg, Germany) are already underway, and many other x-ray FELs are in development elsewhere.



The PBPL team now collides high energy physics style, a well-focused laser with electron beams, shortening the light-producing region to less than a mm. This technique, called inverse Compton scattering (ICS), can create brilliant (but unfortunately only partially coherent) radiation extending in spectrum from x-rays to g-rays.. Shown above: a radiographic image of a wasp taken by UCLA-INFN team using ICS x-rays, in which edges are enhanced by phase contrast effects.

Claudio Pellegrini

Claudio is Professor Emeritus of Physics as of November 1, 2010. His research interests are in particle beams and accelerators. Claudio received a Libera Docenza from the University of Rome in 1965 and worked in the Frascati National Laboratory from 1958 to 1978. He was subsequently recruited to the Brookhaven National Laboratory where he was associate chair of the National Synchrotron Light Source and founder and co-director of the Center for Accelerator Physics until 1989 when he joined UCLA as Professor of Physics. At UCLA, he founded and served as the first director of the Particle Beam Plasma Laboratory (1981 – 2001) and was department chair (2001 – 2004.) He is a Fellow of the American Physical Society and won the Robert Wilson Prize of the American Physics Society in 2001. His honors also include a Fulbright Fellowship (1997) and the International FEL prize (1999). He has authored or co-authored over 250 scientific publications.



James Rosenzweig

Jamie is Professor and Chair of the UCLA Department of Physics and Astronomy and Director of the UCLA PBPL. His current research embraces creation and use of sub-fs beams in FELs and plasma and dielectric wakefield accelerators, coherent radiation schemes, optical acceleration, and inverse Compton scattering, as well as the technology of advanced electron sources and magnetic devices. Jamie obtained his Ph.D. at the University of Wisconsin in 1988, after which he held a Wilson Fellowship at Fermilab. He joined the UCLA physics faculty as an assistant professor in 1991; Jamie has received a Sloan Fellowship, a DOE Outstanding Junior Investigator award, and a SSC Junior Faculty Fellowship; he is a Fellow of the American Physical Society, and received the 2007 International Free-Electron Laser Prize. Jamie has been a visiting scientist at Fermilab, Argonne, and Frascati, and holds a visiting professorship at University. Roma “La Sapienza”. He is author or co-author of over 400 scientific publications and has developed a course in charged particle and laser physics, for which he has written a textbook: Fundamentals of Beam Physics, published by Oxford University Press, 2003.



Gil Travish

Gil is a Researcher in the UCLA Department of Physics and Astronomy, working in beam physics, radiation production and accelerator technology, lasers and optics, and energy generation. Additionally, he is an entrepreneur and has experience forming small businesses and commercializing technologies. His current work includes the Micro Accelerator Platform, a laser-driven optical-scale accelerator, as well as other dielectric-based advanced accelerators. Gil received his Ph.D. from UCLA in 1996. Prior to his recruitment to the UCLA physics department in 2002, he was a founding principal in three wireless technology ventures and a staff scientist at Argonne National Laboratory. Gil has authored over 100 scientific publications.



Pietro Musumeci

Pietro is Assistant Professor of Physics and directs the PBPL PEGASUS laboratory. His research interests lie in laser technology, in particular the development of ultra-short particle beams from compact accelerators. Pietro received his Ph.D. from UCLA in 2004. He then moved to University of Rome La Sapienza as a researcher. In 2005 – 2006, he led the commissioning phase of the first Italian photoinjector at the SPARC facility in Frascati. He was recruited to the UCLA faculty in 2007. His current interests include inverse free-electron laser acceleration, high brightness beam generation, and the development of a new application for RF photoinjector—ultrafast relativistic electron diffraction. He has authored over 100 scientific publications. In 2009 Pietro was been awarded a DOE Outstanding Junior Investigator grant.



Photos of Pellegrini, Rosenzweig and Musumeci courtesy of Robert Palmer

CHAIR'S DISCRETIONARY FUND

| | | |
|------------------------------------|---|--|
| Alexander, Ann D. | Hubbard Ph.D., Edward Leonard | Prestwich, Jack Thomas |
| Allen Jr., John Van | Hung Ph.D., Pham Quang | Quimby, Lawrence Stephen |
| Altizer, Robert James | Hyman Jr. Ph.D., Jay | Reimer, Fred B. |
| Amperics, Inc. | IBM Corporation Matching Grants Program | Richard B. Kaplan Living Trust |
| Anderson, Teresa Louise | Integrity Applications Corporation | Ridge Ph.D., Robert Joseph |
| Angliongto, Maryanne | Intel Political Action Committee | Royden III Ph.D., Herbert N. |
| Anthony, Dennis Robert | Jensen Ph.D., Louis Koehler | Ruby Ph.D., Lawrence |
| Arenton Ph.D., Michael W. | Jewish Community Federation | Ryan, Andrew Bradley |
| AT&T Foundation | Marcos & Ilene Lederman Phil Fnd | Sarkissian, Gevik |
| Baker Ph.D., Steven Richard | Jiang, James | Schneider, Robert Lawrence |
| Baker, Robert | Joel, Ian David | Schrier, Judith Sanow |
| Berenji, Bijan | Jones Ph.D., Thomas Edward | Scott Ph.D., Andrew Ferrell |
| Bernini, Lara Ellen | Kadogawa, Miyako | Sheng, Chu-Chih |
| Biddick Ph.D., Christopher J. | Kagiwada Ph.D., Reynold Shigeru | Shoucric, Merit M. |
| Brejeveh, Sarah L. | Khacheryan Ph.D., Sahak | Smith, Celestine Star Grady |
| Brown, Kirk Christian | Khan, Sarah | Spahn, David L. |
| Caldwell Ph.D., David Orville | Kindel Ph.D., Joseph Martin | Tanamachi, Clifford Sho |
| Chai Ph.D., Jason C. S. | Kleinberg Esq., Marvin H. | Tarbell, Michael K. |
| Chin, Robin Eric | Korechoff Ph.D., Robert Paul | Teymourian, Artin Paul |
| Christensen, Howard Lee | Kriss, Aaron | The Boeing Company |
| Christian, Mary Elizabeth | Krupke Ph.D., William F. | The Capital Group Companies Charitable |
| Chu, Karen H. | Krupp, E. C. | Foundation |
| Clarke, Theodore Charles | Lanaro, Perry Eugene | The DIRECTV Group Program Giving |
| Coroniti Family Trust | Lau Ph.D., Kim Ming | Timmerman, Lyle Charles |
| Crowe, Steven William | Lin, Chi-Hsiang | Trippe Ph.D., Thomas Gordon |
| Cutler, Robert Alan | Lung, Jo-Ann Y. | Turnbach Ph.D., Susan Elizabeth |
| Dameron, Donna | Lymberis, Costas Triantafylloy | Uchizono, Shiro Alfred |
| Daugherty Ph.D., Michael James | Malenfant Ph.D., Jerome Edward | Vasan, Varadarajan Srinii |
| Davis Ph.D., James I. | Martin, Timothy David | Wagner Ph.D., Richard John |
| Decyk Ph.D., Viktor Konstantyn | Mc Donald, Timothy Kevin | Wahba Ph.D., Karim A. |
| Desio, Cathy Louese | Mc Elmell, Roger Todd | Wang, Aileen |
| Donovan Ph.D., Steven Thomas | Mc Neil Ph.D., John Alfred | Wang Esq., Anne |
| Drayer, Debi Ann | Mead Westvaco Foundation | Wang Ph.D., Eric Hut-Jun |
| Enright, James Dennis | Melis Ph.D., Carl Anthony | Wang Ph.D., Zhengzhi |
| Eva Ph.D., Sakkar A. | Meshkat, Susan A. | Webber, Mary Boodakian |
| Fidelity Investments | Mohamedy M.D., Imran Arif | White Ph.D., Anne Elisabeth |
| Scheifele-Holmes Family Foundation | Montroy, John Thomas | Wilson, David E. |
| Folley, Christopher Norman | Morimoto D.D.S., Rick H. | Wong, Lem Lamb |
| Forber Ph.D., Richard Alan | Morimoto, Patricia | Wright Ph.D., Byron T. |
| Franco, Albert Julius | Murt, Gary | Wu Ph.D., Shu Yi Weng |
| Freyne Ph.D., Francis G. | Nasser, Mohammad Sadegh | Wuerker, Ralph F. |
| Froidevaux, Lucien | Nefkens, Bernard M. K. | Yoon, Un Ju |
| Garbin Ph.D., H. Douglas | Nguyen, Xuan Van | Zarinshenas, Reza |
| Gillespie, Steven Craig | Northrop Grumman Foundation | Ziff Ph.D., Robert Michael |
| Gondolo Ph.D., Paolo | Ossakow Ph.D., Sidney L. | |
| Grigorian, Alexander | Pau Ph.D., Jacqueline Tze-Ho | |
| Guzman, Frank H. | Petty, Connor Patrick | |
| Henriksen, Mark Jeffery | Pinkstaff, Roger K. | |
| Honea Ph.D., Eric Charles | Portwood, Brett Edward | |

Physics & Astronomy 2009-10 Donors

ANDREA GHEZ RESEARCH

Marott, Janet Elizabeth

VARIOUS DONORS/CHAIR

Fidelity Char Gift Fund Emily Dunkel
and Brian Milch Fund

The Maloney Family Foundation Inc.

PHYSICS & ASTRONOMY ALUMNI ALLIANCE

Baran, Harold Elliot

Coffer, John Gordon

Dawes Esq., Daniel Lewis

Hirai, Takeo Theodore

Michaelis, Roland Paul

Ross, Erno H.

REGENTAL FUND

Hinkes M.D., Elliott

Norton, Wesley Ann

Whitehall Foundation Inc.

RUDNICK-ABELMANN ENDOWED FUND

The Abelman Living Trust

The Morris Foundation, Inc.

THE DAVID SAXON PHYSICS GRADUATE FELLOWSHIP FUND

Saxon, Barbara

Saxon, Shirley G.

PHYSICS ALUMNI GRADUATE FELLOWSHIP

AllianceBernstein Holding LP

Brugman Ph.D., Brian Thomas

CONDENSED MATTER PHYSICS EXPERIMENT RESEARCH FUND

Anonymous

DR. WALDO LYON SCHOLARSHIP FUND IN PHYSICS

La Vonne M. Bloom Trust

GRADUATE COLLOQUIUM FUND

Preston Ph.D., Howard J.

JOHN ENGEL GRADUATE FELLOWSHIP AWARD FUND

Agnes Lucille Engel Trust

MICHAEL AND GRETCHEN KRISS TEACHING ASSISTANT AWARD

Kriss Ph.D., Michael Allen

PRESTON RESEARCH FUND

Preston Ph.D., Howard J.

SETH PUTTEREMAN GROUP FUND

Elwood & Stephanie Norris Foundation

THE EUGENE Y. WONG PHYSICS GRADUATE FELLOWSHIP

Wong, Dorothy Pan

JANET MAROTT STUDENT TRAVEL AWARDS

Marott, Janet Elizabeth

PHYSICS AND ASTRONOMY CAPITAL DONATIONS

Armini, Anthony J.

Holmes, Ben

Kriss, Michael and Gretchen

Preston, Howard and Astrid

Woo, Charles C.

Endowments

ADAMS, John Mead Memorial Fund

Adams, Mrs. John

CAMP, Alyne & Leon Graduate Fellow-
ship in Physics

Camp, Alyne & Leon

DAWSON, John Memorial Fund
Theragenics Corp.

DELSASSO Fund

Delsasso, Mary Mussen Estate

DELSASSO, Leo P. Fellowship in Physics
Delsasso, Leo & Mary

FINKELSTEIN, Robert Fellowship in
Theoretical Physics
Finkelstein, Robert & Norma

LEICHTMAN, Lauren B. & LEVINE,
Arthur Astrophysics Endow Chair
Leichtman & Levine Family Foundation

LYON, Dr. Waldo Scholarship Fund in
Physics

PHYSICS ALUMNI SUMMER
UNDERGRAD Resch Fellowship
Multiple Donors

PHYSICS ENDOWMENT FUND
Multiple Donors

RICHARDSON, J. Reginald Fund
Richardson, Louise F.

RUDNICK-ABELMANN Endowed
Fund
Multiple Donors

SAXON, David S. Presidential Chair
Fund in Physics
Multiple Donors

SAXON, David S. Presidential Chair in
Mathematics & Physics
Multiple Donors

WINSTEIN, Dr. Bruce & Joan
Endowment
Winstein, Bruce

Gifts for Academic Year July 1, 2009 - June 30, 2010

Ben Holmes

Ben Holmes contributed to the capital campaign for the Physics and Astronomy Building and helped inaugurate the Ben L. Holmes Auditorium on the first floor of the Physics and Astronomy Building that is used daily as a classroom and on occasion for special events. He also made a large gift as part of the Bruce and Joan Winstein matching gift-challenge that encourages alumni to support students in the Physics and Astronomy Department.

Ben is the President of Holmes Company, a firm specializing in healthcare consulting with a focus on the medical device industry. Prior to forming his own company, Bruce spent 24 years at Hewlett-Packard in a number of management roles. He was elected Vice-President of the Corporation in 1985.

Ben is a member of the Sciences Board of Visitors. As a life member of the Alumni Association, he was honored as the Distinguished Alumnus for 2005-2006.

Ben's annual donations are instrumental in keeping the Department's reputation as one of the finest in the nation.

Michael Kriss

Michael Kriss established the Kriss Teaching Assistant Award Fund. The recipients for 2010 are Samuel Barber who is focusing on Atomic Molecular Optical Physics and Dalit Engelhardt who is interested in theoretical research, particularly in working on formal aspects of string theory and investigating the cosmological and particle physics implications of string theory.

While studying at UCLA, Michael received his BS in Physics in 1962, his MS in Physics in 1964 and his Ph.D. in 1969. After his doctorate he began his career at Eastman Kodak Research Laboratories. Prior to retirement, he was the Executive Director of the Center for Electronic Imaging Systems and taught in the Department of Computer and Electrical Engineering at the University of Rochester.

Michael is the President of MAK Consultants. His company focuses on a wide range of color imaging problems.

Michael's many professional achievements include receiving the prestigious Davies Medal of the Royal Photographic Society. Presently, he serves as a member of the Sciences Board of Visitors.

We are grateful that Michael directs some of his boundless energy to benefit the Physics and Astronomy Department.

Howard and Astrid Preston

The Department constantly improves as the Prestons continue to provide their financial support through the Astrophysics Graduate Colloquium and Preston Research Fund and, in addition, also fund the Preston Reading Room in the Physics and Astronomy Building.

Howard is President of Preston Cinema Systems and was honored by The Academy of Motion Picture Arts and Sciences when he received the Technical Achievement Award and Scientific and Engineering Award.

While at UCLA, Howard earned a BS in Physics in 1965 and a Ph.D. in Physics in 1974. Astrid is a painter, originally from Sweden. She received her BA in Art and her work has been displayed at the Oakland Museum, the Orange County Museum of Art, the Laguna Art Museum and the Grunwald Graphic Arts Center at the Hammer Museum in Los Angeles. Astrid also supports the English Department.

The loyal support and ongoing commitment of the Prestons enable the Department to maintain a prominent place in the global scientific community.

Lauren B. Leichtman and Arthur E. Levine

Lauren and Arthur hosted an Astronomy Donor Salon in September 2010 in their home in Beverly Hills. Prominently featured and honored was Professor Andrea Ghez who graciously thanked her hosts.

A few years ago another milestone was reached when they created the Lauren B. Leichtman and Arthur E. Levine Astrophysics Endowed Chair and simultaneously celebrated Professor Ghez's appointment as the Chair. Co-partnered in Levine Leichtman Capital Partners, Inc. this most involved team is passionate about Professor Andrea Ghez's work and women in science. They continue to support the ground-breaking discoveries that are ongoing in Astrophysical research here at UCLA.

Alumnus, Arthur, earned a BA in Philosophy in 1973 and an MBA in 1976.

Professor Ghez spends a great deal of her time staring into space...deep space that is. "...Arthur and Lauren's unwavering support has afforded me the opportunity to do so much more than I could have, otherwise..."

We join Andrea in adding our appreciation to Lauren B. Leichtman and Arthur E. Levine for their gift that keeps giving.

Elwood(Woody) and Stephanie Norris

Like his inventions, Woody and Stephanie's UCLA contributions continue to grow. Woody and Stephanie set up the Elwood and Stephanie Norris Foundation, and they frequently donate to the Seth Putterman Group Fund to insure that this important research continues.

Woody's curiosity began at any early age when he decided to take apart one luxury item in their home. He was 8 when he dismantled the family radio to learn how it worked and produced sound. From that moment, he became captivated with electronics and a hobby developed that shaped his world famous scientific career.

Today, Woody continues to be fascinated by how sound works, and holds over 100 patents worldwide. His HyperSonic Sounds (HSS) invention is said to be the first big improvement in acoustics since the loudspeaker was invented 80 years ago. He won the Lemelson-MIT prize in April 2005, the largest cash prize in the world for inventors.

We salute the Norris' for their contributions and promotion of innovative research at UCLA.

John Wagner

As a member of the Board of Trustees at the Ahmanson Foundation, John Wagner facilitated a generous gift from the Ahmanson Foundation to support the Physics and Astronomy undergraduate laboratories. These laboratories provide a hands-on learning experience for nearly 10,000 undergraduate students each year.

John is the Founder, Managing Partner and Senior Portfolio Manager at Camden Asset Management. Prior to this position, he served as a Portfolio Manager at Westridge Capital.

John attended UCLA and received the following degrees: BS in Physics in 1980, MS Physics in 1983 and an MS in Electrical Engineering in 1985. The family tradition marches on as his son, Thomas, is currently in his first year at UCLA with plans to study history.

John Wagner's loyal support helps us prosper and maintain the department's reputation as one of the leaders in the scientific community.

Thank you for your continued support



Ben Holmes, Michael Kriss, Howard & Astrid Preston, Lauren Leichtman & Arthur Levine, Elwood/Woody Norris

Ron Abelman



Ron Abelman has played a significant role in funding the Rudnick-Abelman Fellowship. This year he posed a generous matching challenge to increase the fund and gifts are being matched by alumnus, John Marcus and the Morris Family Foundation. Dean Rudnick has agreed to match a second challenge with resources from the Chair's Discretionary Fund. This Fellowship has already benefited many students; most recently, the fund has been awarded to the following five outstanding recipients: Aria Asghari, Michael Gutierrez, Nick McColl, Aviva Shackell and Steve Suh. Ever in touch with UCLA, the Department was honored to have him deliver the keynote address at the 2010 Physics and Astronomy Commencement.

In 1959, Ron received his BS in Physics and his MS in Physics in 1960. He has fond memories of studying under Isadore "Izzy" Rudnick who realized, early on, Ron's passion for Physics. He believes his physics education was crucial to his business success because it taught him how to be a problem solver.

Ron Abelman is currently the President, CEO and Chairman of CyberStateU.Com Inc., a company that offers web-based information technology certification training. Emigrating from South Africa, he now resides in Alamo, California.

We join the many in saying thank you Ron for your commitment to the Department of Physics and Astronomy.

Elliott and Eileen Hinkes

Dr. Elliott Hinkes started his relationship with UCLA in 1970 when he began a fellowship in Hematology and Oncology at the School of Medicine.

Dr. Elliott was in private practice specializing in Medical Oncology and Hematology in the Los Angeles area for more than 30 years. In addition, he served as a Clinical Associate Professor in the Department of Medicine until his retirement.

A rare book collector, Dr. Hinkes concentrated on Physics and Astronomy. To further his knowledge of the scientific material in his collection, he participated in physics and astronomy classes with matriculating students at UCLA. In the course of his studies, he developed great respect for Astronomy Professor Andrea Ghez. He showed his appreciation through various donations including a series of scientific volumes titled Physical Review.

Eileen, Elliott's wife, is honored that UCLA remembers her husband's loyalty. Dr. Hinkes passed away in November 2009. "I was so pleased that Elliott received such intellectual stimulation and joy from attending these classes. We tried to show our appreciation by supporting the work of the Department."

We here at UCLA would like to add that we are most grateful for Elliott and Eileen's support that enables us to continue providing quality education to future scientists.

Janet Marott



Janet Marott through the Janet Marott Student Travel Awards is actively engaged in supporting student travel to the Keck Telescope Astronomical Observatory located near the summit of Mauna Kea in Hawaii. The Keck Observatory is considered one of the world's most important astronomical viewing sites. This Award is under the supervision of Professor Andrea Ghez and offers students the unique opportunity to travel to Hawaii and have the first-hand experience of viewing this extraordinary scientific marvel.

Our donor has chartered an impressive record in her professional life. She retired from Boeing as Director of Information Protection and Assurance and prior to Boeing was the Senior VP of Decision Support for Carter Hawley Hale Information Services (which owned the Broadway department store chain).

Janet earned her BS in Chemistry at UCLA in 1966. Janet is President of the South Bay UCLA Alumni Association. She is also active in the Women in Philanthropy and is a new member of the Sciences Board of Visitors. She lives in Redondo Beach but takes time to travel to Los Angeles where she volunteers at the Griffith Observatory.

Janet has many philanthropies and the Department of Physics and Astronomy is most grateful to be listed among them.

phi·lan·thro·py is the effort or inclination to increase the well being of humankind

Bruce and Joan Winstein

It is an understatement to describe the Winsteins as long-time supporters of the Department.

Joan and Bruce recently posed a matching gift challenge for the Bruce and Joan Winstein Endowment Fund and with the support of alumni, Ben Holmes, William Layton and others, the fund has grown substantially.

In 1965, Bruce was graduated from UCLA with a BS in Physics. In 2003, he received the 1st Distinguished Alumnus Award from the UCLA Department of Physics and Astronomy. Professor Winstein is now teaching at the University of Chicago. Bruce's research focuses on cosmic microwave background radiation and the afterglow from the big bang for information about the physical conditions in the early universe.

This multi-generation UCLA family began with his father, Saul, who was an alumnus and distinguished Professor of Chemistry on campus and his mother, Sylvia, who was active in supporting the Departments of Chemistry and Biochemistry.

Bruce is quoted "...My family and I are proud to be associated with the Physics and Astronomy Department.."

The Department is proud and grateful for the loyal support of the Winstein Family.



Ralph Wuerker

Ralph Wuerker has been a friend of UCLA since 1974 and to this day funds many projects in the Department. For many years, he worked at GRW, a defense contractor that developed the first satellite. Ralph later joined UCLA as the Associate Director of UCLA HIPAS Laboratory where his knowledge and insight are still in evidence. Ralph's areas of expertise are vast and include the pioneering of holography, lasers and the RF Quadrupole Trap.



Ralph is passionate about enhancing math and science education in elementary schools. This effort includes introducing future generations to the world of science and all the wonder that lies therein. The Director of Lecture Demonstrations, Marty Simon adds "Ralph is known to frequently bring high school students to UCLA..."

Although residing in Westlake Village, California, he still finds time to come to UCLA. When he visits the Department, he not only brings along his enthusiasm and scientific acumen, but is also known to instantly respond to a specific research need to move the project toward completion.

Ralph, on behalf of all the students you have encouraged and mentored both outside and inside the Department.

*"I can no other answer make, but,
thanks, and thanks."* ~William Shakespeare

UCLA INFRARED LAB 20TH ANNIVERSARY.

UCLA Infrared Lab in 2009-2010 academic year celebrated its 20th anniversary. To celebrate the event, we organized an Open House on November 20, 2009. Professor McLean gave a talk in which he explained the reasons for establishing the Lab in 1989 and described many of its successes. The lab's first two Ph.D. students, Bruce Macintosh (1994), now a senior scientist at the Lawrence Livermore National Lab (LLNL), and Suzanne Casement (1995), now a senior scientist at Northrop-Grumman were welcomed guests. Guests of honor were representatives from Teledyne Imaging Sensors (formerly Rockwell Scientific), Drs. Kadri Vural and Jim Beletic. Kadri* was our guest 19 years ago at our first anniversary and continues to be a strong supporter of infrared detectors for over 20 years. Jim Beletic*, formerly at the Keck Observatory and the European Southern Observatory, delivered a short speech in which he applauded the



From left: Eric Becklin, Ben Zuckerman, Dr. Kadri Vural*, Dr. James Beletic*, Ferdinand Coroniti, Michael Jura, Michael Fitzgerald, James Larkin and Ian McLean

UCLA Lab's success and compared our international reputation to that of a major national facility. Chair, Ferdinand Coroniti, recalled the department's plan in the late 80s to devise a way to become a major player in the 10-meter Keck Telescope project that was just getting under way. It was recognized that this novel telescope, with its concept of using 36 hexagonal-shaped mirrors that were computer-controlled to function like one continuous mirror, was a high-risk endeavor that might fail to produce good images at visible wavelengths (it didn't) but would nonetheless be perfect at much longer wavelengths of light, the infrared. In the end, two telescopes each with 10-m (400-inch) diameter mirrors were constructed on the 14,000 ft summit of Mauna Kea, Hawaii. In 1989 Eric Becklin, the discoverer of many infrared sources starting in the late 60s, was recruited from the University of Hawaii to establish a new infrared program at UCLA. Eric recommended the establishment of a laboratory to design and develop infrared instruments for the era of giant telescopes. The idea was to capitalize on recent developments in infrared detector technology at California companies, such as Teledyne and Raytheon. Ian McLean from the Royal Observatory Edinburgh, who in 1986 unveiled the first facility-class infrared camera designed specifically for astronomy at the 3.8-m UK Infrared Telescope on Mauna Kea, joined Eric at UCLA and the lab built its first infrared camera in 1990. The rest, as they say, is history.

The UCLA IR Lab went on to build the first twin-channel infrared camera which provides infrared images at two wavelengths simultaneously. This instrument has been in operation for 17 years at the 3-m Shane telescope of UC's Lick Observatory, Mt. Hamilton, CA. Under McLean's leadership the IR Lab provided the first cryogenic, cross-dispersed, high-resolution infrared spectrograph to use a 1 megapixel infrared camera. This instrument, known as NIRSPEC, was delivered to the 10-m Keck telescopes in April 1999. In 1997, Eric and Ian were joined by James Larkin. James obtained his Ph.D. at Caltech and was then working at the University of Chicago on the new field of Adaptive Optics (AO). With this corrective technique, image quality becomes limited by the diffraction of light. The importance of this technology for the infrared and for the Keck Observatory in particular is significant. A major effort was established among the Keck partners to develop an AO system. Teaming with Caltech to provide the detector system for the first diffraction-limited infrared camera at Keck (NIRC2), and then under James Larkin's leadership we delivered the first integral-field infrared spectrograph in 2005. Known as OSIRIS, this powerful instrument obtains the image and spectrum of each point in the field simultaneously, achieving such high angular resolution that it is possible to "see" surface features on Saturn's moon Titan, and resolve the complex structure of distant galaxies just forming in the early universe.

Today, the IR Lab works on two major projects, MOSFIRE, the multi-object spectrometer for infrared exploration. MOSFIRE has just achieved first-light in the laboratory and is due for delivery in late 2010 or early 2011. Our second major project is for the Gemini Planet Imager (GPI). GPI is an advance, high-contrast adaptive optics system to be installed on the Gemini South 8-m telescope in Chile. The science instrument for GPI is an infrared imaging spectrograph similar in many respects to the Keck OSIRIS instrument, and this part of the project is led by Professor James Larkin at UCLA. Delivery to Chile is expected in 2011.

As the IR Lab celebrates its 20th year we are looking forward to the future. The University of California is a founding partner in the Thirty Meter Telescope (TMT) concept. This telescope will extend the segmented mirror approach to create an aperture three times larger than Keck and with nine times the light-collecting area. Already, James Larkin is leading a multinational conceptual design study for IRIS, the first-light AO-based infrared instrument for the TMT. Adaptive optics and exceptionally high-angular resolution will play a major role in the new era of extremely large telescopes. Recognizing that fact, the department recruited Professor Michael Fitzgerald, an expert in this technology and someone who has already made use of adaptive optics to study planets and planetary formation around nearby stars. Although appointed in 2009, Michael joined the IR Lab for the new academic year beginning on July 1, 2010. In addition to his own proposals he will also be involved in science planning for GPI.

Infrared Laboratory Group: Ian McLean, James Larkin and Mike Fitzgerald

Ian McLean has continued his research in sub-stellar objects known as brown dwarfs. An almost decade-long study using NIRSPEC on the Keck 1 telescope has led to the creation of a public archive of infrared data called the Brown Dwarf Spectroscopic Survey. In addition to the MOSFIRE project, McLean has continued as Associate Director for the University of California Observatories (UCO) and he supports graduate students Kristin Kulas and Gregory Mace.

The primary research of James Larkin focuses on the early development of galaxies like our own Milky Way. Using his instrument OSIRIS at the Keck Telescopes, he and his former

graduate student Shelley Wright (now a Hubble Post-doctoral Fellow at UC Berkeley) measure the internal motions of galaxies more than 9 billion light years away at a time soon after their formation. A primary goal of this research is to learn when and how these vast structures began to mature into the stable rotating disk galaxies we see in the Universe today. As a by-product of these measurements they are also able to identify black holes growing at the galaxy centers and can measure the composition of the gas going into the early generations of stars. Larkin's effort to construct the Gemini Planet Imager spectrograph has been assisted by graduate student Jeffrey Chilcote.

During 2009-2010 Mike Fitzgerald completed his Michelson Fellowship at the Lawrence Livermore National Lab while preparing for his move to UCLA. He has continued his study of planet formation through the direct detection of extrasolar planets. The relationship between exoplanets and dusty circum-stellar debris disks, which act as tracers of planet formation processes, remains a prominent target of his research. Fitzgerald will continue to apply the NIRC2 camera and the Keck AO system to search for faint emission from planets and disks around nearby stars, and will be developing similar techniques for the powerful Gemini Planet Imager. He will be working with graduate students Jeffrey Chilcote and Thomas Esposito to develop and apply high-contrast imaging techniques to these exciting systems.

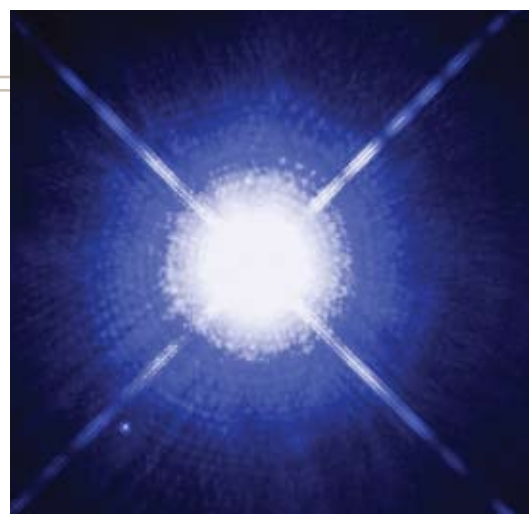


Upper Left panel: the MOSFIRE diffraction grating mechanism being assembled. Lower left: the completed Camera Barrel. Right: rear view of the instrument showing the Electronics Cabinet.

Extrasolar Planetary Systems: Michael Jura

Mike Jura along with graduate student Beth Klein and others, have found that the extrasolar asteroid that has been accreted onto the white dwarf GD 40 is composed largely of oxygen, magnesium, silicon and iron. These are the same four elements that largely compose the Earth. We can now compare and contrast the elemental compositions of extrasolar planets with our own solar system planets.

Along with Siyi Xu, a then-undergraduate at Nanjing who is now a graduate student at UCLA, Jura has shown that an asteroid's internal water may survive the external heating produced by its host star. Consequently, we have found a pathway to assess whether extrasolar planets possess large amounts of water, a pre-requisite for life as we know it.



Measuring a White Dwarf Star
Image Credit: NASA, ESA, H. Bond (STScI) and M. Barstow (University of Leicester)

Wide-field Infrared Survey Explorer (WISE): Edward (Ned) L. Wright

Edward L. Wright spent 2009-2010 working on the Wide-field Infrared Survey Explorer (WISE) (see <http://wise.astro.ucla.edu>) mission, which launched on December 14, 2009, started its sky survey on January 14, 2010, and finished its first coverage of the sky on July 17, 2010. WISE has observed over 150,000 asteroids of which over 33,000 were new, including more than 100 new Near Earth Objects, as well as discovering 16 comets. WISE has found hundreds of cold brown dwarf stars in the solar neighborhood, and many very distant ultra-luminous infrared galaxies.

Ned Wright in front of rocket December 2009



Galactic Center Research Group: Andrea Ghez

Andrea Ghez's research group focuses on the scientific gains that can be obtained using the Adaptive Optics system with the Keck telescope. Observations of the center of our Galaxy continues to yield unexpected surprises. Using Adaptive Optics spectroscopy at the Keck telescope, Ghez and her graduate student Tuan Do have shown that there is a deficit of giant (old) stars compared to what was predicted based on theoretical models of how stars are expected to interact with the central supermassive black hole. Four dynamical scenarios may be responsible for removing these stars from the center and producing a flattened cusp profile: (1) mass segregation with stellar remnants such as black holes or neutron stars, (2) in-fall of an intermediate mass black hole, (3) collision between these evolved giants and stars or binaries in this high-density region, (4) tidal stripping of stars with eccentricities that bring them to the tidal radius of the black hole. Understanding the origin of this discrepancy may influence our notions of how galaxies form and evolve over time.

With recent graduate, Quinn Konopacky, Ghez has also studied brown dwarfs, which are objects that are formed similar to stars but with insufficient mass to sustain stable hydrogen fusion at their cores. By studying the orbital motion of close binaries stars, they have obtained some of the first direct estimates of the masses of these objects

and show that there are systematic discrepancies between our dynamical mass measurements and the predictions of theoretical evolutionary models. These discrepancies are a function of spectral-type (temperature). If these spectral-type trends are correct and hold into the planetary mass regime, the implication is that the masses of directly imaged extra-solar planets are over predicted by the evolutionary models, resolving the recent apparent stability paradox of the first multiple planet system ever imaged.

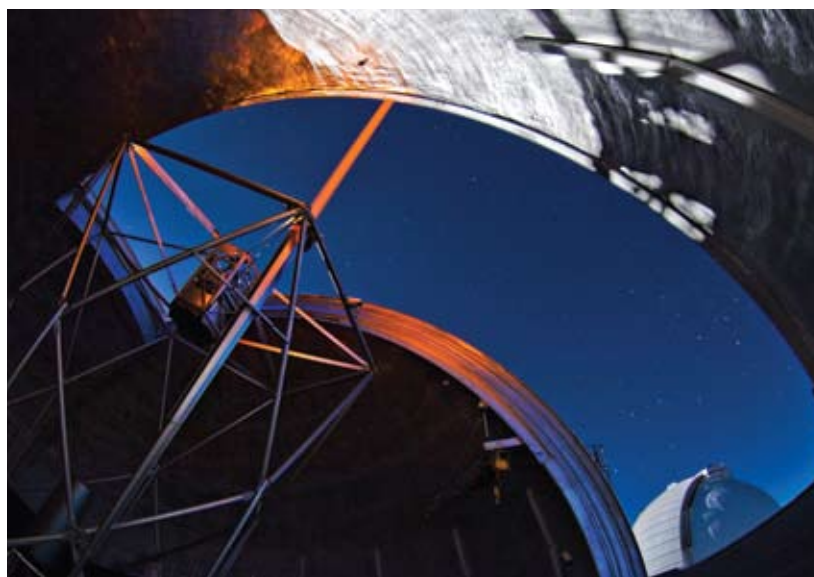
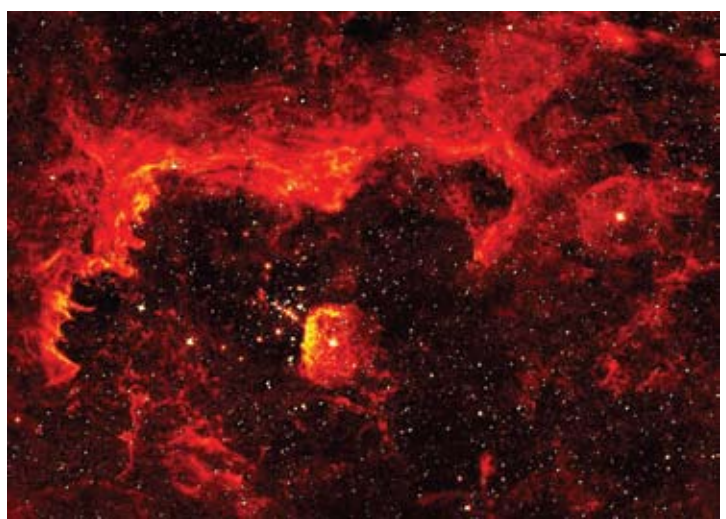


Image taken at the Keck telescope courtesy of Laurie Hatch Photography. Please do not download or use without written permission from the photographer.

Galactic Center Astronomy: Mark Morris

Mark Morris has worked with X-ray astronomers to gather information on a gigantic X-ray flash that took place in the Galactic center about 100 or 200 years ago. Although the flash has long since shut off, the X-ray wave front is still propagating through the dense clouds of the central molecular zone of our Galaxy, and is provoking fluorescent X-ray emission in the 6.4-keV K-alpha line of neutral iron atoms. By observing this line from year to year, one can see the light-speed movement of the wave front through the clouds and infer the 3-dimensional placement of the fluorescing clouds. Working with radio astronomers in Madrid, Morris has also found that millimeter-wavelength emission from SiO molecules in these clouds closely tracks the fluorescent emission. This implies that the SiO molecules may be sputtered into the gas phase by the impact of the hard X-rays in the flash upon interstellar dust grains.

Working with a nationwide team of astronomers, Morris has used the NICMOS infrared camera on the Hubble Space Telescope to image a 300-light-year strip across the Galactic center in the Paschen-alpha line of hydrogen. This line arises in the ionized gas that has been produced at various places near the Galactic center by the ultraviolet emission from massive, young stars. The images reveal the



Paschen-alpha emission from ionized gas surrounding the Quintuplet Cluster, one of the massive, young clusters near the Galactic center.

importance of the strong magnetic field in this region for shaping and ordering the gas into filamentary and columnar structures.

Much of this ultraviolet light comes from one of the most massive clusters of young stars in our Galaxy, the Arches Cluster. Using the Keck Telescope in the infrared, Morris and UCLA collaborators have shown that some of the stars in the Arches cluster still have their primordial disks of gas and dust that are remnants of their epoch of formation, 2.5 million years ago. These disks have survived in the harsh radiation environment of the cluster, and are presumably in a stage in which planet formation is taking place.

Galactic and Extragalactic Astronomy: R. Michael Rich

The Galaxy Evolution Explorer Satellite, or GALEX, continued to turn in exciting discoveries in the past year; Rich is on the science team. GALEX is a telescope with a remarkably wide field of view—four times the size of the Moon. It has now imaged over 2/3 of the sky in the “satellite ultraviolet” wavelengths of light that pack far greater energy than the UVB light responsible for sunburns, and that can only be studied from space. Combining the ultraviolet and visible-light images, Rich and former UCLA postdoc Samir Salim, along with UCLA postdoc Yeong Loh, have found that galaxies broadly divide into those that actively form stars, and those that are “dead”, having formed no stars for many billions of years. A relatively small minority of galaxies appear to be sitting on the fence—they are forming some stars, but not enough to really be called active? Are they dead galaxies that have captured some fresh gas, or are they heading toward star forming retirement? Rich and Loh explored the environments that these galaxies live in, and found that indeed, they may be star forming galaxies that are moving in to the higher density clusters, where they will stop forming stars. Salim

and Rich used the Hubble Space Telescope to take images of old galaxies much more massive than our Milky Way; the GALEX images suggested that these galaxies might have star formation. Indeed they did, but the surprise was that some of these galaxies were forming stars at huge distances from their centers—one has a disk that is 4 times the size of the Milky Way. Viewed in visible light, one sees no trace of star formation in these galaxies, which is revealed only in the ultraviolet. The new studies may help to solve a decades long mystery about the inexorable transformation of blue, actively star forming galaxies, to the quieter, “old, red, and dead” galaxies of the present day.



A galaxy dominated by old red stars in encircled by a ring of recently formed stars? Is this ring the final remnants of a once actively star forming disk, or did the old galaxy acquire gas to form a modest number of stars, after which its final fling with star formation will end. Courtesy: NASA/ESA/STScI/ Hubble Heritage Project

Galactic Astronomy

Jean Turner

Professor Jean Turner continued her program of star formation studies in local galaxies. With graduate student Chao-Wei Tsai, she explored variations in star formation efficiency within galaxies. Her team has found that gas clouds do not form stars at rates in proportion to their gas surface densities, but appear to form stars at preferred locations determined by gas dynamics. This could explain the buildup of dense clusters of stars within the central few hundred light years of galactic nuclei. Tsai received his Ph.D. and is now working on the WISE mission. With former student David Meier (New Mexico Tech) and Sara Beck (Tel Aviv), she

reported the discovery of a new nearby starburst galaxy, IRAS 04296+2923, the sixth brightest infrared galaxy in the local universe, which is forming stars at roughly ten times the rate of the Milky Way, more typical of galaxies in the early universe than present-day galaxies. The nucleus of this galaxy forms stars ten times more efficiently than its disk does, the first time a systematic variation of star formation efficiency has been noted within a galaxy. The low star formation efficiency observed in the disk is necessary for the process of secular evolution, which is believed to govern the structure and evolution of most spiral galaxies.

High-Redshift Galaxies

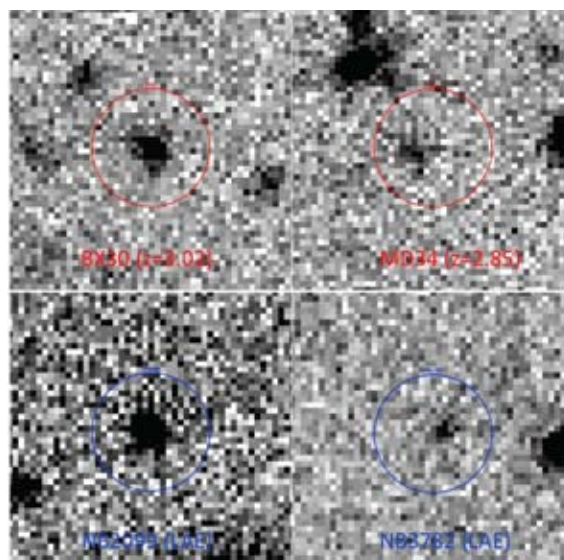
Alice Shapley

Research Highlights (for the academic year only July 1, 2009 to June 30, 2010) Please provide a brief description of any new and important scientific results obtained, along with any graphics, pictures or photos which you think would enhance your research. For individual contributions the space limit is 200 to 300 words.

Alice Shapley, postdoc Daniel Nestor, and graduate student Robin Mostard are studying the escape of hydrogen-ionizing radiation from galaxies roughly 11 billion light years away. These observations probe back in time to when the universe was only a couple of billion years old. Using a custom near-ultraviolet filter along with the Low Resolution Imaging Spectrometer on the Keck telescope, Shapley and collaborators have reached unprecedented sensitivity in near-UV imaging, and achieved detections of ionizing photons leaking from a large sample of distant galaxies. These observations and their interpretation will be crucial for untangling the process of “reionization” during the first billion years following the Big Bang. In the reionization process the universe underwent a global phase transition, as the atomic matter was split apart into protons and electrons. The sources of photons capable of splitting apart the atoms may consist of massive stars forming in distant galaxies. Understanding how these photons escape from their galactic star-forming nurseries constitutes an important piece of the puzzle confronting both observational and theoretical cosmologists.

Graduate student Kevin Hainline is investigating the demographics of black hole accretion in the early universe, and the effects of so-called black-hole “feedback”, which may be a very important ingredient in the galaxy formation process.

Graduate students Katherine Kornei and Kristin Kulas are both addressing the question of feedback using different approaches – characterizing the factors driving large-scale outflows of mass, energy, and momentum in distant star-forming galaxies. All of these investigations make intensive use of observations obtained at the Keck Observatory, including both optical and near-infrared spectroscopy.



Images of star-forming galaxies in the early universe (11 billion light years away, or “ $z \sim 3$ ”). These near-ultraviolet images probe hydrogen-ionizing radiation escaping from the galaxies. First emitted as far-ultraviolet light, the wavelengths of these photons have actually stretched by roughly a factor of four on their journey towards Earth, due to the expansion of the universe. Photons like these, escaping from galaxies within the first billion years following the Big Bang, may be responsible for the global phase transition known as “reionization.” Understanding the reionization process remains one of the frontiers of observational cosmology.

Astroparticle Physics: Rene Ong and Vladimir Vassiliev

A major focus of the astroparticle physics group led by Rene Ong and Vladimir Vassiliev is on VERITAS – the Very Energetic Radiation Imaging Telescope Array System. Located in southern Arizona on Mt. Hopkins, VERITAS is an array of four 12m-diameter telescopes that use the atmospheric Cherenkov technique to detect very high energy (VHE, $E > 100$ GeV) gamma rays. Since the completion of construction in 2007, VERITAS has been remarkably successful, detecting more than 30 astrophysical sources of gamma rays. These sources include Galactic objects such as supernova remnants, X-ray binary systems, pulsar wind nebulae and unidentified objects. The UCLA group on VERITAS is supported by funding from the National Science Foundation. The group was recently strengthened by the arrival of postdoc Pratik Majumdar from Germany.

A major result during the last year was the completion of the VERITAS Sky Survey, a 75 square-degree scan of the Galactic plane in the Cygnus region. The survey, which was led by UCLA postdoc Amanda Weinstein and graduate student Ken Chow, was the most sensitive wide-field survey ever done in the northern hemisphere. A number of sources were detected, including an unexpected object near the famous gamma-Cygni supernova remnant. This work comprised the Ph.D. thesis of Chow, who graduated in May 2010.

Another important area of research for VERITAS relates to active galactic nuclei (AGN). These intrinsically bright extragalactic VHE sources are thought to harbor super-massive black holes at their centers. VERITAS has proven very capable of detecting new AGN – in fact, five new sources were discovered in the last year alone, with each discovery being marked by an astronomical telegram to the community. In addition to being fascinating objects in their own right, AGN can be used to probe intergalactic radiation fields with which VHE gamma-rays of AGN are expected to interact and produce secondary observable effects. Graduate student Tim Arlen is exploring a novel idea to detect or constrain the intergalactic magnetic fields via observation of spectral, time, and angular signatures of electromagnetic cascading in intergalactic space. For example, in some scenarios a gamma-ray “halo” may surround a point-like AGN image. Essential for these studies are the broad spectrum VHE observations conducted by both VERITAS and the Fermi Gamma-ray Space Telescope (FGST).

An important observational program pursued by the VERITAS collaboration is the research into the nature of dark matter in the Universe. One of the most favored theoretical dark matter particle candidates, a weakly-interacting massive relic, is expected to self-annihilate and



VERITAS array 2010

produce VHE radiation detectable by VERITAS. From observations of astrophysical sources (e.g dwarf galaxies) that are thought to harbor large concentrations of dark matter, VERITAS has placed significant constraints on the dark matter self-annihilation cross section as a function of dark matter particle mass. A prominent contribution to this research was carried out by graduate students Matthew Wood who completed his Ph.D. in October 2010. Wood will continue his career in astrophysics at SLAC/KIPAC working on FGST

The success of VERITAS has motivated exploration of a future, more powerful ground-based gamma-ray observatory. Vassiliev and Ong have been working for several years on the concept of a large Atmospheric Cherenkov Telescope Array (ACTA) covering an area of up to 1 square-kilometer. Vassiliev has led the design and development of a novel two-mirror, Schwarzschild-Couder-type, telescope that would permit much wider field-of-view observations with higher angular resolution than present technology. After a favorable review by the 2010 Decadal Survey in astronomy and astrophysics (Science, Vol 329, 2010 p.895), this project is expected to merge with the European lead efforts to construct a world-wide gamma-ray observatory that would deliver its first science before the end of this decade.

UCLA is playing a key role in the balloon-borne experiment called GAPS (General AntiParticle Spectrometer) that seeks to understand dark matter through the unique signature of anti-matter. Supported by NASA, GAPS aims to make the first detection of anti-deuterons in cosmic rays that would provide telltale evidence for dark-matter annihilation. GAPS is in the development phase, with the eventual goal of a long-duration balloon flight in Antarctica. The UCLA group, including Ong, research scientists Jeffrey Zweerink and Isaac Mognet, and graduate student Tracy Zhang, is building the time-of-flight and trigger system for a prototype instrument that is scheduled for a balloon flight in Fall 2011.

Theoretical Astrophysics: Brad Hansen

Brad Hansen is currently working to understand the effects of tidal forces between stars and planets in extrasolar systems. By comparing and contrasting the properties of planets with different size host stars and different separations, one can calibrate how strong the underlying tidal forces are. The resulting analysis shows how even very close planets can survive for a significant length of time, and casts doubt on recent claims that some planetary radii are inflated as the result of tidal dissipation.

Brad Hansen, along with Michael Rich and collaborators at the University of British Columbia and the Space Telescope Science Institute, are continuing their study of globular cluster white dwarfs with the Hubble Space Telescope. The most recent observations include a follow-up to the previous study on the cluster NGC 6397, as well as an observation of another cluster, named 47 Tucanae, which will provide an age

from the white dwarf cooling sequence for a third globular cluster.

Brad Hansen, along with collaborator Travis Barman, of Lowell Observatory, and graduate student Ian Crossfield, is using the Keck telescope to observe bright stars that host close-in giant planets. They are searching for absorption features in the atmosphere of the planet by studying the differences between the normal stellar spectrum and the spectrum observed when the planet passes in front of it.

Hansen and Crossfield have also recently published, in conjunction with an international team of collaborators, an updated phase curve for the close-in giant planet upsilon Andromeda b. This shows that the temperature on the surface of the planet is not uniform, and that the hot spot is significantly shifted from the planetary dayside, suggesting the presence of strong winds in the atmosphere.

Astroparticle Physics Katsushi Arisaka, David Cline, Hanguo Wang

There is overwhelming evidence that our Universe is filled with unknown particles called Dark Matter. Its direct detection is the central effort in today's community of particle physics, astronomy and cosmology. For the last two decades since David Cline recognized its importance in the early 90's, together with Dr. Hanguo Wang, UCLA has been playing a leading role on innovative detection techniques using noble liquids such as Xenon and Argon.

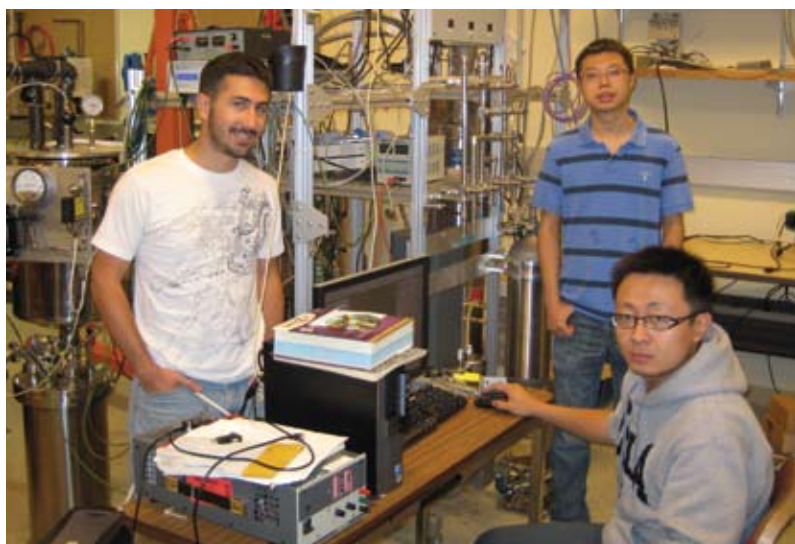
Katsushi Arisaka joined this program in 2006. Since 2008, the group, consisting of one postdoc (Emilija Pantic) and five graduate students (Artin Teymourian, Ethan Brown, Chi Wai Lam, Kevin Lung and Yixiong Meng) has been fully engaged in the world's largest Xenon detector, XENON100 (100kg),

at Gran Sasso in Italy. The first 11 days of data gave the most sensitive weakly interacting massive particles (WIMP) limits ruling this out as a dark matter signal, we were able to set the best limits in the recent Physics Review Letters paper. XENON100 started taking "blind" data January 2010. The box will be opened soon after a yearlong collection of high-quality data.

Arisaka and Wang invented an ultra low radiation photon detector named QUPID (Quartz Photon Intensifying Detector) in 2007. After three years of research and development, it was successfully operated in Liquid Xenon in 2010. Encouraged by this success, QUPID has become a natural choice for future large-scale detectors in both Xenon and Argon.

- 1) A new proposal DarkSide50 (Depleted Argon 50 kg) was submitted to DOE/NSF and fully funded. It will be equipped with 38 QUPIDs as the first test-bed.
- 2) A conceptual design of the XENON1Ton detector (consisting of 242 QUPIDs) is under way. A full proposal will be submitted to DOE/NSF by early 2011.
- 3) MAX (Multi-ton Argon Xenon) proposal to NSF for the DUSEL S4 was approved for engineering design. The detectors would consist of thousands of QUPIDs. David Cline is co-PI on this project.

In addition to the dark matter search, Cline and Wang are active in ICARUS, a 600-ton liquid argon detector for proton decay and long baseline neutrinos at Gran Sasso in Italy. The same group is also active on LBNE (Long Baseline Neutrino Experiments) project (from FNAL to DUSEL), a 300k-ton scale water Cherenkov detector and 50k-ton scale liquid argon TPC.



Three graduate students, Artin Teymourian (left), Michael Lam (back) and Yixiong Meng in the dark matter lab in PAB next to the liquid argon and liquid xenon cryogenic systems

Nuclear Physics – Relativistic Heavy Ion and Intermediate Energy:

Charles Whitten and Huan Huang

The nuclear physics group (Whitten-Huang) has research programs in 1) heavy ion collision physics to study Quantum ChromoDynamics (QCD) under extremely high energy density and temperature and the QCD quark-hadron phase diagram; 2) spin physics to investigate the spin structure of the proton; and 3) neutrino physics to search for neutrinoless double beta decay from the isotope ^{130}Te (34% natural abundance). Our experimental effort centers on the STAR (Solenoidal Tracker at RHIC (Relativistic Heavy Ion Collider)) experiment at Brookhaven National Laboratory and the Cryogenic Underground Observatory for Rare Events (CUORE) experiment at Gran Sasso, Italy.

Our heavy ion physics program focuses on measurements of the nuclear modification factor and of elliptic flow (azimuthal angular anisotropy) for heavy quark (charm and bottom) and strange quark production in nuclear collisions. We are also interested in collective dynamics of bulk dense matter such as possible formation of meta-stable domains in nuclear collisions. Theoretical calculations predicted possible formation of microscopic domains where local parity symmetry may be violated. In nucleus-nucleus collisions the strong magnetic field created due to the incoming colliding nuclei could exert a chiral magnetic effect on quarks from the Quark-Gluon Plasma and may induce quark charge separation across the reaction plane of the collision. One of the STAR scientific highlights in 2010 is the observation of the charge separation effect in nucleus-nucleus collisions. We continue our experimental investigation of the charge dependent azimuthal angular correlations with respect to the reaction plane. Identification of the local parity violation in strong interaction would be an important discovery of fundamental QCD nature for bulk properties of quarks and gluons.

At STAR/RHIC we have successfully completed run 2010 with unprecedented data volume of Au+Au collisions at several beam energies. Our scientific goal is to understand the energy loss mechanism of quarks while traversing the dense matter created in nucleus-nucleus collisions and to search for possible critical point in the QCD phase diagram using a beam energy scan at RHIC. Our physics analyses centers on non-photonic electrons from heavy quark semi-leptonic decays, W/X particle production and multi-particle fluctuations and correlations.

Our recent spin physics result includes the first measurement of asymmetry for W decay electrons from polarized p+p collisions which is sensitive to polarization of up and down quarks. Our measurements of longitudinal double spin asymmetry (ALL) for jet production in polarized p+p collisions over the years have shown that the gluon contribution to the proton spin is relatively small. The spin decomposition of the proton remains a puzzle to be solved. The UCLA group has been responsible for the STAR barrel ElectroMagnetic Calorimeter (EMC) operation which is essential for the jet and electron measurements.

The CUORE is designed to search for neutrinoless double beta decay (0nbb) process in ^{130}Te . It uses 988 TeO_2 crystals operating in a large cryogenic refrigerator at 10 mK temperature located in the underground laboratory at Gran Sasso, Italy. The scientific goal is to reach the 0nbb sensitivity for an effective neutrino mass relevant to inverted mass hierarchy. The construction of the CUORE experiment has been approved by both INFN and US Department of Energy/National Science Foundation. The UCLA group is working on the CUORE electronics project. The construction is scheduled to complete in early 2013.

Four graduates finished their Ph.D. thesis research in 2010:



Dhevan Gangadharan on “Local Parity Violation in the Strong Interactions and Parton Collectivity in Au+Au Collisions at RHIC”, now post-doc at Ohio State University working on ALICE experiment at CERN LHC.



Priscilla Kurnadi on “Measurement of non-photonic electron cross section and double longitudinal spin asymmetry, ALL, in polarized p+p collisions at $\sqrt{s} = 200$ GeV”, now a research staff at Decision Sciences International Corporation working on imaging techniques related to homeland security.



David Staszak on “Measurements of the Jet Cross Section and Spin Asymmetry ALL using Polarized Proton Beams at RHIC”, now a post-doc at McGill University working on gamma ray astro-particle physics from VERITAS experiment.



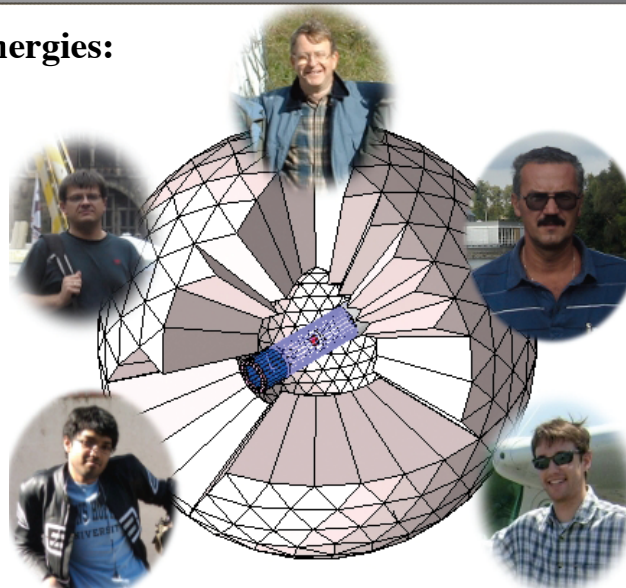
Bertrand Biritz on “Electron-hadron azimuthal correlations in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV”, now a post-doc at Weill-Cornell Medical College working on radiation oncology to become a medical physicist.

Nuclear and Particle Physics at Intermediate Energies:

Bernard Nefkens

The main objective of the Research and Teaching Group “Nuclear and Particle Physics at Intermediate Energies” is testing the validity of the symmetries that control the new features found in subatomic physics. Much work is done on determining the structure of the chief building block of our universe, the proton. The group is led by Bernard (Ben) Nefkens. Post doctoral researchers are Aleksandr (Sasha) Starostin and Serguei Prakhov. In 2009 two new postdoctoral researchers, Milorad Korolija and Alexander Lapik, started their collaboration with the group working part-time on the Crystal Ball project at Mainz, Switzerland where the group is spearheading a collaboration of some 12 universities in research on multi-meson photoproduction. Subject of John Goetz doctoral thesis is a search for doubly strange nucleons using the improved CLAS detector at Jefferson Laboratory. John has obtained the experimental data for his thesis in 2008 completing the preliminary analysis of the data in early 2010. Now he is finalizing the results which include production of the ground and the excited cascade states, search for the exotic five-quark cascade states, first attempt to look for the omega baryon photoproduction, and more. Sriteja (Teja) Upadhyayula joined the group in 2008 as a undergraduate Research Assistant. Teja's primary responsibility is to maintain the group's Linux computer cluster, which is heavily used for the data analysis as well as Monte Carlo simulation. In 2010 Teja got his bachelor degree with major in biophysics and now he is taking graduate classes at UC Riverside.

The group pursues two experimental programs. One is centered around a special detector, the Crystal Ball multi-photon spectrometer that has an acceptance of almost 4π steradian. It has been installed in the 1.5 GeV beam of tagged photons at the University of Mainz. This enables



Members of the group: from top, clockwise, Bernard Nefkens, Serguei Prakhov, John Goetz, Teja Upadhyayula and Aleksandr Starostin. Image on the background is the cover page of the Physical Review Letters issue 100 (2008), highlighting the first Crystal Ball article from MAMI “Incoherent Neutral Pion Photoproduction on C12”

measurements 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 photo production of selected neutral mesons with polarized and unpolarized beam and targets to probe the structure of the proton. The second program uses the large CLAS (CEBAF Large Acceptance Spectrometer) detector, which measures charged particles. This device is located in the 5.75 GeV tagged photon beam of Jefferson Laboratory. It is used to investigate cascade hyperons, which are rare, doubly strange baryon specimens. The cascade particles are particularly well suited to study the quark structure of the proton, probing the quark-quark correlations inside the proton.

Condensed Matter Theory

Elihu Abrahams

Elihu Abrahams' research is on the application of quantum many-body theory to understand the physical properties of strongly-correlated materials. These are compounds whose behavior is primarily determined by strong interparticle interactions that dominate the various contributions to the energy of the system. His recent research is on the new iron particle superconductors and on the so-called heavy-fermion metals. For the pnictides, there is some controversy as to what is the appropriate theoretical starting point. In a collaboration between theory and experiment, Abrahams and coworkers discussed [Phys. Rev. Lett. 104, 216405 (2010)] an iron-based oxychalcogenide compound that is closely related

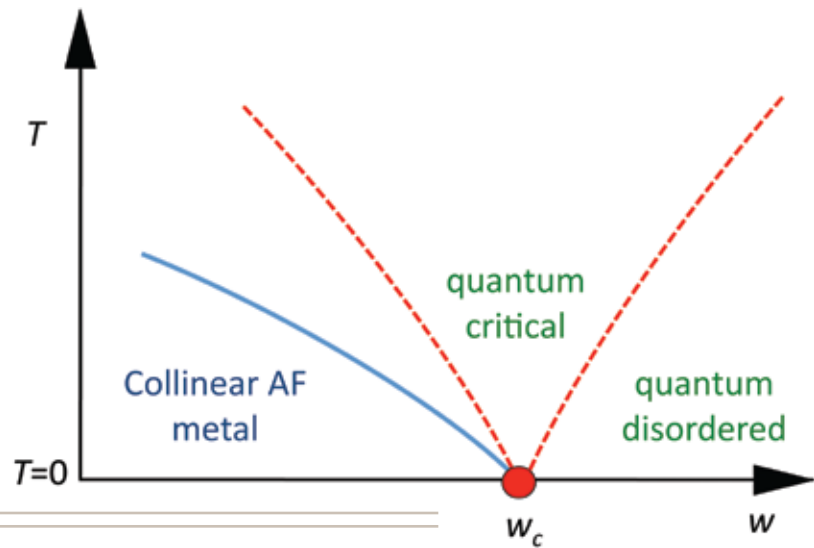
to the pnictides. This compound has such strong correlations that it becomes a “Mott insulator,” and this is compelling evidence that the related pnictides are themselves to be understood from a strong correlation viewpoint and that their phase diagram contains quantum critical points.

The experimental observation of electron spin resonance in the heavy-fermion compound ytterbium-rhodium-silicon (YRS) created much confusion about the nature of the phase diagram of this prototypical strongly-correlated material. Abrahams has collaborated with Peter Wölfle (Karlsruhe) on two papers that have shown how the theory

of the Fermi-liquid regime of the periodic Anderson model (the canonical starting point for the heavy-fermion physics) is consistent with the experiment, thereby laying the issue to rest. See Phys. Rev. B 80 235112 (2009).

Elihu Abrahams came to UCLA from Rutgers University at the end of 2009. He is a member of the National Academy of Sciences and the American Academy of Arts and Sciences.

Pnictide phase diagram near a quantum critical point tuned by a parameter w .



Condensed Matter Theory: Sudip Chakravarty

Sudip Chakravarty has been conducting research in the areas of high temperature superconductivity, strongly correlated electron systems, disordered systems, and dissipative quantum systems. Among his recent publications is the invited paper, in press, in Reports on Progress of Physics, where he discusses the key issues facing the field of high temperature superconductivity: arXiv:1006.4180.

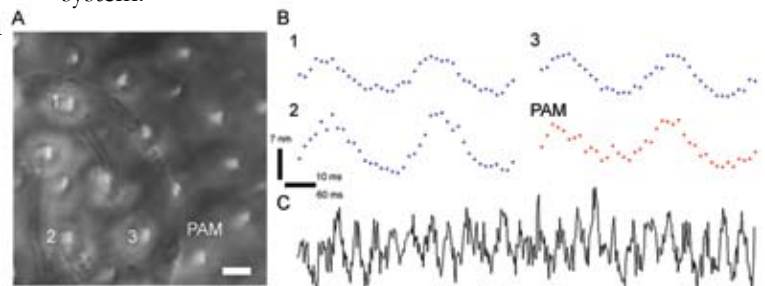
Chakravarty has been very active in understanding the startling magnetic quantum oscillations in high temperature superconductors. In June 2010 he co-chaired the Correlated Electron Systems Gordon Research Conference (<http://www.grc.org/programs.aspx?year=2010&program=correlec>), which was a tremendous success with a record number of participants. Chakravarty is also organizing the coming 2011 Aspen Winter Conference on “Contrasting Superconductivity of Pnictides and Cuprates” (<http://home.physics.ucla.edu/calendar/conferences/cm-sc-2011/index.htm>). The research group currently consists of six graduate students and one postdoc. Chakravarty is also mentoring two undergraduates in their senior year.

Soft Condensed Matter: Dolores Bozovic

The Bozovic laboratory has been exploring the role of inter-cell coupling in shaping the response of auditory systems. A significant discrepancy exists between the existing measurements of individual hair cells and the sensitivity observed *in vivo*. We are pursuing the hypothesis that the coupling between nonlinear oscillators could provide the missing link. To study this effect, we used semi-intact *in vitro* preparations, which preserve the overlying membrane – a thin gelatinous layer that connects to the tips of the stereocilia in hair cells and thus provides direct mechanical coupling. Using high-speed CMOS cameras, we were able to image movements of hair bundles through this overlying layer. Comparing the dynamic state of these cells before and after membrane removal, we showed that innate limit cycle oscillations observed in individual cells are suppressed in the coupled system. This indicates that under more natural loading, the system is poised close to the instability but within the quiescent regime.

We next used electrical stimulation to induce mechanical movements in hair cells, to probe whether phase-locked motion of a number of cells could provide sufficient force

to move more macroscopic overlying structures. This was studied in two ways. First, we used a preparation with the overlying membrane partially removed, so as to couple only hair cells of comparable orientations. Secondly, we used a hybrid preparation, with polylactide artificial membranes fabricated so as to couple only 10-20 hair cells. The electrical signals evoked movement in the hair bundles and both sets of overlying structures. These experiments served as a demonstration that if an external signal entrains the active motility of an number of hair bundles, the synchronized movement could lead to an instability in a much larger system.

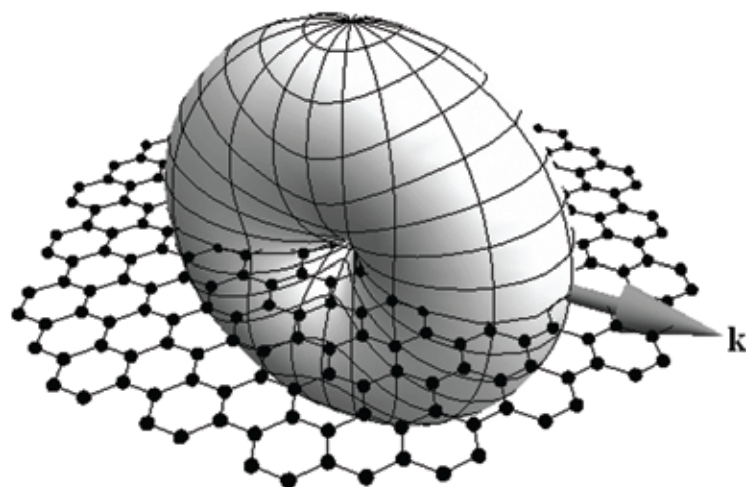


Hair bundles coupled to a polylactide artificial membrane (PAM). Scale bar, 5 mm.

Condensed Matter: B.C. (Chris) Regan

This year Chris Regan's group performed the first fully quantum-mechanical calculation of electron-photon interactions in graphene. This schematic, one of our results, shows the three-dimensional emission pattern of the photons produced when electrons in graphene (moving in the k direction) annihilate with holes. We also showed that Ohmic dissipation in perfect graphene can be attributed to spontaneous emission, and established the baseline requirements for building a graphene laser.

Tree-level electron-photon interactions in graphene: Mecklenburg, Matthew; Woo, Jason; Regan, B. C. *Physical Review B*, vol. 81, Issue 24, id. 245401 (June 2010)



Graphene, a single layer of graphite, is a two-dimensional network of carbon atoms arranged in a honeycomb lattice. This year's (2010) physics Nobel prize was awarded to Andre Geim and Kostya Novoselov for groundbreaking experiments on graphene

Neurophysics Group : Mayank Mehta

It is commonly believed that the mind is an emergent property of the activities of ensembles of neurons. But, we don't know what those emergent properties are and what the neural dynamics is. To address these questions, the Neurophysics group was recently established at UCLA. The goal of this group is to develop theories of emergent neural ensemble dynamics, test those theories using measurements of neural dynamics during behavior, develop analysis tools to interpret the data, and develop hardware to enable these experiments.

Mayank Mehta joined the neurophysics group in late 2009. Currently, his group has six graduate students and four postdocs, trained in engineering, neurobiology and physics (see image). Mayank has also established fruitful collaborations with Katsushi Arisaka with whom he co-supervises two graduate students (Daniel Aharoni, Bernard Willers). He collaborates with Robjin Bruinsma (Physics), Bahram Jalali (Electrical Engineering), Raphael Levine (Chemistry) and Alcino Silva (Genetics).

Since the completion of laboratory renovations in April 2010, Mehta laboratory has completed the construction of natural and virtual reality mazes to test the neural mechanisms of perception of space-time. They have also devel-



Mehta lab members: Left to right: Front row Prof. Mayank Mehta, Dr. Chanpreet Singh, Dr. Pascal Revassard, Ashley Kees, David Ho, Zhiping Chen; Second Row: Dr. Jesse Cushman, Daniel Aharoni, Bernard Willers, James McFarland, Dr. Daniel Bush, Stuart Servier, Jason Moore.

oped hardware to target distinct brain regions involved in perception of space and measured the activity of ensembles of neurons. On theoretical front, they have developed analysis tools to detect the instantaneous state of an ensemble of neurons and detect transitions between states in these neurons. In particular, they have developed a theory of how the brain activity oscillates between two states up and down during sleep and the potential role of these in learning the structure of space-time.

To support these activities Mehta submitted a grant proposal to NIH to measure and detect state transitions in the activity of neural ensembles. This has recently been funded. He is also supported by the NSF Career award and a grant from the Whitehall foundation.

Condensed Matter – Molecular Biophysics: Giovanni Zocchi

Biological macromolecules such as enzymes and DNA couple conformational motion to chemical reactions and ultimately function. Research in the Zocchi Lab is focused on probing and exploiting this mechano-chemical coupling, using forces and elastic energies to control chemical reactions [1]. With a DNA “molecular spring” we mechanically stress an enzyme, and measure the effect on the chemical reaction catalyzed by the enzyme. Now for the first time we coupled the DNA spring to different locations on the enzyme (Fig. 1) and determined in each case how the reaction rate is affected [2]. Standing on the shoulders of 50 years of structural studies of proteins, this work looks beyond the structural description at the dynamics, specifically the question of affecting reaction rates by mechanical forces.

Considering the above it is interesting to know the force delivered by a DNA “molecular spring”. It turns out this question is related to the following mechanical instability. A straight rod compressed longitudinally at first (for small

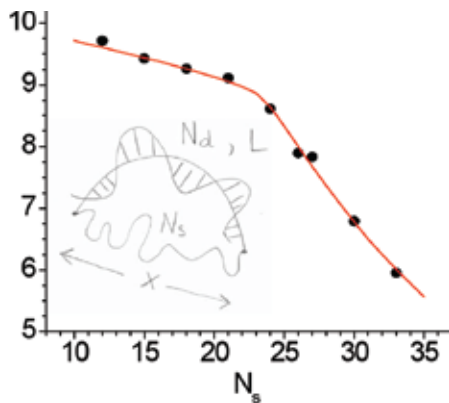


Fig. 1. A short piece of ds DNA tied at the ends by a short piece of ss DNA (inset) forms a molecule under stress (the ds DNA is forced to bend by the ss DNA, which is forced to stretch). The graph shows the elastic energy of this molecule measured for increasing N_s (the number of bases in the ss part). The kink in the graph corresponds to the formation of a kink in the ds part of the molecule.

force) remains straight, but will buckle at a critical force. This instability, or bifurcation, was first described mathematically by Euler. Considerations of the critical force enter for example in the design of support pillars in architecture.

In our experiments, we see a similar instability, but at the scale of molecules. A 6 nm long molecule of double stranded (ds) DNA is shown to develop a kink at a critical compressive force of about 3 pico Newtons (pN). The compressive force which buckles the ds DNA molecule is provided by a molecular spring, itself made of single stranded (ss) DNA. It is a system of two coupled nonlinear springs, at the molecular scale. The

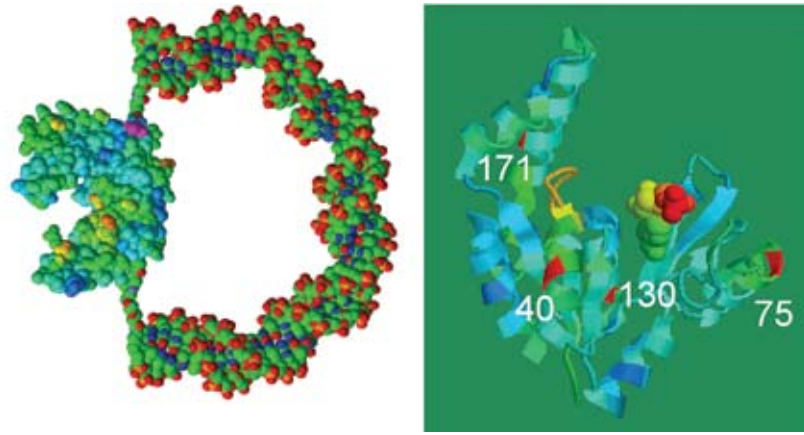


Fig. 2. A DNA “molecular spring” (greenish) coupled to the enzyme Guanylate Kinase (bluish) provides a mechanical stress (this structure is about 5 nm across). We stress the enzyme in different ways, by attaching the DNA spring at different locations, shown in red on the ribbon structure (drawn in space fill is a substrate of the enzyme).

achievement is to measure the elastic energy of this stressed molecule (Fig. 2), and from the elastic energy characterize the kink [3]. The study answers the long standing question in the physics of biopolymers of what is the elastic energy of sharply bent ds DNA.

Finally, in an unrelated fluid dynamics project, we introduced a simple but quantitative description of a complex everyday phenomenon, namely, the shape of (fair weather) clouds. Clouds are formed by convection currents, which also give rise to thermal plumes. Starting from a simple description of the plumes in terms of mathematical singularities (sources and sinks), we understand the shape of clouds in terms of thermal plumes. The cloud is a collection of droplets, advected by the flow field created by randomly generated plumes. Each time a plume goes through the cloud, it leaves behind a hump in the spatial distribution of droplets. This process dynamically generates the characteristic “cauliflower” shape of cumulus (“fair weather”) clouds.

The importance of this work is that it describes quantitatively one specific aspect (the shape) of a complex system (the cloud) starting from the coherent structures in the system.



Fig. 3. A generated cloud (light scattering inside the cloud is not taken into account).

Atomic, Molecular and Optical Physics

Eric Hudson Group

Constant Change

From global-positioning to cellular telephones to the synchronization of modern-day electrical power grids much of the world's most useful technology relies on the timing precision of atomic clocks for their daily operation. Despite their impressive precision, however, atomic clocks have been unable to conclusively answer one of the most interesting questions in fundamental physics: are the constants of nature actually constant? Current theories that attempt to unify gravity with the other fundamental forces as well as recent astrophysical measurements suggest that nature's constants may be variable; however, at the current level of precision, laboratory measurements have been unable to resolve any such variation.

To address this interesting problem, our laboratory is developing a new type of clock based on a nuclear transition inside the $A = 229$ isotope of thorium. A nuclear clock has several advantages over traditional atomic clocks. First, because atomic electrons screen the nuclear oscillator, detrimental environmental effects that limit atomic clock performance are removed. And second, because of the large interaction energies associated with the strong nuclear force, the clock frequency is roughly one million times more sensitive to any variation in the fundamental constants of nature. These

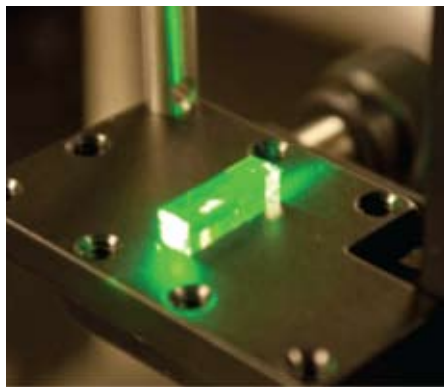


Fig. 1. Th:LiCaAlF₆ crystal under laser illumination. The nuclear clock will operate by locking the frequency of a vacuum ultraviolet narrowband laser to the absorption signal produced by the $A = 229$ thorium nuclei contained in the crystal.

traits combine to suggest it may be possible to measure e.g. any variation of the fine-structure constant α to better than 1 part in 10^{20} !

In the last year our project has constructed prototype fluoride crystals to be used as thorium host in the nuclear clock and partnered with Los Alamos National Laboratory, where the rare ^{229}Th isotope is available. Our collaboration is poised to open the field of nuclear optical clocks.

Extending the ultracold



Fig. 2. Ultracold calcium atoms held in a magneto-optical trap. The calcium atoms are used as refrigerant for molecular ions trapped inside the atomic cloud. The electrodes which comprise the ion trap are slightly visible at the periphery of the photograph.

Driven by the promise of the observation and control of many interesting phenomena, e.g. quantum chemistry, precision measurement, long-range topological order, and quantum computation, the field of ultracold molecule research now represents a significant fraction of AMO physics. However, despite this immense effort, progress has been slow. To date all of the proposed cooling methods have either been hampered by unexpected complications or are only applicable to restricted classes of molecules. Thus, the study of many of the aforementioned phenomena is still inaccessible to researchers.

An exciting solution to this problem is the study of ultracold molecular ions. Because molecular ions are easily trapped for many minutes (due to their excess charge), there are possibilities for cooling and interrogation that are not applicable to neutral molecules. Utilizing this feature, our lab has recently

proposed a new method to produce ultracold molecular ions via sympathetically cooling collisions with ultracold atoms. Similar to an ice cube cooling a drink, overlapping a cloud of ultracold calcium atoms with a cloud of trapped molecular ions quickly can cool the molecular ions to ~ 1 mK.

Over the last year we have constructed the necessary lasers and molecular ion cooling. Current work is focused on developing a laser thermometer for the ultracold molecular ions. Once the molecular ion temperature and cooling is characterized the project will begin to use the molecular ions to study several important ultracold chemical reactions as well as begin work towards implementing a chip-scale version of the ion refrigerator for use as quantum memory in a quantum computer architecture.

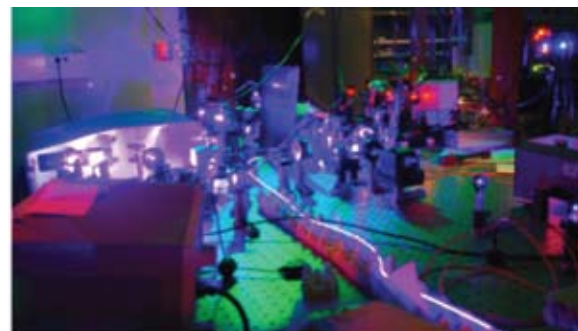


Fig. 3. Lasers used for cooling the calcium atoms to ~ 1 mK. The blue laser drives a strong cooling transition ($^1P \leftarrow ^1S$), while the red laser keeps the atomic population from decaying into dark states (1D and 3P states)

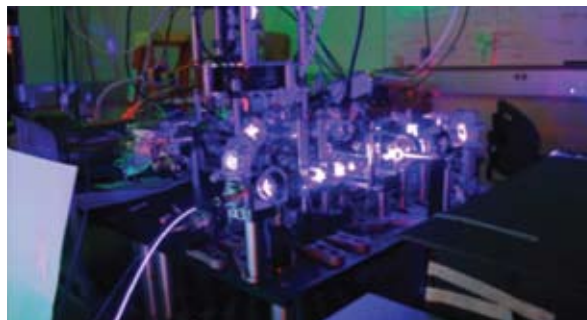
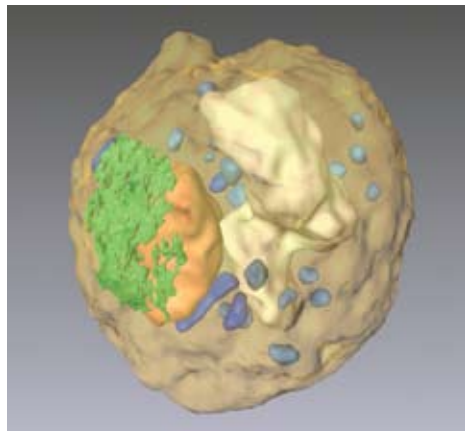


Fig. 4. Molecular ion refrigerator and laser cooling optics. Inside the vacuum chamber in the center of the photograph molecular ions are trapped and cooled by collisions with ultracold calcium atoms.

Coherent Imaging Group:

Jianwei (John) Miao

Microscopy has greatly advanced our understanding of biology. Although significant progress has recently been made in optical microscopy to break the diffraction-limit barrier, reliance of such techniques on fluorescent labeling technologies prohibits quantitative 3D imaging of the entire contents



Quantitative 3D imaging of a whole, unstained yeast spore cell at a resolution of 50–60 nm by using coherent x-ray diffraction microscopy.

of cells. Cryoelectron microscopy can image pleomorphic structures at a resolution of 3–5 nm, but is only applicable to thin or sectioned specimens. Now, the Miao group and collaborators report quantitative 3D imaging of a whole, unstained cell at a resolution of 50–60 nm by X-ray diffraction microscopy.

They identified the 3D morphology and structure of cellular organelles including cell wall, vacuole, endoplasmic reticulum, mitochondria, granules, nucleus, and nucleolus inside a yeast spore cell. Furthermore, they observed a 3D structure protruding from the reconstructed yeast spore, suggesting the spore germination process. Using cryogenic technologies, a 3D resolution of 5–10 nm should be achievable by X-ray diffraction microscopy. This work hence paves a way for quantitative 3D imaging of a wide range of biological specimens at nanometer-scale resolutions that are too thick for electron microscopy. This paper was published in *Proceedings of the National Academy of Science USA* 107, 11234–11239 (2010). Researchers from the Miao group, Huaidong Jiang, Chien-Chun Chen, Rui Xu, Kevin Raines, and Benjamin Fahimian, have contributed to this work. Other collaborators include Prof. Fuyuhiko Tamanoi's group from Department of Microbiology, Immunology, and Molecular Genetics at UCLA, Dr. Changyong Song and Professor Tetsuya Ishikawa from RIKEN SPring-8 Center, and Professor Ting-Kuo Lee's group from Academia Sinica.

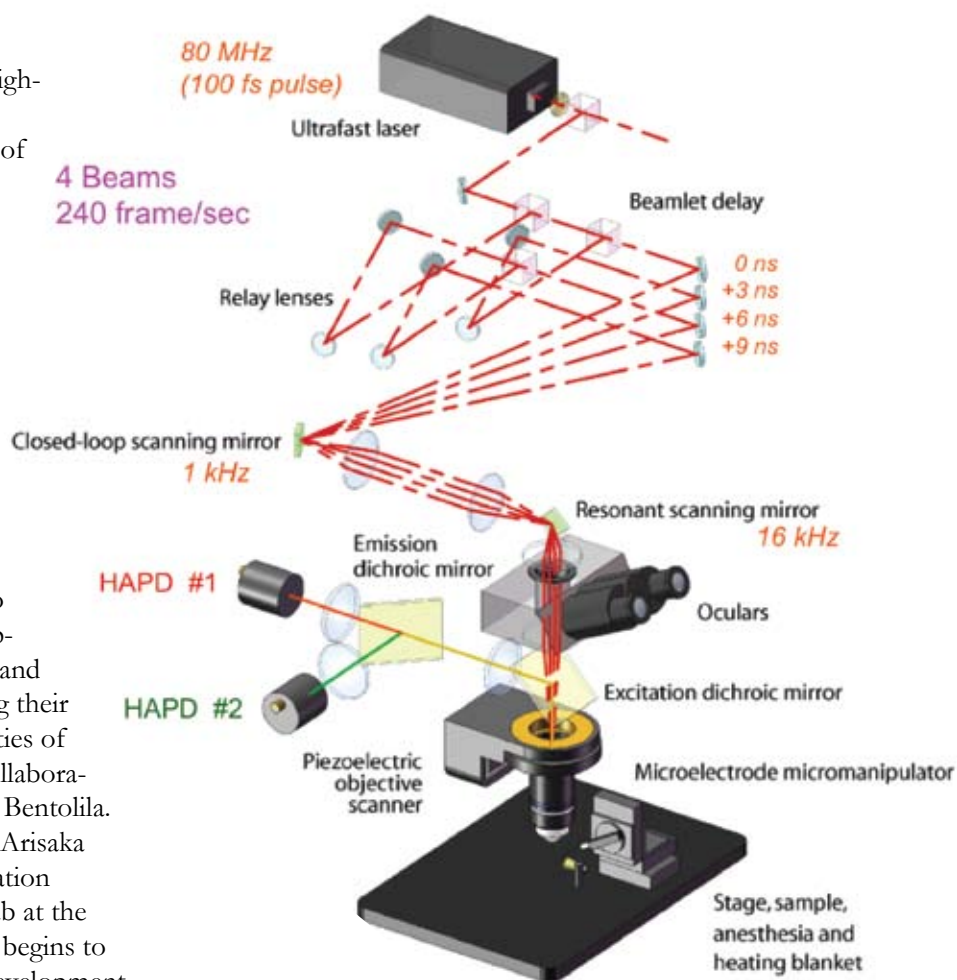
Biophysics:

Katsushi Arisaka

Prof. Katsushi Arisaka continues to work on high-speed bio imaging, utilizing state-of-the-art photon detectors from particle physics. After three years of research and development (supported by National Science Foundation (NSF), Major Research Instrumentation (MRI) and National Institute of Health (NIH)), two major developments have been completed: 1) Ultra high-speed CMOS camera with Image Intensifier (with GaAsP photocathode with 50% Quantum Efficiency) at > 1,000 frame/s; and 2) Two-photon excitation microscope with Hybrid APD at 240 frame per second.

Collaborations with Photron (the world leader of high-speed cameras) and Hamamatsu Photonics (the world leader of photon detectors) were so successful that both companies donated their equipment to California NanoSystems Institute (CNSI), and they became official industrial partners. By utilizing their in-kind contributions, Arisaka has set up user facilities of ultra high-speed optical microscopes at CNSI in collaboration with Professor Shimon Weiss and Dr. Laurent Bentalila.

Dr. Adrian Cheng (Ph.D. in Physics 2010) and Arisaka have developed the world fastest two-photon excitation microscope at Professor Carlos Portera-Cailliau's lab at the Medical school. The system is fully functional and begins to produce exciting scientific data to investigate the development of neural networks in the infancy of mice.



The world's fastest two-photon excitation microscope, developed by Adrian Cheng, Katsushi Arisaka, and Carlos Portera-Cailliau.

Elementary Particle Physics: Katsushi Arisaka, David Cline, Bob Cousins, Jay Hauser, David Saltzberg and Rainer Wallny

This year saw the christening of the first new accelerator in 25 years at the energy frontier of particle physics, the Large Hadron Collider (LHC) at the CERN laboratory near Geneva, Switzerland. UCLA elementary particle physicists Katsushi Arisaka, Dave Cline, Bob Cousins, and Jay Hauser have participated in the excitement with the Compact Muon Solenoid (CMS) experiment. Starting in March 2010, proton-proton collisions were produced at 7 trillion electron-volts of energy and with greatly increasing intensity.

The UCLA team has concentrated much of its work on muon particle detection, starting in the mid-1990s with Cline and Hauser participating in the early construction of muon chambers and electronics. The team now participates in many aspects of running the complex detector, and is now heavily involved in the data analysis phase of the experiment.

Already, all of the known elementary particles have been seen by CMS (Fig. 1), and 2011 promises to bring an exciting hunt for the Higgs Boson, the long-sought-after agent

thought to give other elementary particles their masses.

This year and next, Hauser is Project Manager for the CSC muon detector, while staff scientists Gregory Rakness and Mikhael Ignatenko are the CSC Operations and Detector Maintenance managers, respectively. An unfolded map of particle positions (Fig. 2) shows that nearly the entire CSC muon detector is reporting high quality data.

After serving for three years as Deputy Spokesperson of the CMS experiment, Cousins is now deeply involved in data analysis. Meanwhile, staff scientist Viatcheslav Valuev is co-convenor of the muon Physics Object Group. The excellent preparatory work of this group is

evidenced by Fig. 3, which shows the angles of muons in the most common “minimum-bias” type of proton-proton collision – curves are shown for prior simulations that very well reproduce the data.

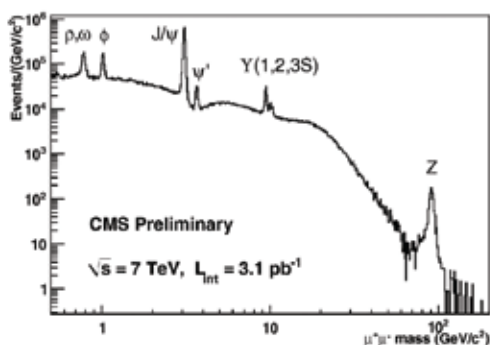


Figure 1: Various particles composed of quark-antiquark pairs (and the Z boson particle) manifest themselves as peaks in the di-muon mass spectrum as seen with the first data from CMS.

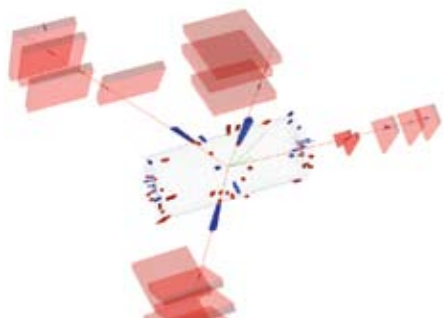


Figure 2: An event in CMS that contains four candidate muon particles. Each of the two pairs of muon particles results from the decay of a Z boson particle.

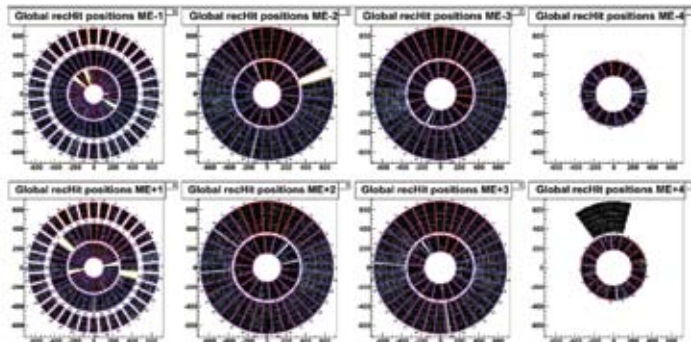


Figure 3: A particle occupancy map shows that nearly all of the CSC muon detector is alive and functioning as expected.

A particularly nice event containing two Z bosons, each of which decays to two muons was recently collected and is shown in Fig. 4. This signature, in fact, is a major background in the Higgs Boson search.

Postdoc Amanda Deisher recently won a CMS Achievement award for her work to improve the internal timing and synchronization of the muon detection system. Through diligent application of timing corrections and by hunting down and fixing faulty information from the apparatus, she managed to considerably improve the timing of the muon detector (Fig. 5) to a few nanoseconds accuracy.

In the search for physics beyond the Standard Model, Bob Cousins, together with Valuev and graduate student Jordan Tucker have made improvements to CMS standard track finding algorithms and are already searching for hints of extra Z' gauge bosons. Postdoc Chad Jarvis is searching for extra W' gauge bosons, and graduate student Chris Farrell is using the newly precise muon timing from Deisher's work to look for heavy stable particles predicted by some theories of Supersymmetry. Deisher and Charles Plager are studying top quarks in preparation to search for anomalies in event signatures including leptons, jets and missing transverse energy, which could be indicative of a dark matter candidate particle.

The UCLA hadron collider group looks forward to a much increased rate of proton-proton collisions and possibly higher collision energy to yield exciting discoveries in 2011.

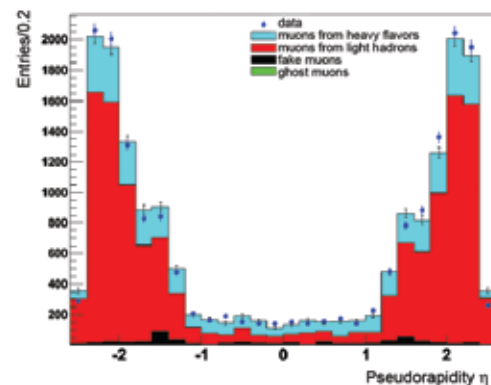


Figure 4: Muon particle angles in proton-proton collisions, as compared with prior simulations. Technically what is plotted is a function $\log(\tan(\theta/2))$ where θ is the angle from the beam line.

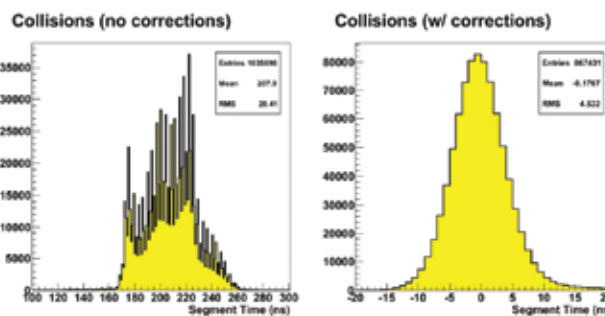


Figure 5: Muon chamber timing as measured with CSC muons from proton-proton collisions: before (left) and after (right) corrections.

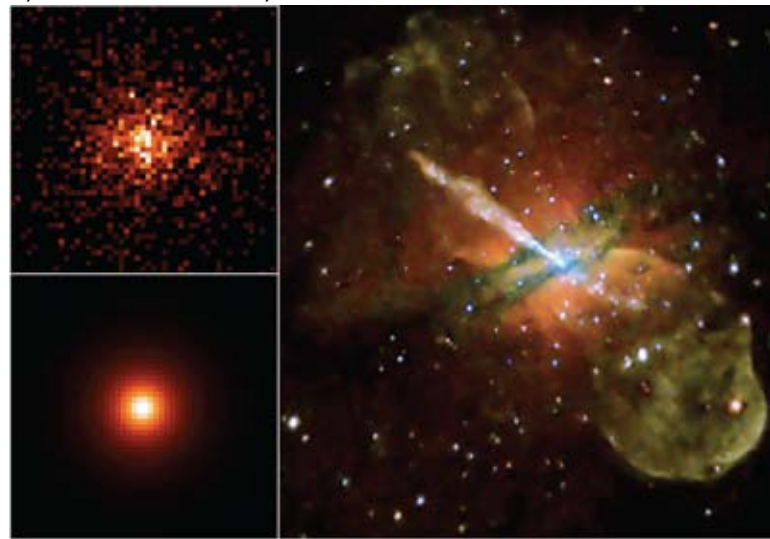
Theoretical Elementary Particle Physics and Astrophysics:

Alexander Kusenko

Dr. S. Ando (Caltech) and Alexander Kusenko have made a discovery and the first measurement of intergalactic magnetic fields, using the data from Fermi Gamma-Ray Space Telescope. Their results are published in *Astrophysical Journal Letters*. The discovered universal femtogauss fields permeate deep space, probably, since long before the stars and galaxies have formed.

Kusenko, Antoine Calvez a UCLA student, and S. Nagataki a physicist from Kyoto University, have found compelling evidence of natural nuclear accelerators, such as gamma-ray bursts in the past in our own galaxy. In the paper published in *Physical Review Letters* (and featured in *Nature* highlights), they show that such galactic sources are necessary to explain the cosmic-ray data from Pierre Auger Observatory.

Warren Essey and his advisor Kusenko have found a link between the observed gamma-ray signals from distant sources and the cosmic rays produced by supermassive black holes consuming stellar matter in other galaxies. The surprising connection explains the observed spectra of the brightest gamma-ray sources in the universe and sheds new light on cosmic backgrounds and magnetic fields. Their



The Force? A composite image of 170 supermassive black holes like this one (right) proved fuzzier in reality (upper left) than predicted by computer models (lower left). Credit: Source: NASA; (insets, top and bottom) S. Ando and A. Kusenko, *The Astrophysical Journal Letters* (October 10, 2010)

results are published in *Astroparticle Physics* and in *Physical Review Letters*.

UCLA graduate students Antoine Calvez and Warren Essey were invited to make oral presentations of their results, published in *Physical Review Letters*, at two major international conferences, “TeV Particle Astrophysics 2010” in Paris, and SnowPAC 2010 in Snowbird, Utah

Theoretical Elementary Particle Physics:

Christian Fronsdal

Christian Fronsdal, at first stimulated by the problem of dark stars and black holes, has started an ambitious investigation of the relation between General Relativity and Thermodynamics. The first papers on stellar structure opened many questions about thermodynamics, notably the problem of finding a thermodynamical action principle. A series of 4 papers discussed the action principle with application to atmospheres, stability of polytropic stellar structures, mixing and changes of phase. A new paper, finally taking up the fusion of thermodynamics and general relativity directly, is in progress.

“Growth of a Black Hole”, *J. Geom. Phys.* 57, 167-177 (2006). “Ideal Stars and General Relativity”, *Gen.Rel.Grav.* 39 1971-2000 (2007). “Cosmology with an Action Principle” (in preparation). “Stability of Polytropes”, *Phys.Rev. D* 77 (2008). Reissner-Nordstrom and Charged Polytropes, *Lett./Math.Phys.* 82, 255-273 (2007) “Heat and Gravitation. I. The Action Principle”, to be submitted for publication. “Heat and Gravitation. II Stability” *Gen.Rel.Grav*, September 2010. “Heat and Gravitation. III Phase change”, in preparation.

Basic Plasma Physics:

Reiner Stenzel and Manuel Urrutia

In Basic Plasma Physics the discovery of new instabilities makes a main contribution. Two such instabilities have been observed. The first is an electron drift wave instability around a spherical electrode in a magnetized plasma. Energetic electrons are trapped in a ring around the positive sphere (fig.1). Their transit time through the magnetized sheath across the field matches the drift velocity of a wave around the sphere which leads to an absolute instability.

The second instability arises in a fireball created in a gridded hollow anode (fig.2). A strong instability arises from the spherical counter-streaming electrons. The oscillation period corresponds to the electron transit time through the sphere. The

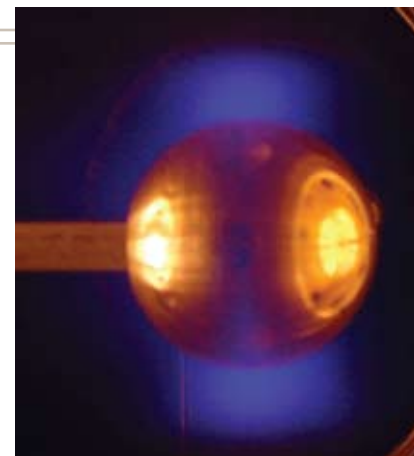


fig.1

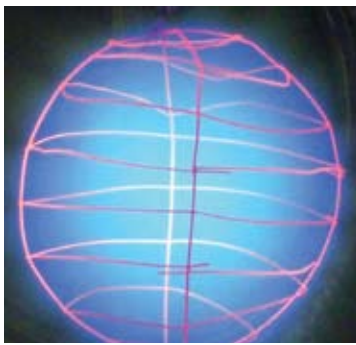


fig.2

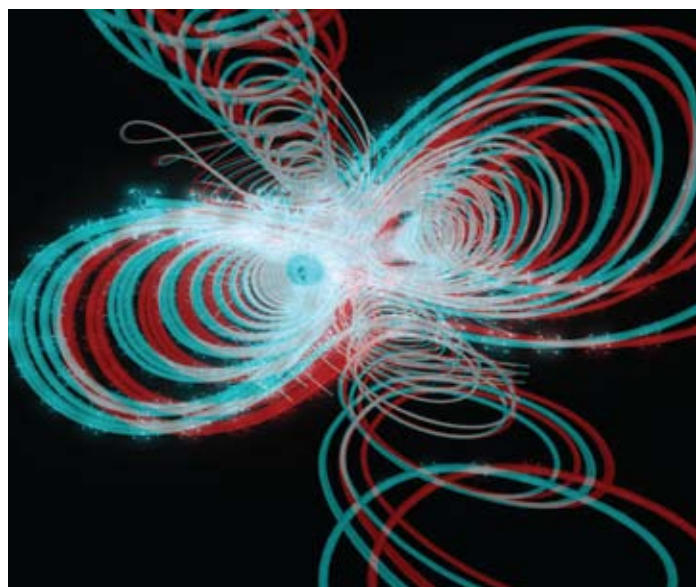
physics is similar to wave-particle interactions in reflex klystrons or vircators.

Finally, our group has also studied whistler wave propagation in nonuniform magnetic fields. On closed field lines oblique whistlers with parallel group velocity are trapped. Their phase velocity is oblique. Eigenmodes along and across the field lines form two-dimensional standing wave patterns.

Large Plasma Device (LAPD) Plasma Group: Walter Gekelman

This has been a productive year for the LAPD group and the Basic Plasma Science Facility. We have published four Physical Review Letters with one presently in review. Papers have also been published in the Physics of Plasmas, the Review of Scientific Instruments, Physica Scripta and Radio Science. These have covered a wide range of topics such as: a laboratory simulation of a solar flare (Shrikrishna Tripathi, Walter Gekelman, picked up by Wired Online Magazine); measurement of ion distribution functions in space and time in a plasma processing tool (Brett Jacobs, Gekelman); the first experimental measurement of a quasi-separatrix layer (E. Lawrence, Gekelman); measurement of standing waves over a wafer in a processing tool (Gekelman, M. Barnes, Pat Pribyl, Steven Vincena); 3D studies of a diamagnetic “bubble” produced in a laser plasma experiment (Andrew Colette, W. Gekelman); studies of Alfvén waves in multi-species plasmas (Vincena, George Morales, James Maggs); study of Debye scale size electron holes, (B. Lefebvre et al, this involved microscopic probes grown by micro-electric mechanical system (MEMS) techniques in the school of Engineering); and development of a large, high emissivity plasma source (Christopher Cooper, Gekelman). Three students received their doctorates last Spring (Andrew Collette, E. Lawrence, Brett Jacobs) and all landed great jobs. The group has a plenary review talk to be given by Gekelman at the Fall American Physical Society (APS) meeting and two graduate students have invited talks at that meeting. The review talk will be given in 3D. The figure

below is an anaglyph (which will also be on the cover of the APS bulletin) that you need red/blue glasses (get them at any 7-11) to see. The BaPSF User facility had a successful site visit this summer past and we were told by our funding agencies that the facility would be renewed.



Magnetic field lines of shear Alfvén waves produced 1.6 microseconds after the collision of two laser produced plasmas in a background magnetoplasma. The image is derived from vector magnetic field data acquired at 18,000 spatial locations and at 16,000, 10 ns intervals. The background magnetic field (not shown) is out of the plane of the image. The transverse dimensions are 30X30 cm. The inductive electric field is calculated from the time varying magnetic field and is rendered as sparkles on the field lines. There is a reconnection region in the center of the figure which coincides with the generation of large electric fields--the brighter the sparkle the higher the field. Image courtesy of Walter Gekelman, Stephen Vincena

Particle Beam Physics : Gil Travish

Gil Travish and his team have extended their efforts to develop a novel “particle accelerator on a chip”. The device—the Micro Accelerator Platform (MAP)—finds applications in x-ray and gamma-ray production which would be suitable for cancer therapy, industrial inspection and security applications (a more detailed description of the MAP can be found in the feature article, page 3). In addition to the three-year grant from the Defense Threat Reduction Agency (DTRA) awarded last year, this year Travish has obtained a grant from the Department of Energy and National Nuclear Security Administra-

tion (DOE/NNSA) to consider applications such as radio-nucleotide replacement in industrial inspection which aids in the nation’s non-proliferation mission. UCLA spin-off RadiaBeam Technologies also continues to explore a version of the MAP relevant to high-energy colliders through a DOE Phase II SBIR. In addition, this year, Radius Health, a member of UCLA’s CNSI Incubator, has licensed related technology invented by Travish, James Rosenzweig and long-time collaborator, Professor Yoder (Manhattanville College). The company is seeking to develop flat-panel x-ray sources as would be used in medical imaging.

This past year, the MAP team has seen the undergraduate graduation of Alfonse Pham, Ninel Vartanian and Esperanza Arab. Alfonse has continued on to a Ph.D. program in physics at University of Indiana. Ninel continues with the UCLA family in a master program in the school of engineering. Esperanza is off traveling the world. Last summer's REU student David Fong graduated from Occidental College and has joined UCLA in a graduate program in the School of Engineering.

In addition to Josh McNeur (Graduate Student), the team

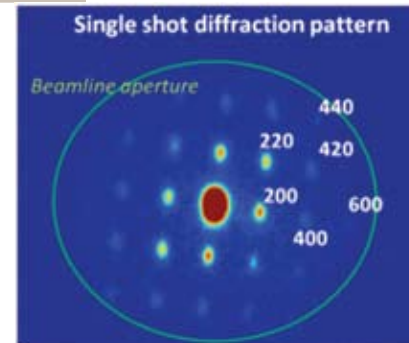
has been enhanced with the addition of Jianyun Zhou (Post-doctoral Scholar), Hristo Badakov (Staff Engineer); and, James Allen, Nestor Carraza, Ritika Dussad (Undergraduates). The team also had the privilege of working with visiting scholar Huarong Gong (Chengdu University) and REU student Peyton Rose (College of William and Mary).

Particle Beam Physics : Pietro Musumeci

The Pegasus photoinjector Laboratory led by Pietro Musumeci continued to make progress in the generation and application of high brightness ultrashort electron beams. A recent paper on experiments carried out at Pegasus pointed out that multiphoton photoemission can be very efficient in generating large amounts of electrons from a cathode if the laser intensity is sufficiently high. Usually electrons in photoguns are obtained by illuminating metallic cathodes with ultraviolet photons to overcome the material work-function. It turns out that due to multiphoton photoemission it is possible in the case of intense ultrashort laser pulses to eliminate the lossy frequency upconversion stage and illuminate the cathode directly with infrared laser photons and obtain very large charge yields. These results can make significant changes in how photoinjector driver laser systems are designed.

Another significant result achieved this year by our group was the experimental demonstration of the use of ultrashort electron beams with MeV energy from an RF photoinjector

to investigate the ultrafast laser induced dynamics in a single crystal gold sample. Prior to this development, ultrafast structural dynamics studies could only be conducted by using bunches containing only few electrons to limit the space charge induced pulse-lengthening. This required the integration over many pulses to obtain a single diffraction pattern. In the novel relativistic electron diffraction technique demonstrated at UCLA, Musumeci and collaborators took advantage of the suppression of space charge effects at high electron energy and were able to follow the sub-ps heating and melting dynamics of the sample by taking single-shot diffraction patterns (see figure) at different delays between a 400 nm pump pulse that initiated the material dynamics and the probing electrons.

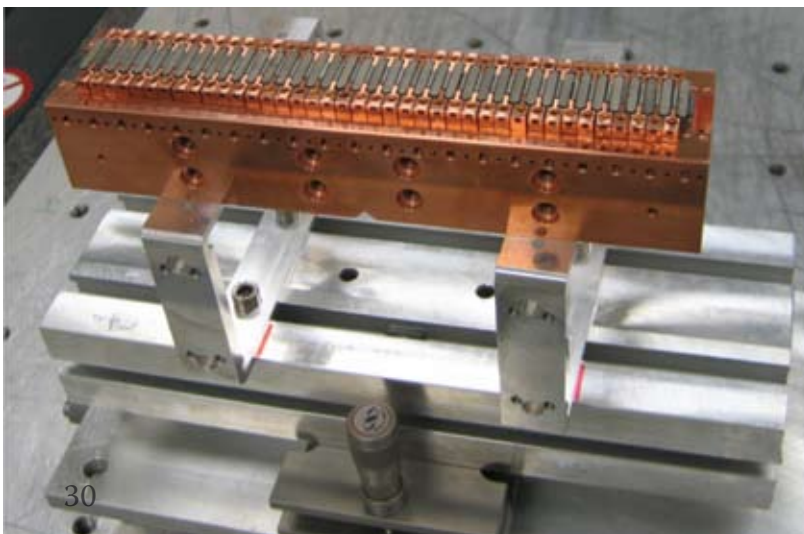


Single shot diffraction pattern obtained with 100 fs relativistic electron beam at the UCLA Pegasus photoinjector.

Particle Beam Physics : James (Jamie) Rosenzweig

At the end of the 2009-10 academic year, James (Jamie) Rosenzweig made the transition to department chair, but has maintained a vigorous research program as director of the Particle Beam Physics Laboratory. His group has mounted numerous experimental and theoretical campaigns in diverse

areas of ultra-fast, high field beam physics: single component plasma microbunching instability; coherent Cerenkov radiation, angular momentum in FEL modes; inverse Compton scattering, GeV/ per meter dielectric wake-field acceleration and TeV/m plasma wake-field acceleration. Much of this effort is geared at reinventing, through new physical principles and technology, both high energy frontier accelerators and free-electron lasers, as discussed in more detail in this report's feature article. In the service of these goals the PBPL program engages in advanced instrument development, currently exemplified by such as high field radio-frequency photoinjectors, and novel cryogenic undulators. This latter type of device is being developed in the context of Max-Planck Institute of Quantum Optics, Ludwig-Maximilians Universität (LMU) Garching, Germany, centered collaboration, which has as a motivating dream, a table-top-terawatt soft X-ray free-electron laser.



One-half of ultra-high field, short wavelength praseodymium-based cryo-undulator for table-top X-ray FEL designed at UCLA PBPL, under assembly and testing at HZ-Berlin.

The Computer Simulations of Plasma Group : Warren B. Mori, Adjunct Professors Viktor Decyk, and Phil Pritchett

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 includes three research physicists (Frank Tsung, John Tonge, and Lu), two post-doctoral researchers, and six Ph.D. students. Its research remains focused on the use of fully parallelized particle based simulation models to study laser and beam plasma interactions, space plasmas, Alfvénic plasmas, and high-energy density science. The group specializes in particle-in-cell (PIC) techniques and continues to develop and maintain over five separate state-of-the-art PIC simulation codes, OSIRIS, PARSEC, Magtail, QuickPIC, and the UPIC Framework. These codes are used throughout the world and are run on as many as 300,000 processors on some of the world's fastest computers.

The group recently received \$1.78 million from the National Science Foundation (NSF) to develop a cluster of 192 General Purpose Graphical Processing Units to compute at “Warp” speed. The project is titled, “Acquisition of a GPU-Based Cluster for Plasma, High-Energy Density, and Computational Science at UCLA”. The Computer Simulations of the Plasma group has also been awarded a new NSF Collaborative Research Grant on “Graduate Student Training Through Research on Plasma-Based Accelerators.” In the past year, the group also received several Innovative and Novel Computational Impact on Theory and Experiment (INCITE) Awards that provides access to the largest computers managed by the Department of Energy (DOE). The Awards are in plasma-based acceleration and in fast ignition fusion. We continue to be affiliated with DOE Scientific Discovery through Advanced Computing (SciDAC) grants titled, “Community Petascale Project for Accelerator Science and Simulation” (COMPASS), and “Center for Gyrokinetic Particle Simulation of Turbulent Transport in Burning Plasma,” as well as a DOE Fusion Science Center (FSC) on “Extreme States of Matter and Fast Ignition Physics”.

Advances continue to be made in the field of plasma-based acceleration. In the past year, together with our close collaborators at the Instituto Superior Técnico (IST) in Portugal, we have confirmed our own scaling laws using a novel computational technique in which the calculation is done in a Lorentz boosted frame (see figure 1). This work was

published in Nature Physics and highlighted in the National Energy Research Scientific Computing Center (NERSC) annual report (http://www.nersc.gov/news/annual_reports/annrep0809/research_news/Reframing_Accelerator.html) and in the MIT technology review (<http://www.technologyreview.com/blog/mimssbits/25635/?ref=rss>). We have also made progress in designing experiments for the new FACET facility being built at the Stanford Linear Collider. We have collaborated on proposing and testing in simulations a new method for injecting particles into the plasma wave wakes.

The group continues to be actively engaged in simulating laser plasma interactions of interest to inertial confinement fusion (ICF) energy. The National Ignition Facility (the world's largest laser) was recently commissioned and its aim is to demonstrate inertial confinement fusion. We have developed a new understanding of how lasers generate plasma waves as they propagate towards their target. This includes studying fundamental questions related to large amplitude plasma waves and how their energy is converted into very energetic electrons which are not desirable in ICF. Examples are shown in figure 2. We have also studied how an intense laser is absorbed at a steep interface near the density of a solid. We have found a new absorption mechanism which

helps to predict the spectrum of electrons. This work is also of relevance to the acceleration of ions in laser-solid interactions. Modeling the kinetic aspects of fast ignition is daunting due to the large range of time, length, and density scales. Recently, together with our collaborators at IST we have incorporated a new hybrid model into our code OSIRIS. It has the potential to speed up our calculations by more than a factor of 300. We are also developing new algorithms for particle-in-cell codes that can run on graphical processing units (GPU). These units have hundreds of processing cores and they are the basis for high end video games. They have the potential of greatly speeding up scientific calculations but programming is harder to do than a standard central processing unit (CPU). Our new algorithms on GPUs show speed ups by as much as 50 from a traditional CPU. We will use these new algorithms on our new NSF funded cluster once it is built. The next year promises to be very exciting.

Last, we are happy to report that Viktor Decyk received the John Dawson Award at the International Conference on the Numerical Simulation of Plasma “for his pioneering advances to plasma physics obtained through simulation,” and Mr. Ian Ellis was selected to be a Lawrence Scholar.

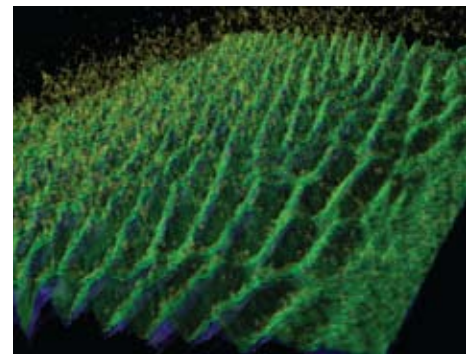


Figure2: A sea of plasma waves generating by the coupled stimulated Raman scattering instability and the two-plasmon decay instability (green) and the white water of trapped electrons generated as the plasma waves break.

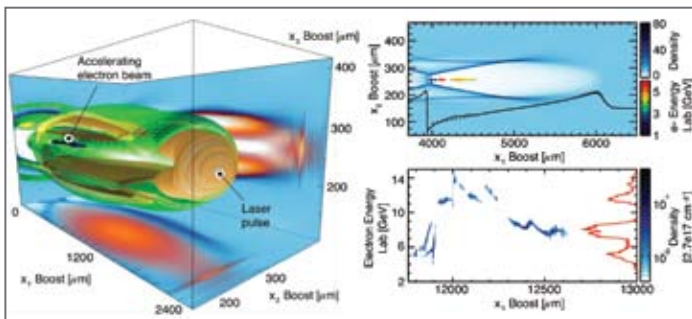


Figure 1: On the left, isosurfaces of the laser pulse, plasma density, and accelerating electron beam. On the right contour plots of the plasma density and electron beam and a lineout of the accelerating field (top) and the energy of the electron beam (bottom).

Professors

Elihu Abrahams (Adjunct Professor)
 Katsushi Arisaka
 Maha Ashour-Abdalla
 William Barletta (Adjunct Professor)
 Zvi Bern
 Stuart Brown
 Robijn Bruinsma
 Sudip Chakravarty
 David Cline
 Ferdinand V. Coroniti -
 Department Chair
 Robert Cousins
 Eric D'Hoker
 Sergio Ferrara
 Christian Fronsdal
 Walter Gekelman
 Graciela Gelmini
 Andrea Ghez
 George Grüner
 Jay Hauser
 Károly Holczer
 Huan Huang
 Hong-Wen Jiang
 Michael Jura - Vice Chair of
 Academic Affairs
 Per Kraus
 Alexander Kusenko
 James Larkin
 Matthew Malkan
 Thomas Mason
 Ian McLean- Vice Chair of
 Astronomy and Astrophysics
 Jianwei Miao
 George J. Morales
 Warren Mori
 Mark Morris
 William Newman
 Rene Ong
 C. Kumar N. Patel
 Roberto Peccei -
 Vice Chancellor for Research
 Claudio Pellegrini
 Seth J. Putterman
 James Rosenzweig -
 Vice Chair of Resources
 Joseph A. Rudnick -
 Dean of Physical Sciences
 David Saltzberg
 Reiner Stenzel

Terry Tomboulis
 Jean Turner
 Roger Ulrich
 Charles A. Whitten
 Gary A. Williams
 Edward Wright

Associate Professors

Troy Carter
 Michael Gutperle
 Brad Hansen
 Mayank Mehta
 Jianwei Miao
 Thomas Mason
 Alice Shapley
 Yaroslav Tserkovnyak
 Vladimir Vassiliev
 Rainer Wallny
 Giovanni Zocchi

Assistant Professors

Dolores Bozovic
 Michael Fitzgerald
 Steven Furlanetto
 Eric Hudson
 Pietro Musumeci
 Christoph Niemann
 B. Chris Regan

Professors Emeriti

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

Researchers

Viktor Decyk
 Weixing Ding
 Samim Erhan
 James Maggs
 William Peebles
 Philip Pritchett
 Terry Rhodes
 R. Michael Rich
 Gil Travish
 Steven Trentalange
 Hanguo Wang

Associate Researchers

Luca Bertello
 Lothar Schmitz
 Frank Tsung
 Stephen Vincena

Assistant Researchers

Carmen Constantin
 Neal Crocker
 Xiaoping Ding
 Mikhail Ignatenko
 Huaidong Jiang
 Wei Lu
 Shoko Sakai
 Alexandr Starostin
 John Tonge
 Shreekrishna Tripathi
 Bart Van Compernelle
 Jeffrey Zweerink



Michael Fitzgerald

After being hired in 2009, Michael Fitzgerald joined the department full-time in July 2010.

Mike has had a long-term interest in the use of adaptive optics technology for high-contrast imaging study of planet formation, including direct imaging of young exoplanets and circumstellar debris disks.

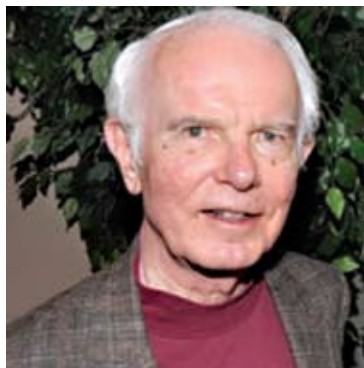
He received his Ph.D. in 2007 from the University of California, Berkeley with a dissertation titled, "Revealing Planet Formation: Technique, Observation, and Analysis."

After graduation he was a Michelson Postdoctoral Fellow at Lawrence Livermore National Laboratory, where he worked with Bruce Macintosh (Ph.D. '94), the Principal Investigator of the Gemini Planet Imager.

Mike is continuing his high-contrast imaging research, in part as a member of the Gemini Planet Imager science team. He will be applying his planet-detection experience to future instrumentation projects as a member of the Infrared Laboratory.

John Cornwall 75th Birthday Celebration- November 14-15, 2009

John Cornwall's 75th Birthday - was celebrated by UCLA Department of Physics & Astronomy with a conference on "Quantum Field Theory and Beyond" Attendees came from as far away as Kobe University in Japan, China and Rio de Janeiro, Brazil. Mike Cornwall has been a faculty member at UCLA since 1965, where he does his research in elementary particle theory. To read about the many accomplishments of John Cornwall, please visit: <http://home.physics.ucla.edu/calendar/conferences/cornwallfest/about/>



Joseph A. Rudnick, former Chair of the Department of Physics & Astronomy (2004-06) was appointed Dean of the Division of Physical Sciences in the College of Letters and Science effective August 1, 2009. Dean Rudnick had been serving as acting dean of the Division of Physical Sciences since October 2006.

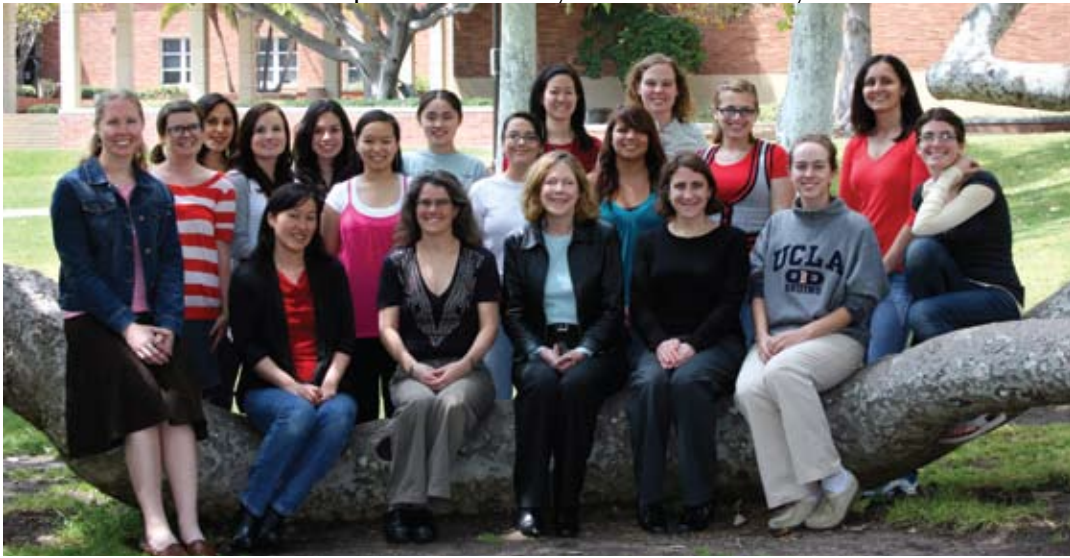
Robert Cousins presented a talk on "The Big Bang Machine at CERN outside Geneva, Switzerland" to an audience of more than 500.

At UCLA Covel Commons on March 31, 2010 Robert Cousins presented a talk which was jointly organized by UCLA, Department of Physics and Astronomy and the Division of Physical Sciences, and the Swiss Consulate General in Los Angeles, on the Large Hadron Collider, world's largest science experiment.

Cousins, who spent three years at CERN as a deputy to the leader of one of the huge experiments at the Large Hadron Collider, presented the goals of revolutionizing elementary particle physics and the implications for our understanding of the Big Bang and dark matter.

For more information and to see slides of talk go to: <http://events.pna.ucla.edu/lhc/>





Women Astronomy faculty, surrounded by astronomy undergraduate and graduate students, post-doctoral scholars and researchers.

WOMEN & ASTRONOMY

Astronomy is one of the most ancient of all the sciences and has fascinated humankind since we first looked up at the night sky. Nowadays people are becoming increasingly aware of the study of celestial objects and phenomena as astronomers discover more about the mysteries of the universe. Up until early in the 20th century, noted astronomers were mostly men, but women began to play a greater role in the field from then on. On May 25, 2010, the UCLA Planetarium hosted 50 guests, the maximum number for the planetarium, in an event to showcase the cutting edge research of the three women on our Astronomy faculty, Andrea Ghez, Alice Shapley, and Jean Turner. The event was a joint effort by the Department of Physics & Astronomy and Women & Philanthropy. Those attending were very enthusiastic about the event, and found it a unique opportunity to learn about the “star” women in astronomy.

KATSUSHI ARISAKA: Awarded 2010 UCLA Distinguished Teaching Award

March 2010 UCLA Distinguished Teaching Award was presented to Katsushi Arisaka. While Dr. Arisaka is extremely successful at both undergraduate and graduate instruction, he has been particularly effective in teaching physics to non-physics majors. It is a special professor who not only manages to get his students to willingly come to class, but also piques their interest in the field. Arisaka teaches several classes at UCLA, including general astronomy and cosmology; undergraduate and graduate particle physics and cosmology for physics majors; and Physics 6B for life science majors. Physics 89, is especially praiseworthy. Often those interested in biological science avoid mathematics and quantitative reasoning. However, by developing Physics 89, Professor Arisaka has very powerfully and successfully introduced our students to science. From one of the students who wrote in support of Katsushi Arisaka’s Distinguished Teaching Award came the words, “Toward the end of the quarter, Dr. Arisaka kept thanking us for taking his class. No, Dr. Arisaka, thank you for teaching us so many valuable things!” Excerpts from UCLA Today article by Wendy Soderburg March 24, 2010

“Once students are self-motivated, they start to study in their own way and devote enormous amounts of time because they begin to love physics, rather than hate it.” Katsushi Arisaka, UCLA Today, May 2010



STEVEN FURLANETTO: Awarded 2010 Sloan Research Fellowship

Steven Furlanetto, Division of Astronomy at UCLA was awarded a 2010 Sloan Research Fellowship. The Sloan Research Fellowships seek to stimulate fundamental research by early-career scientists and scholars of outstanding promise. These two-year fellowships are awarded yearly to researchers in recognition of distinguished performance and a unique potential to make substantial contributions to their field. You may also want to visit the Alfred P. Sloan Foundation website to find out more about this prestigious organization.



department outreach & education news

Los Angeles Physics Teachers Alliance Group

LAPTAG (Los Angeles Physics Teachers Alliance Group) is still going strong after 15 years! The high school outreach program has its own plasma laboratory and has been doing experiments of whistler waves. In the early Spring of 2010, we attended the APS meeting in Washington DC (two high school teachers, five high school students) and gave a poster on our results. LAPTAG will be represented at the Fall APS_DPP meeting in the educational outreach session with two posters. A paper on this work in under review for the American Journal of Physics.



From the Left- Dr. Walter Gekelman, Brian Baum, Kevin Kuns, Max Praglin, Roland Hwang, Joe Wise



As evidenced in the photo above, the presentations were well received by the children and their parents.

Celebra la Ciencia Community Fair” March 28, 2010

With the support of the UCLA Plasma Science and Technology Institute, a booth at the “Celebra la Ciencia Community Fair” held at the end of the “Chavez Memorial March” on Sunday, March 28, presented physical principles to the public. The effort was organized by Dr. J. Manuel Urrutia and was assisted by Prof. Charles Whitten, Dr. Martin Simon, who is in charge of the Department’s lecture demonstrations, and Mr. Gueorgui Gueorgiev.

May 15, 2010 UCLA Alumni Day

The Department of Physics & Astronomy once again participated in Alumni Day. The astronomy students offered 30 minute Planetarium shows throughout the day, and during the morning a number of students volunteered to run various physics demonstrations, as well as assist the alumni and their families to view the sun via two solar telescopes. We were pleased to see that these demonstrations generated a great deal of interest and curiosity. Professor Ian McLean, the director of the UCLA Infrared Laboratory in Astrophysics, along with Anna Fisher, a NASA Astronaut, spoke on the topic of “Watching the Skies: Bruins in Space”. They discussed dozens of ways that UCLA is helping us understand the cosmos in manned and unmanned space exploration, from discovering planets around distant suns, finding massive black holes or visiting our nearest neighbors in the solar system.



ASTRONOMY LIVE!

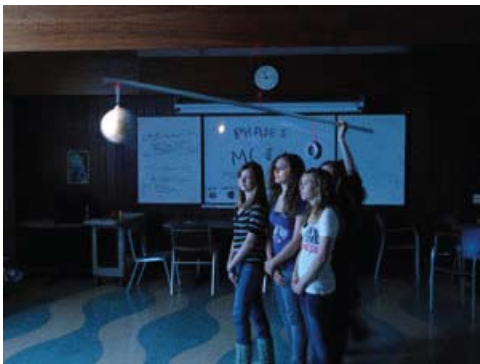
Astronomy Live! is UCLA's astronomy outreach program run by a group of graduate students in the Department of Physics and Astronomy. Our Outreach is UCLA-based, which means that a variety of activities for the public are on campus! They include daytime Planetarium shows and astronomy based science workshops. The workshops include "Galaxies: Shapes, Sizes, and Distances" - This workshop is an hour long and goes through the different types of galaxies, the distances between galaxies, and the scales of masses and numbers of galaxies; "Stars: Our Sun and Our Stellar Neighbors" - This is a 30-minute workshop and includes solar telescopes, a description of the Sun's interior, and the different sizes, colors, and properties of stars; and also "Comet Making and the Solar System" - A hour long workshop which goes over the different properties of the planets, the minor bodies of the solar system, moon phases, and a comet making activity.



In developing this program, Astronomy Live! wants to be able to visit schools, hospitals, and local events to interact

with the community in addition to fostering interest in astronomy and science in general. On November 14, 2009 the UCLA Physics and Astronomy and Earth and Space Sciences Departments put on an exciting free public event. The event was to celebrate the International Year of Astronomy and the launch of Astronomy Live!. Visit the website http://www.astro.ucla.edu/~outreach/UCLA_outreach.html for upcoming events to schedule outreach programs and more. Don't miss the planetarium! Planetarium shows can be coordinated along with the activities mentioned above for larger groups of students. For less than 50 students, please contact planet@astro.ucla.edu to request a show.

Planetarium website - <http://www.astro.ucla.edu/planetarium/>



The Big Bang Theory

Scientific American recently highlighted UCLA Physics and Astronomy Professor David Saltzberg's role as a scientific consultant to "The Big Bang Theory," a popular TV sitcom that revolves around physicists who lack social skills.



David Saltzberg

2010 Career Night

The department's annual Career Night on April 12, 2010 was a great success with students and panelists enjoying pizza, drinks and dessert, followed by interesting questions from the students and equally interesting and helpful answers from the panelists (Dan Dawes, Matthew Lee, John Taborn, John Vaszari, Tatiana Vinogradova, Thomas Wilcox and Clara Yoon). This event provided the students with a wonderful opportunity to talk with some of the department's alumni about the reality of finding jobs after graduation in a variety of career paths.

Career Night 2010



Research Experience for Undergraduates (REU program) 2010

The Physics & Astronomy Department is hosted the 8th annual Research Experience for Undergraduates (REU program) during Summer 2010. Fourteen undergraduate students have come from across the country to engage in real frontier level research with a UCLA faculty member for a period of ten weeks. Each of the participants was matched with a faculty mentor according to the student's interests. The projects spanned the various fields represented in the department, such as plasma physics, biophysics, cosmic ray physics, astrophysics, accelerator physics. The students are being trained in the newest lab, computational and theoretical techniques to prepare them for the world of research. Over the last eight years, the department has hosted a total of 106 students under this program.



Fellowships...

Martin Simon and Alexander Kusenko, in collaboration with several other faculty members, including Bob Cousins and Graciela Gelmini, are developing innovative on-line materials for teaching physics to non-science majors. This work is currently funded by UCLA CCLE, OID, and the Department of Physics and Astronomy.

The University of California's Dissertation Year Fellowship Program provides support to outstanding Ph.D. candidates during their final year of graduate school support that allows them to focus on writing their dissertations. 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 Department are: Warren Essey, Yu Guo and Jonathan Landy

congratulations

RUDNICK-ABELMANN SCHOLARSHIP

Ding Dang Wang
Seung Keun Ji
Taylor Barrella
Natalie Mashian

CHARLES GEOFFREY HILTON AWARD

Breann Nicole Sitarski
James Yi Tian

E. LEE KINSEY PRIZE OUTSTANDING GRADUATION SENIOR

Tyler Alexander Hill



Bachelor of Science in Physics

Victor Aguilar
Zeve Akerling
Oswaldo Alvarenga
Andrew Axley
Lyle Douglas Kaiser Barrere
Frank Berglund
Nathan Rogers Bernard
Neal Andrew Carmody
Hin Yan Chan
Kim Kwok-Kee Chan
David Chon
Tyler Dawson
Boris Dzyubenko
Nicholas Robert Forbes
Michael Gutierrez
Frank Vincent Guzman
Suiting He
Tyler Alexander Hill
Timothy Jacoby
Dustin Toews Jantz
Kaitlin Noelle Judy
George Khaburzaniya
Byung Jim Kim
Laura Alene Marchand
Michael Grant Martin
Karan Kartik Mehta
Razvan Melen
Marc Joseph Miller

Tristan Lim Miller
Isain De Jesus Monge
Jeremy Francois Neuman
Alex Perloff
Isaac Hart Ribakoff
Kevin Grattan Roberts
Sara Lai-Ming Rose
Steven Seung
Jonathan Samuel Sheng
Kyle Susumi Shigekuni
Radoyeh Shojai
Christina Elizabeth Sprouse
Dane Michael Tikunof
Hoson Lay To
Brian Matthew Van Biezen
Ninel Vartanian
Adria Katarina Vidovic
Mark Thomas Westfall
Michael Gerard Winters
Pao M Xiong
Bonan Zhou

Bachelor of Art in Physics

Christina Louise Brown
Jerry Chil Kim
Alex Yang
Andrew M. Yach

Bachelor of Science in Astrophysics

Esperanza Reem Arab
Ruslan Babayan
Veronica Ashley Benitez
Mary Elizabeth Christian
Kenneth Ocba Gibson
Yat Tien Lee
John Henry Livingston
Tracy Ly
Cynthia Nicole Niehaus
Aldrich Lazatin Rivera
Jose Angel Salcido
Breann Nicole Sitarski
James Yi Tian

Bachelor of Science in Biophysics

Mary Kim Hoang
Ziming Ji
James Jiang
Brian Tae Kim
Nikita Kuznetsov
Hyunwoo Lee
David Xiaotian Liu
Hiroki Makita
Charles Ng
Joshua Minoru Tokuda
Sriteja Upadhyayula

Graduation 2009-2010 Keynote Speaker, Ron Abelman



This year's commencement saw the largest graduating class thus far in the department. In all, 75 undergraduate degrees were conferred, nine MS degrees and 26 Ph.D. degrees. One of the highlights was the address of alumnus Ron Abelman.

Ron Abelman's keynote speech captivated his audience with words of wisdom from his past and hope for the future. He underlined the challenges of overcoming obstacles by sharing his own early financial problems. He attributed much of his business success to the years he spent in the Physics Department at UCLA.

Ron offered the students many prescient thoughts "... know yourself ... know what turns you on; what environment you thrive in and what stifles you ... Get into a position that lights your fire ... This has to be your most important goal. It is a prerequisite for success ... If your current environment is wrong for you, don't be afraid to change ... but do so for the right reasons ..."

DOCTORAL DEGREES AWARDED

Astronomy

Tuan Do
Quinn Konopacky
Chun Ly
Ryan Mallery
Carl Melis
Chao-Wei Tsai
Matthew Wood

Astrophysics

Steven Berukoff
Yeuk Chun Chow

Theoretical Biophysics

David Schwab

Experimental Biophysics

Adrian Cheng
Nicholas Wisniewski

Theoretical Condensed Matter

Warren Lybarger
Aviva Shackell

Experimental Condensed Matter

Michael Cheung
Alex Gittings
Brian Kappus
Damien Ramunno-Johnson
Steve Suh

Experimental High Energy

Stephen Hoover
Chi Wai Lam
Abigail Viereg

Nuclear

Bertrand Birtz
Dhevan Gangadharan
Priscilla Kurnadi
David Staszak

Theoretical Plasma

Benjamin Winjum

Experimental Plasma

Andrew Collette
Brett Jacobs
Eric Lawrence
Travis Yates

Theoretical Elementary Particles

John Joseph Carrasco
Marco Chiodaroli
Efunwande Osoba
Ian Shoemaker

...We don't see it enough today, but I have always believed that especially in the business world ... the Golden Rule applies ... Deal with others as you would be dealt with. Conduct yourselves ethically and with virtue. This will define your reputation ... and there is little that is more important ..."

... Whatever your situation, always put yourself in the shoes of your audience ... and then respond accordingly. By getting this ability honed, over time, you will develop a 'street sense' ... an intuition. It comes from looking at the world not only through your eyes ... but also through the eyes of others ... before you respond ... before you decide ... before you act ... The combination of Street Sense and Intellect will make you a far more effective professional."

Ron Abelmann closed his remarks with these insightful observations: "...We live in a loud and noisy world. A world of sound bites ... a world of word-smithing and playing loose with the facts. You have come from a different cloth. Everything you have done in your curricula has required truth and accountability: it has required depth in thinking and quality ...These assets are part of who you are ...you own them ... use them. You are a 'special few' and the world desperately needs what you have to offer. You can make a difference ... but never forget your UCLA roots ..."

UCLA Department of Physics and Astronomy
405 Hilgard Avenue
Box 951547
Los Angeles California 90095-1547

NON-PROFIT ORG.
U.S. POSTAGE
PAID
UCLA

