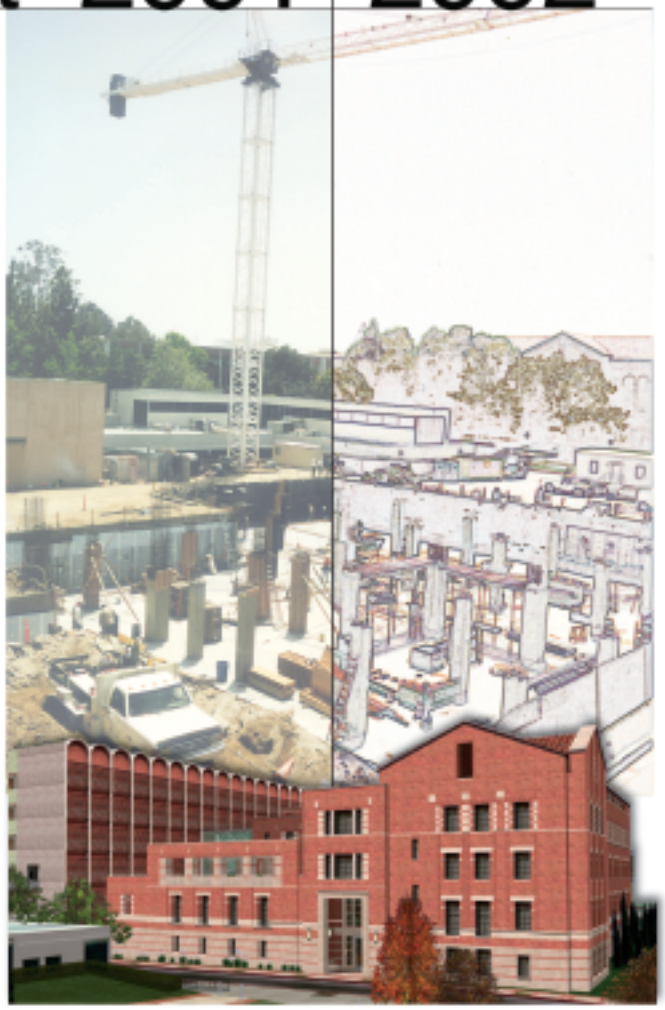
UCLA

Department of Physics & Astronomy

University of California Los Angeles

Annual Report 2001 2002



Department of Physics and Astronomy

2001 - 2002

University of California, Los Angeles

Physics and Astronomy Department
2001-2002

Chair
Claudio Pellegrini

Editor
Barbara L. Pawley

Assistant Editor
Mary Jo Robertson

Contributing Editors
Andrea Johnson, Francoise Queval, Penny Lucky, Joanne Yung, Kris Moghaddami

Photography
Andrea Johnson

Design
Mary Jo Robertson

Cover (designed by Mary Jo Robertson)
The front cover is a rendering of the new physics and astronomy building with a computer-manipulated image of the construction site. The back cover is a collage of some of the images and equations that will be etched on the elevator doors of the new building.

This report covers the period July 1, 2001 through June 30, 2002

Requests for additional copies of the publication
Department of Physics and Astronomy
2001-2002 Annual Report *may be sent to*

Office of the Chair
UCLA Department of Physics and Astronomy
405 Hilgard Avenue - Knudsen Hall
Box 951547
Los Angeles, California 90095-1547
Phone (310) 825-3440

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

Contents

Claudio Pellegrini, Chair

Message from the Chair

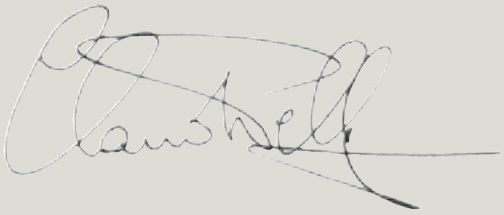
The 2001-2002 academic year has been a fruitful one for the UCLA Department of Physics and Astronomy. The former departments of physics and astronomy are now successfully merged and we all benefit from the closer connections between astronomers, astrophysicists, elementary particle physicists, and plasma physicists. Our growing astroparticle physics group is the best example of these benefits.

Ground has been broken for the new physics and astronomy building and construction is well underway. We expect completion by the end of 2003. Faculty and students will have the advantage of improved facilities for research, as well as new classrooms with state-of-the-art audiovisual capabilities for seminars and conferences.

Results of the research conducted by faculty during the year are discussed in the Research Highlights portion of this report. This listing is by no means exhaustive, but represents a major part of our accomplishments during the period. The department continues to see an increase in grant support and research activity.

The Education Highlights section of this report presents significant academic milestones, including a list of our graduating students. It has been a pleasure to participate in the 2002 graduation ceremony. I wish our students all the best for their future careers, in any area of work that they choose.

We are pleased to introduce a new faculty member, Per Kraus, to the department this academic year. His expertise in string theory will enrich our research and teaching programs. We are saddened by the loss of three faculty members who greatly contributed to the university and the field of physics: John Dawson, Kenneth MacKenzie and Robert Satten. We will miss them, but will always remember their place in our family of scientists and educators.



Claudio Pellegrini

New Physics and Astronomy Building

A Tour of the New Physics and Astronomy Building

Ferdinand V. Coroniti, PhD, professor and former chairman of the department who led the faculty through-out the years of hoping and planning for a new building, summarized the situation: "We desperately needed a 21st century research and teaching facility. Our current space, Knudsen Hall, does not have the vibrational stability nor does it have enough power and gas, or even air and water that is of sufficient quality to conduct today's experiments. Existing classroom space is antiquated in terms of multimedia requirements of both faculty and students and inadequate for setting up and conducting experiments. We do not have enough offices or seminar rooms to accommodate the graduate and postgraduate academic needs of the department. Our space issues are being driven, in part, by changes in research, which often require high precision measurements, and in teaching, which now involves multimedia presentations."

For UCLA's physicists and astronomers, two consequential events in 1994 kindled their long-time dream of a new home. The Northridge earthquake, which inaugurated the year, initiated a spate of new building projects on campus and the consolidation of the departments of physics and astronomy, which followed in July of 1994, prioritized the need for a new building. The subsequent planning and negotiating through many structural configurations ended in 2000. The Regents approved a $39.3 million construction project, to be funded by bonds and by private donations. The University is currently seeking a major donor to name the building.

Construction is now underway and projected for completion in late 2003 or early 2004. The finished structure will be a unique, state-of-the-art science building that has been fashioned through the passionate energy of the architects, the faculty, and other contributors. The building plans leave no doubt that it will be a working tribute to their efforts. Its location alone in the historic Royce-Powell core of the campus, which was first developed in 1929, affords an imposing neighborhood. Among the preeminent adjacent structures are Powell Library, Kinsey Hall and Moore Hall, all built in elegant Romanesque style, and considered prime examples of the UCLA signature building type. These buildings are characterized by distinctive red brick and cast stone exteriors with terra-cota ornamentation, arched windows, projected cornices, and red clay tile roofs. The first architectural challenge was to construct a modern building that would blend with its historic neighbors in style and size. The second challenge was to build a wholly functional environment for teaching and research. **Claudio Pellegrini,** newly appointed chair of the department, is confident that the architects, along with his colleagues, have accomplished both.

Overview

The finished 120,000 gross square feet will be organized on six floors: two subterranean and four above ground. Although the overall building occupies a square grid, the above-ground floors take the form of an "L" wrapped around the two-story height of a large lecture hall. The roof of this lecture hall provides an open-air terrace accessible from the third floor. Modular planning, including the allocation of utilities, has been adopted throughout in order to facilitate future changes in research or departmental organization that might affect laboratory and office configurations. With the exception of the ground floor, the physics and astronomy building will connect to Knudsen Hall, the department's current home, by way of glass walkways above ground and tunnels below ground.

Research Laboratories

The extraordinary environmental requirements of physics and astronomy experiments have dictated a structural integrity that has few peers. Vibration control was best met by allocating the space below ground to laboratories: The sub-basement floor slab will be

composed of 12-inch-thick concrete and the basement floor slab will be a 38-inch-thick concrete waffle deck. All stairways leading below ground, as well as the sub-basement corridors, will be structurally isolated to neutralize footfall traffic. The adjacent alley will be routinely barricaded to vehicular traffic except for specifically monitored situations. The sub-basement provided an opportunity to create non-magnetic pits for specialized experiments. The floor slab will be fitted with polypropylene micro fiber to satisfy the requirement of non-magnetic reinforcement in the pits. In all, 18 laboratories for condensed matter physics, biophysics and astrophysics will be accommodated in the subterranean levels.

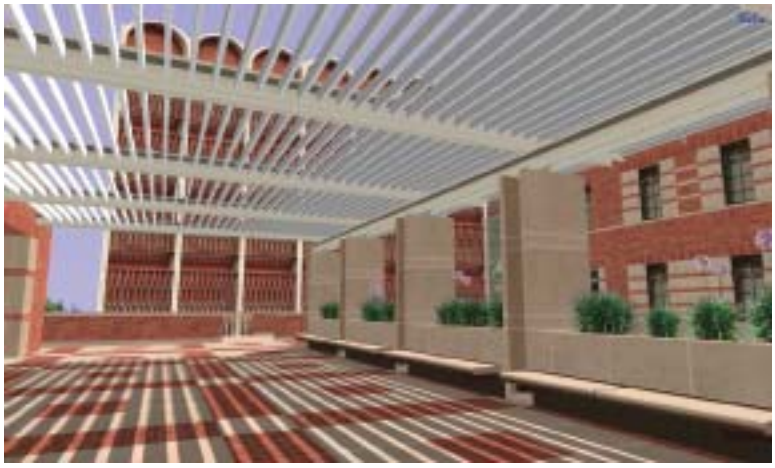
Classrooms

Because of the high level of traffic associated with classrooms, it was determined that all five would be located on the first and second floors of the building, facilitating the movement of large numbers of people without disturbing the occupants on the floors above or below. Two of the classrooms will be traditional 40-seat rooms with moveable furniture. The 189-seat lecture hall that spans the first and second floors and the 102-seat and 50-seat facilities will have fixed tables and chairs with built-in data/electronic ports. All classrooms will be equipped for multi-media presentations. A preparation room with a 20-foot-diameter platform will rotate to the large lecture hall, enabling faculty to set up one experiment while another is being conducted. The first floor will also house student services and teaching assistant offices to take advantage of student traffic patterns.

Offices and Conference Rooms

The remaining floors will be dedicated to departmental offices and conference rooms. These areas have been customized to reflect the work pattern of the people who occupy them. For instance, it was recognized that the academic personnel function must accommodate large numbers of confidential files. Therefore, a secure file room will be part of that space. The configuration of faculty offices will reflect the reduced need for secretarial support and the increased need for collegial collaboration in today's academic environment. Offices will take advantage of the window spaces, leaving the center of the building for conference rooms, reading rooms and computer rooms. The new construction will enable the centralization of departmental divisions, which are currently geographically fragmented among several campus buildings. Astronomy will occupy the third floor. The fourth floor will house theoretical elementary particle physics, plasma physics, and accelerator physics. Administrative functions will be housed on the second floor. Other divisions will remain in Knudsen Hall, which will undergo renovation.

Department manager **William Robinson**: "The budget for the new building includes a modest amount for furnishings, but it will not cover everything. The laboratories, in particular, will need further support for equipment, casework and to install needed services at the bench level."



A terrace atop the large, two-story lecture hall will be accessible from the third floor of the building

RECOGNITION OPPORTUNITIES ARE AVAILABLE AS FOLLOWS:

Building	$15 million
Main auditorium	$2.5 million
Roof terrace and conference suite	$1 million
Lecture auditorium	$750,000
50-seat classroom	$250,000
Chair's suite	$100,000
40-seat classroom (1st floor)	$100,000
Graduate student study area	$100,000
Reading room	$100,000
43-seat classroom (2nd floor)	$50,000

Michael Allen Kriss Gift

Support for the Department's Most Pressing Need

The Physics and Astronomy Department has been fortunate to receive a generous gift of $50,000 from alumnus Michael Allen Kriss. A long-time Bruin, Dr Kriss earned all three of his physics degrees from UCLA, culminating with a PhD in 1969. He has since been a steadfast supporter of the Physics and Astronomy Department, serving on the department's advisory board and helping to establish the Saxon-Kriss Graduate Student Emergency Fund, designed to help graduate students meet short-term obligations.

Dr Kriss spent 24 years as a researcher and manager at Eastman Kodak, where he specialized in digital imaging. After taking early retirement, he brought his skills to the University of Rochester, where he taught and conducted research in his field. Currently he is a manager with Sharp Labs of America in Camas, Washington, where he continues to advance digital imaging technology.

This most recent and very generous gift will be applied toward construction of the new physics and astronomy building. Dr Kriss stated, "I feel fortunate to be able to support the construction of this magnificent research and education facility. It is my hope that the new building will act as a catalyst for collaboration between students and faculty, providing them the same opportunities that I and my fellow classmates enjoyed some 40 years ago."

Donations for 2001–2002

Regental Fund

Benjamin Steven Gewerter
Industrial Technology Research Institute
Leon Knopoff
Michael Allen Kriss
Marina Laguna Investors, Ltd.
Steven A. Moszkowski
John H. Munier Revocable Living Trust
National Academy of Sciences
B. M. Nefkens
Marian V. Peterson
Chun Wa Wong
Youngs Market Company

The John Dawson Memorial Fund

Herbert L. Berk
Victoria R. Castillo
Edward F. Dawson
Thomas Kenneth Fowler
Elee K. Gross
Lonnie K. Harden
Ching Yi Hung
Y. H. Ichikawa
Tetsuo Kamimura
Elizabeth Kruer
Massachusetts Institute of Technology
Steven A. Moszkowski
Joseph H. Orens
Ruth E. Phillips
Faith Foster Stephan
Theragenics Corporation
Katherine H. Wyly
Theodore D. Wyly

Dr Waldo Lyon Scholarship

Diane L. Bentley
Gene L. Bloom
David S. Boyd
Richard J. Boyle
George F. Dibella
Jeffrey A. Fishbeck
Michael Hacking
Alan Havashida
Levine & Felix LLP Lazar
Robert D. McWethy
John H. Nicholson
Thomas E. Ross

Physics & Astronomy Capital Program

Michael Allen Kriss
Ben L. Holmes

J. Reginald Richardson Fund

Pamela L. and Kenneth R. Chrisman
Louise F. Richardson

Physics And Astronomy Alumni Alliance (PAAL)/ Chair's Discretionary Fund

Boyce D. Ahlport
A. T. Anderson
Michael W. Arenton
Andrew N. Baker
Robert S. Baker
James F. Bamber
Arnold Benton
Uri Bernstein
Jonathan A. Blau
H. Karl Bouvier
BP Foundation Matching Gifts Program
Thomas B. Brown
Jack W. Burkig
Howard L. Christensen
W. Gilbert Clark
John G. Coffer
Mark T. Cowan
Steven W. Crowe
Donna Dameron
Daniel L. Dawes
Viktor K. Decyk
James A. Dixon
Steven T. Donovan
Thomas La Guerre Drouet
Emily R. Dunkel
Gordon E. Eggum
James D. Enright
Thomas A. Ferguson
Ivan L. Finkle
Frank S. Fontanella
Barry J. Forman
Albert J. Franco
Allan M. Frandsen
Robert W. Fredricks
Francis G. Freyne
Anthony F. Gangi
Henry D. Garbin
David R. Garfinkle

Erik Helgren received the PAAL 2001-2002 award from PAAL President Bob Baker.

Donors

Donors

Stephen J. Gayer
Pamela S. Gillis
Harold A. Glick
Frank J. Goebels
Ira M. Green
Moses A. Greenfield
Gunter Hagen
William F. Hall
Bernard Hamermesh
Ronald N. Hartman
Jim Haynes
Charles M. Heard
Takeo T. Hirai
Holly R. Hogan
Joseph F. Hook
Edward L. Hubbard
Stanley L. Hubler
Jerald R. Hyde
Julius Hyman
William N. Jacobson
Inge Jechart
Louis K. Jensen
Hiroshi Kadogawa
Reynold S. Kagiwada
Charles S. Kaufman
Wallace Richard Keene
Charles F. Kennel
Beth L. Klein
Robert P. Korechoff
Michael Allen Kriss
E. C. Krupp
Perry E. Lanaro
James Larkin
Erick Le Roy Lindman
Willis A. Livesey
Myron A. Mann
Valerie Margaziotis
Roland P. Michaelis
Gilbert A. Miranda
Mark Morris
Myers Dawes & Andras LLP/Dan Dawes
Makoto Nagata
George H. Nakano
Northrop Grumman Litton Foundation
Ocean Acoustics Associates
Joan B. Ossakow
Physitech Corporation
Robert W. Pollock
Leslye J. Prum
Mark A. Pumar
Lawrence S. Quimby
Stanley R. Radom
Alfonso F. Ratcliffe
Raytheon Systems Company
David Redfield
Melvyn J. Rodrigues
Erno H. Ross
Herbert N. Royden
Lawrence Ruby
Philip J. Sakimoto
Richard D. Schachter
Douglas W. Scharre
Scheifele-Holmes Family Foundation/ Fidelity Investments
Joseph H. Schulman
Larry L. Simmons
Gloria M. Smith
Dean M. Sumi
TRW Foundation
Egbert Sau-Nam Tse
Universal Studios Inc. Corporate Contributions
Javier Urbina
Richard C. Vinetz
Richard J. Wagner
Raymond C. Walter
Donald S. Webber
Kay Weiss
Iddo Wernick
Guy M. Weyl
Gordon R. White
Ralph M. Wilcox
Chun Wa Wong
William K. Woo
John J. Wood
Thomas J. Woods
Byron T. Wright
Ben Zuckerman

Gintaras Duda received the 2001-2002 Waldo Lyon Scholarship from Mrs Lorraine Walls, daughter of Dr Lyon.

The Abelman-Rudnick Scholarship and Fellowship

The Abelman-Rudnick Scholarship and Fellowship are the newest departmental awards for students. Established in 2000 by a number of friends and alumni, most particularly Ronald Abelman, whose gift represents the bulk of the endowment, the awards are intended to recognize the contributions of the late Isadore Rudnick to the University. His association with UCLA began in the 1930s as a summer student, and later a doctoral student. In 1948 he accepted a faculty position, which he held for almost four decades, earning international recognition. Throughout his career, it was his relationship with students that he most treasured, so when it came time to memorialize his exceptional life and career, the choice was clear. Ronald Abelman was Professor Rudnick's student who later used his knowledge of physics to construct a highly successful career in industry. He saw this memorial as a way to both honor his mentor and create future opportunities for promising students. The Abelman-Rudnick Scholarship is a cash award to an undergraduate student in the Department of Physics and Astronomy; the Abelman-Rudnick Fellowship is a cash award to a promising graduate student.

Benefactors

Benefactors (2001-2002)

Richard J. Boyle
Thomas B. Brown
Kenneth R. Chrisman
W. Gilbert Clark
Edward F. Dawson
Fidelity Investments/Scheifele-Holmes Family Foundation
Benjamin S. Gewerter
Y. H. Ichikawa
Industrial Technology Research Institute
Tetsuo Kamimura
Michael Allen Kriss
Marina Laguna Investors, Ltd.
John H. Munier Revocable Living Trust
Myers Dawes & Andras LLP/Dan Dawes
National Academy of Sciences
Ruth E. Phillips
Louise F. Richardson
Herbert N. Royden III
Theragenics Corp.
Byron T. Wright

Benjamin L. Holmes

An Investment In The Future

Not long after earning a degree in applied physics from UCLA in 1959, Ben Holmes began working for a firm that experienced phenomenal growth, the Hewlett-Packard Company (HP). He held a variety of management positions with HP's instruments, computer systems, and medical groups. In 1994, after more than three decades, he retired as Vice President of Hewlett-Packard Company and General Manager of HP's Medical Products Group.

Throughout his distinguished career, Ben Holmes maintained close ties with his alma mater, serving in a variety of supportive roles, most recently as a member of the newly founded Sciences Board of Visitors. Believing that there is no longer much difference between the universities in the UC system and private institutions in terms of the need for private support, he decided to make a leadership gift. Working with UCLA's Office of Planned and Major Gifts, he established a charitable remainder unitrust. This gift arrangement enables him and his wife, Carol, to receive an income tax charitable deduction, as well as annual payments for their lifetimes. Thereafter, the remainder will support the Department of Physics and Astronomy.

"The technical education I received at UCLA is the foundation for what I did in my professional life, said Mr Holmes."Without that fundamental education, I wouldn't have accomplished what I did."

Research Highlights

Ian McLean was appointed Associate Director of the University of California Observatories/Lick Observatory.

Galactic Astronomy

Eric Becklin and **Benjamin Zuckerman**, working with physics graduate student **Jay Farihi**, have continued their infrared study of low mass companions to white dwarf stars. In the process of searching for companions that have the same motion across the sky, Jay Farihi has discovered a new type of star that is a companion to the white dwarf star GD248. This new companion has the colors and spectrum of a low mass main sequence star, but from its luminosity it is clearly a degenerate white dwarf star. Based on a number of observations and models, it appears to be the coolest of a class of Helium white dwarfs known to date. A paper on these results has been submitted to the *Astrophysical Journal* and Jay Farihi gave an invited talk in June at a conference on white dwarfs in Italy.

After pinpointing the location of a supermassive black hole at the center of our galaxy in an earlier research phase, **Andrea Ghez** and team have revealed a star that just this year made its closest approach to this exotic object, passing within a mere half light-day. Although our Galaxy was neither the first nor an obvious candidate for a central super-massive black hole, the results of these experiments have made the Milky Way the strongest case for a central black hole in the million solar mass range. The proximity of our Galaxy's center presents a unique possibility to study the environment and the effect of the black hole with far higher spatial resolution than can be brought to bear on any other galaxy.

The American Astronomical Society elected William Newman as Vice Chair of the Division of Dynamical Astronomy for 2002–2003.

Brad Hansen and **Michael Rich**, were members of an international team that used the Hubble Space Telescope to obtain a novel measurement of the age of the Universe. The team observed the globular cluster Messier 4 for 123 orbits, the largest allocation of Hubble observing time to a single group in 2001. Combining the deep image with other Hubble images, the team was able to identify faint white dwarf stars in M4. White dwarfs are the spent nuclear cinders of stars like the sun, and the cooling of these cinders can age-date the cluster that contains them. Crucial to this effort were new theoretical models developed by Professor Hansen and colleagues for white dwarf cooling. The research team found that Messier 4 is 12.7 +/- 0.5 billion years old, making these stars among the oldest known. As globular clusters are among the first objects to form in the Universe, the measurement suggests that the Universe is no older than 13 to 14 billion years

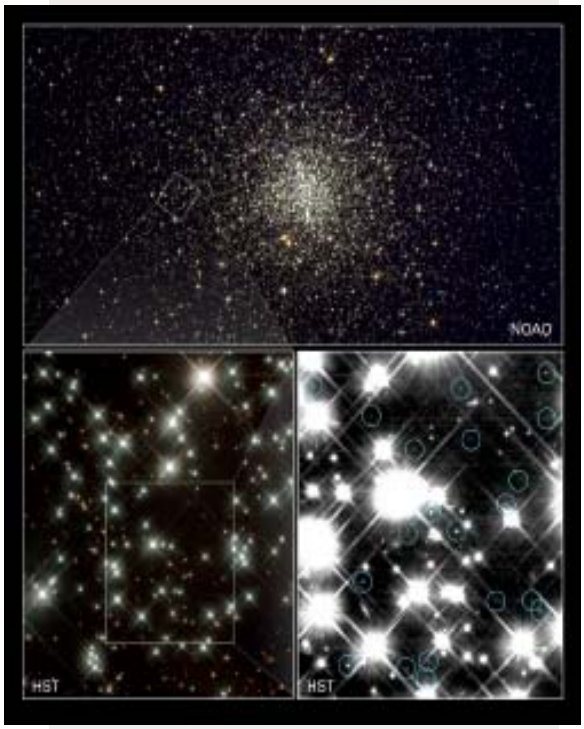
In a continuing study of the supermassive black hole at the center of our Milky Way Galaxy, **Mark Morris** and collaborators, including former UCLA astronomy student **Fred Baganoff**, captured for the first time a powerful x-ray flare apparently arising from a region located very close to the event horizon of the black hole. The short duration of the flare and the temporal substructure within it, limit the size of the emitting region to about 20 Schwarzchild radii. The spectral and statistical properties of such flares were examined in May 2002 using eight of the world's most powerful telescopes, including Chandra. When analyzed and carefully compared,

the data streams at different wavelengths should place strong constraints on the x-ray emission mechanism.

During this past year, the primary observational goals of the NIRSPEC Brown Dwarf Spectroscopic Survey, led by **Ian McLean,** were completed. NIRSPEC (Near Infrared Spectrometer) was designed and built at UCLA by Professor McLean for the W. M. Keck 10-meter telescope on Mauna Kea. This survey was initiated shortly after NIRSPEC was successfully commissioned. The infrared spectra of almost 50 faint, sub-stellar objects known as Brown Dwarfs have been obtained. The new spectra, which have higher resolution than any previous studies, enable spectral classification and analysis to be extended to the infrared where these very cool objects are brighter. The onset of absorption due to methane, characteristic of a very cool atmosphere, was announced in a *Letter to the Astrophysical Journal* in November 2001.

Extra Galactic Astronomy

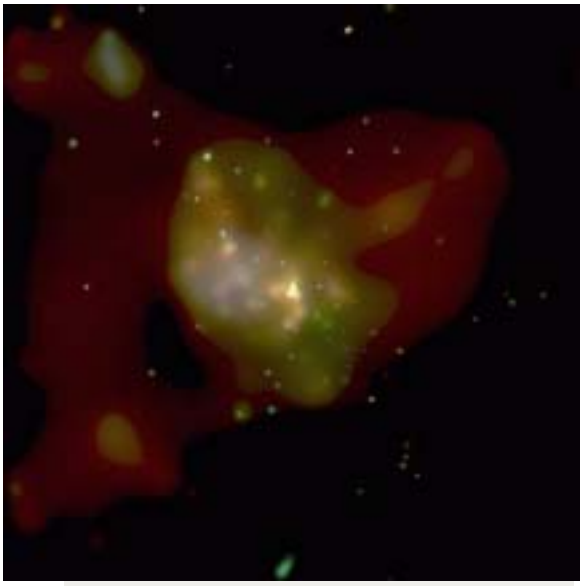
James Larkin and graduate student **Tiffany Glassman** have carried out the first survey of cosmologically distant galaxies with an adaptive optics system. With adaptive optics they were able to compensate for the turbulence in the atmosphere and resolve detailed structures 10 times smaller than traditional ground-based images. This allowed them to not only identify galaxies in the early Universe but also study their substructures, such as stellar bars and galactic bulges. The ultimate goal is to understand how vast structures like the Milky Way, which has over 100 billion stars in it, formed and evolved.



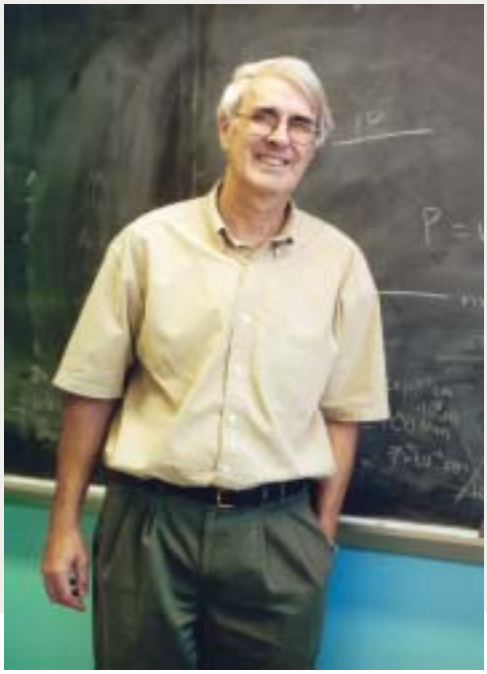
The top picture was created from observations with the T2KA CCD camera at the Kitt Peak Observatory's 0.9 meter telescope in March 1995. *Credit for ground-based photo: NOAO/AURA/ NSF* The bottom left region is an observation by the Hubble telescope. At right is a detailed section of this image. Blue circles pin point dwarfs. *Credit for Hubble telescope photos: NASA and H. Richer (University of British Columbia)*

Michael Rich, Matt Malkan, and other UCLA astronomers recently worked with researchers at Ohio State University to generate one of the deepest images of the sky ever obtained, the Hercules Deep Field. These images, taken by the Hubble Space Telescope, were paired with infrared images. Armed with pictures at six different wavelengths of light, the team was able to use a technique called photometric redshifts, which gives distances to most of the galaxies, and thus depth perspective to the image. Knowing the distances and their brightnesses, they further found the ages and total mass of stars for many of these galaxies, the most distant of which are more than 10 billion light years away. The combined Hubble and infrared images were presented at the annual meeting of the American Astronomical Society in Washington, D.C.

Collaborating with an international team of astronomers, **Jean Turner** continued exploring a young super star cluster in a nearby dwarf galaxy. These researchers discovered this unusual source four years ago and have been studying it with the NIRSPEC instrument at the W. M. Keck Observatory in Hawaii. This past year Professor Turner and colleagues have focused on a supernebula that they discovered, surrounding what may be the youngest known globular cluster. Their initial results were



This false-color image shows the central region of our Milky Way Galaxy as seen by Chandra . The bright, point-like source at the center of the image was produced by a huge x-ray flare that occurred in the vicinity of the supermassive black hole at the center of our galaxy. *Photo Credit: NASA/MIT/F.Baganoff et al.*



Roger Ulrich winner of the Arctowski Medal for outstanding contributions to the study of solar physics and solar-terrestrial relationships

presented at a press conference in 2001arranged by the American Astronomical Society. Smaller wind bubbles around young stars and clusters in our Milky Way are not uncommon; however this wind bubble surrounds a young super star cluster, that is unlike any star-forming region in the Milky Way. With wind speeds of 3000 miles per minute and a power of a billion suns, this young star cluster has the potential to seriously disrupt its parent galaxy.

Astroparticle Physics

David Cline and other members of the UCLA High-Energy Physics group, including **Hanguo Wang,** are building a dark matter detector, Zeplin-II, which will be finished in 2002 and installed at the Boulby underground laboratory in England. Zeplin-II will use extremely sensitive techniques to search for matter in the universe that is not accounted for by stars, planets, dust, or other matter.

Rene Ong and colleagues have been working on the development of the first telescopes, to be installed as part of the VERITAS gamma-ray observatory, under construction in southern Arizona. The observatory will consist of seven telescopes, each with multi-pixel cameras and high-speed electronic read-out. The VERITAS collaboration is carrying out observations with a 10m telescope on Mt. Hopkins with several major recent results, including the detection of a cutoff in the spectrum of a distant quasar Markarian 421 and the discovery of a new very high-energy source of the BL Lac type.

Edward Wright is the principal investigator for the Next Generation Sky Survey (NGSS), one of only four proposals selected for a Phase A feasibility study by NASA for the MIDEX (Medium-Class Explorer) program. If selected, NGSS will fly in 2007, revealing the most luminous galaxies in the Universe and the closest star to the Sun. Professor Wright is also an interdisciplinary scientist on the Space Infrared Telescope Facility (SIRTF), due to launch in 2003.

Solar Physics

The National Academy of Sciences selected 14 individuals to receive awards honoring their outstanding scientific achievements. The Arctowski Medal, given every three years for outstanding contributions to the study of solar physics and solar-terrestrial relationships, went to **Roger Ulrich** "for recognizing the solar five-minute oscillations as acoustic modes in the solar interior and systematically developing both the theory and the observations to establish today's precise standard model of the solar interior." The medal and a monetary award were established in honor of Henryk Arctowski and have been awarded since 1969.

Nuclear Physics

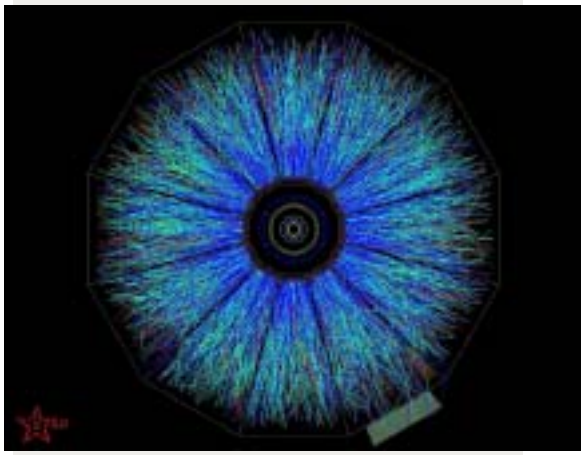
Charles Whitten and **Huango Huang** have been a major part of the STAR (Solenoidal Tracker at RHIC) collaboration, which recorded the first Au+Au collisions from the Relativistic Heavy Ion Collider (RHIC) located at Brookhaven National Laboratory on Long Island. Each Au beam had an energy of 65 GeV/nucleon so that a total energy of 24.5 TeV(10x12 eV) was available for the collisions of these nuclei. These collisions led to the highest energy densities ever created in the laboratory. Two graduate students with the UCLA group, **Eugene Yamamoto** and **Hui Long**, are among the first generation of doctoral awardees doing RHIC research. In another project, **George Igo** and team participated in the first production of polarized proton/proton collisions in the collider mode using the STAR detector at the RHIC facility.

Condensed Matter

In experiments with small balls (glass, nylon, wood, plastic) in sand, **Douglas Durian** and undergraduate student **Jun Susan Uehara** have been able to infer implications for crater formation from meteorite impact. Sand is at once fragile and strong. If you set a ball down in sand, no matter how gingerly, it creates an indentation. One slight tap and the ball digs deeper. Yet, spike the ball into the sand, and the crater it forms will not be very deep. Similarly intriguing combinations of solid-like and liquid-like behavior have led to tremendous recent research activity into the physics of granular media in general. To deduce the salient features of the dissipative forces generated by granular materials, Professor Durian investigated the formation of craters created by impact with a ball. He was able to report trends relative to ball size, ball mass and drop height. The results can be used to infer the average force versus impact speed. He found a remarkable collapse of data that holds for all but very dense balls, offering potential implications for the effect of a meteorite hitting the earth.

In studies of order and fluctuations of the spin density wave phase of the quasi, one-dimensional organic conductor $(TMTSF)_2PF_6$, **W. Gilbert Clark** and colleagues did proton nuclear magnetic resonance measurements up to 1.9 GHz in a magnetic field of 44.7 T using the Hybrid magnet at the National High Magnetic Field Laboratory. It established a world record for high field/frequency proton NMR measurements. A report was presented at the Conference on Physical Phenomena in High Magnetic Fields in October 2001. Other work done by Professor Clark on the spin=1 one-dimensional antiferromagnet $LiGe_2O_6$ using a 42 T field established the correct polarization of the ordered moments—wrongly determined from neutron scattering. This work also showed a huge asymmetry of the crystal field in the material as well as an unusual behavior of the low temperature magnetic fluctuations in the ordered state.

W. Gilbert Clark was appointed to a three-year term on the Users Committee of the National High Magnetic Field Laboratory.



View of one of the first full-energy collisions between gold ions at Brookhaven Lab's Relativistic Heavy Ion Collider, as captured by the Solenoidal Tracker At RHIC (STAR) detector. The tracks indicate the paths taken by thousands of subatomic particles produced in the collisions as they pass through the STAR Time Projection Chamber, a large, 3-D digitial camera.

Steve Kivelson was elected Fellow of the American Academy of Arts and Sciences.

Sudip Chakravarty and **Chetan Nayak**, with their collaborators R.B. Laughlin of Stanford University and D.K. Morr of the Los Alamos National Laboratory, made the proposal that the enigmatic pseudogap state of the high temperature superconductors is, in fact, a new, broken-symmetry state of matter in which strong electronic correlations result in an alternating pattern of circulating currents. According to their theory, superconductivity in these materials competes with this ordered state, the DDW state. Along with graduate students **Xiao Yang** and **Sumanta Tewari** and post-graduate student **Hae-Young Kee,** they have been exploring the possible experimental consequences of this hypothesis. The researchers have been interacting closely with a number of experimentalists whose measurements appear to be consistent with their theory.

Gary Williams and graduate student **Heetae Kim**, along with postdoctoral students **Kazuya Seo** from Japan and **Bernd Tabbert** from Germany, have made the first investigations of a new type of superfluid system—a superfluid fog. This fog is formed by subjecting a liquid helium surface to a strong ultrasonic sound wave, causing small superfluid droplets to be emitted into the helium vapor and forming a thick fog. Photographs of the fog droplets taken with strobe-light illumination showed that changing the frequency of the ultrasonic wave could vary the size of the droplets. Laser scattering measurements from the fog were also carried out in collaboration with **Douglas Durian's** research group. Future work will examine the superfluid properties by measuring the attenuation of sound through the fog.

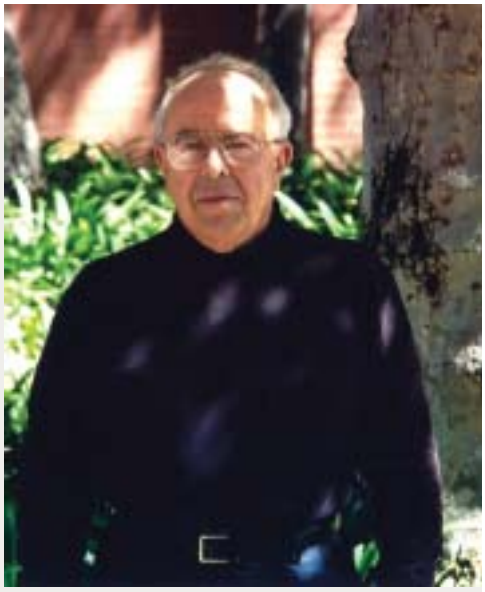
Giovanni Zocchi and his research group study biological macromolecules, proteins and DNA, focusing on their conformational changes. Through optics and nano-mechanical techniques, they detect and force changes of conformation; some experiments are done on single molecules, some on ensembles. One important result from this work in 2001 was the discovery that proteins can be plastically deformed. This result was obtained using a new technique developed in their lab allowing them to measure nm scale deformations and apply pN forces on single molecules. Another important result obtained recently concerns the melting transition of DNA, wherein these researchers have developed a new technique to trap intermediate states. This will allow them to study the nature of the transition, in particular the dependence on sequence.

Experimental Elementary Particles

Katsushi Arisaka, David Cline, Robert Cousins, Jay Hauser, Peter Schlein, and colleagues are preparing the Compact Muon Solenoid (CMS) detector for future operation at the Large Hadron Collider at the CERN laboratory near Geneva, Switzerland. This CMS detector will look at the debris from proton-proton collisions having energy of 14 trillion electron-volts when it begins to operate in 2006. Two new laboratories were set up at UCLA and are now operating at full capacity. One laboratory is

testing CMS muon detectors, and the other is building high-speed programmable electronics for collecting data.

After several years of research, **Nina Byers** has completed work on a unique, historical archive of women physicists who have made original and important contributions in the 20th century. The project was sponsored by the American Physical Society and the Alfred P. Sloan Foundation. A website has been created (www.physics.ucla.edu/~cwp) that documents the lives and work of 86 women. The citations contain photographs and background texts. They have been compiled and carefully researched for accuracy and reliability with the help of UCLA colleagues and students, as well as colleagues from around the world. The electronic archive is being ported into the UCLA Library and will become a permanent part of their digital collection. Documentary materials of historical interest that were collected during the research will be available in the Special Collections section of the UCLA Library. **Steven Moszkowski** and **Chun Wa Wong** were particularly helpful in the course of this work.



Rubin Braunstein and colleagues received a 2001 Research Partnership Award from the U.S. Department of Energy for their role in the Thin Film Photovoltaic Partnership Program.

After five years of construction, **Jay Hauser, David Saltzberg**, and colleagues are studying proton-antiproton collisions at the presently highest accelerator energies (1.8 trillion electron-volts) using the Collider Detector at Fermilab (CDF) experiment, located near Chicago. From these collisions, they can study the detailed properties of top quarks and look for new particles, such as those predicted by the theory of Supersymmetry. Three UCLA-built detector systems are now working beautifully: one calorimeter system has nearly doubled the sensitivity of CDF to electrons; another is used to align the particle tracking layers to an accuracy of 1 micron; and the third is part of an electronics system that selects the most valuable handful of collisions out of the nearly two million per second that are produced.

An exciting new program, "Symmetries in Particle and Nuclear Physics," was launched on November 12, 2001, in Mainz, Germany. **Bernard Nefkens** is the chair of a newly created collaboration that channels the efforts of 15 physics institutions in the United States and Europe in making a comprehensive set of symmetry tests based on meson photoproduction. This research requires the use of the famous Crystal Ball detector, together with the upgraded Mainz Microtron electron accelerator. After two highly successful runs at Brookhaven National Laboratory, the Crystal Ball is being packed for the transatlantic voyage to Mainz. The program is a multiyear endeavor having tremendous potential for original research. It is particularly attractive to graduate students.

A special, two-year creativity extension was awarded to Sudip Chakrvarty by the National Science Foundation, based on outstanding scientific progress achieved to date under his grant "Quantum Aspects of Condensed Matter."

Theoretical Elementary Particles

Zvi Bern, with Lance Dixon from SLAC and graduate students **Abilio De Freitas** and **Henry Wong,** recently computed important two

quantum loop amplitudes for particle production at high-energy particle colliders. These calculations are important contributions to a recent breakthrough for calculating higher order quantum effects. This breakthrough was used in collaboration with Carl Schmidt at Michigan State University to improve a theoretical prediction useful in unraveling the mystery of electroweak symmetry breaking at the future Large Hadron Collider being built at CERN.

Nina Byers was elected Vice Chair of the Forum on the History of Physics of the American Physical Society.

John Cornwall is working on some important questions in quantum chromodynamics (QCD), the theory of strong interactions of quarks, and on particle physics in the early universe. His QCD work involving the nature of topological charge in the center-vortex picture of QCD unexpectedly showed that topological charge is localized in fractions of the units (called instantons), which are long thought to be the only objects carrying topological charge.

Eric D'Hoker and D.H. Phong in the Mathematics Department at Columbia University have made a recent breakthrough in higher quantum loop string theory scattering amplitudes. Superstring theory, in which the elementary constituents of matter are described as one-dimensional strings, automatically encompasses gravity, Yang-Mills theory and supersymmetry in a unified framework that is consistent with quantum mechanics. The starting point for string theory is a summation over fluctuating random surfaces. The number of handles of each surface corresponds to its order in the perturbative expansion in powers of the string coupling. Tree and one-loop contributions were calculated long ago. Progress on higher loop contributions had been halted by profound conceptual inconsistencies encountered in the late 1980's. To address this problem Professors D'Hoker and Phong developed a completely consistent formulation for superstring scattering amplitudes to two-loop order.

In collaboration with Shmuel Nussinov of Tel-Aviv University, **Graciela Gelmini** and **Alexander Kusenko** proposed a method to detect and identify composite galactic dark matter, which according to Alexander Kusenko and Paul Steinhardt of Princeton University, may be in better agreement with observations than commonly assumed point-like particles.

Alexander Kusenko, with Thomas Weiler of Vanderbilt University, proposed a method for studying the neutrino interactions at ultrahigh energies, using the Earth as a detector. Cosmic neutrinos may traverse the earth, interact near the surface, and create an up-going air shower. Observations of these events can yield information about particle physics at extreme energies, far beyond those achievable in a terrestrial laboratory.

Michael Lindgren assumed responsibility for all systems of the Collider Detector at Fermilab (CDF) as the newly appointed Head of Detector Operations.

Terry Tomboulis made an important advance in constructing a consistent description of quark confinement in terms of a soup of quantum objects called center vortices. These results have recently been substantiated through extensive up-to-date computer simulations, as well as through new analytical results. The physics of the confining QCD vacuum is now one of the main areas of activity in nonperturbative quantum field theory.

The Japan Society for the Promotion of Science awarded George Igo an invitational fellowship for research at Nagoya University.

Plasma and Advanced Accelerators

UCLA's Basic Plasma Science Facility, under the direction of **Walter Gekelman,** was awarded a large grant by the U.S. Department of Energy and the National Science Foundation. It is now the country's first national research facility for scientists worldwide to study the mysterious properties of plasma. A fourth state of matter, plasma is believed to make up more than 99 percent of the visible universe, including the sun and stars. The centerpiece of the facility is the Large Plasma Device, weighing in at more than 80 tons. Professor Gekelman and colleagues built the device over three and a half years. It is unique in the world, and through the grant, will offer physicists the opportunity to create and analyze plasma waves and study turbulence and transport, as well as other fundamental issues of plasma science.

George Morales and **Frank Tsung** have used a novel computer simulation to investigate the dynamics of supersonic plumes moving through magnetized plasmas. Events of this type occur in astrophysical plasmas, give rise to structures in the solar wind, and lead to the formation of prominent features observed by spacecraft. A key interaction, not previously captured in fluid/MHD descriptions, has been identified. It consists of the ballistic expansion of plume electrons and results in a long-lived dipolar current system surrounding a region of net positive charge. A three-year National Science Foundation (NSF) grant has been awarded to support the theory/computational effort and another has been awarded (with **James Maggs** as co-investigator) for joint theory/experimental studies of filamentary structures generated under controlled conditions in the Basic Plasma Science Facility (BASPF).

Large Plasma Device

During the last year **Claudio Pellegrini** and **James Rosenzweig** obtained some important results on the physics of Self Amplified spontaneous emission free-electron laser (SASE-FEL). The VISA experiment, in which the UCLA group is a major player, together with SLAC and Brookhaven, has reached saturation at about 800nm with the shortest gain length obtained to day in any SASE-FEL. For the first time the intensity fluctuations at saturation were observed and compared to those during the exponential growth. The third and fifth harmonic of the fundamental wavelength were measured and characterized. A complete simulation of the experiment, starting from the first principles, was conducted and agrees with the data. This is important progress for the LCLS, a revolutionary SASE-FEL being built in collaboration with five national laboratories, which will be capable of producing high peak power, subpicosecond, coherent x-rays at about 1Å.

The UCLA Particle Beam Physics Laboratory (PBPL), under the direction of **Claudio Pellegrini** and **James Rosenzweig,** is a leading center investigating the physics of very high density electron beams interacting with lasers and plasmas, and of their many collective and self organizing phenomena. The applications of these studies range from accelerators for elementary particle physics, to free-electron lasers in a study of complex molecules on a femtosecond time scale. Experiments are done at UCLA and national laboratories. New results obtained during the last year at UCLA include compression of electron bunches to a few hundred femtoseconds, and controlled acceleration in a plasma beat-wave accelerator.

Claudio Pellegrini received the 2001 Robert R. Wilson Prize from the American Physical Society

Rene Pellat received the French "Legion de'honneur" at the officer level for 2001.

Robert Cousins was named 2002 Chair of the Fermilab Physics Advisory Committee (PAC). He has been serving a four-year term on PAC, advising the Fermilab director on priorities and planning for particle physics experiments.

Department of Physics and Astronomy Faculty

Professor
Ernest S. Abers
Katsushi Arisaka
Maha Ashour-Abdalla
Eric Becklin
Zvi Bern
Stuart Brown
Robjin Bruinsma
Charles Buchanan
(Vice Chair Academic Affairs)
Sudip Chakravarty
David Cline
Ferdinand V. Coroniti
Robert Cousins
Steven C. Cowley
Eric D'Hoker
Douglas J. Durian
Sergio Ferrara
Christian Fronsdal
Walter Gekelman
Graciela Gelmini
Andrea Ghez
George Gruner
Jay Hauser
Karoly Holczer
Hong-Wen Jiang
Michael Jura
Steven Kivelson
Matthew Malkan
Ian McLean
George J. Morales
Warren Mori
Mark Morris
Bernard M. K. Nefkens
William I. Newman
Rene Ong
C. Kumar N. Patel
Roberto Peccei
Rene Pellat
Claudio Pellegrini
(Chair)
Seth J. Putterman
James Rosenzweig
Joseph A. Rudnick
Peter E. Schlein
William E. Slater
(Vice Chair Resources)
Reiner Stenzel
Terry Tomboulis
Jean Turner
(Vice Chair Astronomy and Astrophysics)
Roger Ulrich
Charles A. Whitten, Jr.
Gary A. Williams
Alfred Y. Wong
Chun Wa Wong
Edward L. Wright
Benjamin Zuckerman

Associate Professor
Huan Huang
James Larkin
Chetan Nayak
David Saltzberg

Assistant Professor
Per Kraus
Alex Kusenko
Giovanni Zocchi

Professor Emeritus
Lawrence Aller
Hans Bommel
Rubin Braunstein
Nina Byers
Marvin Chester
W. Gilbert Clark
John Cornwall
John Dawson
(deceased 11/17/01)
Robert J. Finkelstein
Burton Fried
Roy Haddock
George J. Igo
Leon Knopoff
Kenneth MacKenzie
(deceased 7/3/02)
Steven A. Moszkowski
Richard E. Norton
Mirek Plavec
Robert Satten
(deceased 10/2/01)
David Saxon
(UC PresidentEmeritus)
Eugene Y. Wong
Byron T. Wright

Researcher
Victor Decyk
Samim Erhan
Jean Noel LeBoeuf
Anthony Lin
James Maggs
William Peebles
Philip Pritchett
Michael Rich
Robert Taylor
Steven Trentalange
Manuel Urrutia
Mahmoud Youssef

Assistant Researcher
Luca Bertello
Yasuo Fukui
Jean Luc Gauvreau
Mark Gilmore
Mikhael Ignatenko
David Leneman
Chuang Ren
Glenn Rosenthal
Shoko Sakai
Frank Tsung
Stephan Vincena
Hanguo Wang

Associate Researcher
Richard Edelson
Vahe Ghazikanian
Michael Lindgren
Ravi Narasimhan
Terry Rhodes
Lothar Schmitz
Ferenc Varadi

Sr. Lecturer, SOE
Arthur Huffman

UCLA Plasma Science and Technology Institute

The Plasma Science and Technology Institute, under the direction of physicist **George J. Morales,** is a unique, multidisciplinary research unit investigating the fourth state of matter known as plasma. Matter in this state is typically at low density and high temperature and is found naturally throughout the Universe, starting at 50 kilometers above the earth's surface. Practical applications of plasmas include fluorescent lamps, television screens and free electron lasers.

Research groups participating in the Institute are drawn from the UCLA departments of physics and astronomy, electrical engineering, mechanical engineering, earth and space sciences, atmospheric sciences and the Institute of Geophysics and Planetary Physics. They are led by 20 faculty members and a comparable number of senior researchers who supervise up to 20 postdoctoral researchers and 30 graduate students. Programs are funded directly through principal investigators by various federal agencies at a level of approximately $12 million per year.

The research activities of the Institute encompass experimentation, theory and computer simulation, and are conducted in medium-sized laboratories housed on-campus in the participating departments, and in the recently completed Science and Technology Research Building in nearby Westwood Village. Collaborative research is also conducted in affiliated laboratories. These include national accelerator facilities (SLAC, Brookhaven) and national fusion facilities (GA, PPPL); and in field observatories (Alaska, Arecibo). Space researchers have instruments on board active spacecraft POLAR, Galileo, and FAST.

Institute research ranges widely from naturally occurring plasmas, such as solar wind, to controlled fusion energy. Plasma-based fusion research is showing great promise as an environmentally benign source of limitless energy.

The Science and Technology Research Building accommodates large-scale programs of the Institute.

Areas of Research

- *basic plasma physics*
- *fusion research*
- *space plasma physics*
- *laser plasma interactions*
- *advanced accelerators*
- *novel radiation sources*
- *plasma materials processing*
- *environment*

Education Highlights

In Memorium

A Celebration of the Life and Career of John Dawson

The US–Japan Workshop on "Simulations of Plasmas" was at once a celebration of the science that John Dawson loved and helped create, as well as a tribute to the man. Held in the Spring of 2002, six months after his death at the age of 71, the event drew colleagues, students, friends and family from around the world. Concurrently, The John Dawson Memorial Fund for student scholarship awards was established at UCLA. John Dawson was a leading figure in the field of plasma physics for over four decades, and though his area of expertise was numerical modeling, his contributions to science spanned all of plasma physics. He was considered to be the father of plasma-based accelerators and computer simulation of plasmas. While others have made pioneering contributions to particle simulations, it was John Dawson who developed this field into a third discipline. He was particularly proud of an isotope separation process that he invented, which was used to save the lives of cancer patients. During his career, he was elected to the National Academy of Sciences and the American Academy of Arts and Sciences. Among his many awards were the prestigious Maxwell Prize and the Aneesur Rahman Prize

Kenneth MacKenzie, the Founder of UCLA Plasma Physics Laboratory

After more than half a century of accomplishments, including ground-breaking contributions to UCLA and the field of physics, Kenneth Ross MacKenzie died in July 2002 at the age of 90. He began working on the atom bomb as a graduate student; helped mentor Ernest O. Lawrence build the first cyclotron (atom smasher), later installing it at UCLA; and in the last half of his career, concentrated on the development of thermonuclear fusion as a nonpolluting energy source. Dr MacKenzie joined the UCLA faculty in 1947 and continued his research as an emeritus professor long after leaving the classroom. During his career he founded UCLA's Plasma Physics Laboratory and with colleague Byron Wright, formed a corporation to build cyclotrons for the purpose of teaching physics.

In Memory of Robert Satten

For almost two decades Robert Satten dedicated his extraordinary career to UCLA's physics department, serving eight years as its vice chairman and devoting two sabbaticals to research under Fulbright Research Fellowships. In September of 2001, in his 79th year, he passed away. His life's work was devoted primarily to low temperature spectroscopy, studying the electrical properties of rare earth and uranium ions in crystals and the interaction of those ions with lattice vibration of the crystals. During his career he developed a new optical method for directing microwave paramagnetic resonance and relaxation, and participated in the project that produced the first laser.

New Faculty Member, Per Kraus

Per Kraus joined the faculty as assistant professor in elementary particle theory. His particular research interest is in string theory as a theory of quantum gravity. Per Kraus comes to UCLA from the University of Chicago where he was a research associate. His educational background includes a doctoral degree in physics from Princeton University, followed by three years as the Lee DuBridge Prize fellow at the California Institute of Technology.

Roberto Peccei and Peccei Fest

In celebration of his 60th birthday, the UCLA Department of Physics and Astronomy hosted Peccei Fest, a one-day scientific conference entitled "CP Violation: Past, Present and Future." The event honored Roberto Peccei and his 13-year career at UCLA as a teacher, scientist and administrator. Arriving in 1989 with an impressive record of accomplishment in particle physics, he served as professor and chair for the then department of physics until 1993 when he was appointed Dean of Physical Sciences in the College of Letters and Science. In 2000 he accepted a new office as Vice Chancellor for Research. While overseeing the University's $500 million annual research effort, he is also charged with promoting new research. His primary goals are to increase the campus' involvement in technology transfer and strengthen its relationship with industry. He is currently leading a collaborative effort with colleagues from UC Santa Barbara to develop a new institute of science and innovation. Growing up in Argentina, the Italian-born boy won a prize that profoundly directed his life—he received a book about building the atomic bomb. Roberto Peccei subsequently pursued a career in physics with a special interest in electroweak interactions and the interface between particle physics and cosmology.

The Life and Times of Enrico Fermi

An international symposium honoring the 100th year of his birth and dedicated to the scientific contributions and teaching legacy of physicist Enrico Fermi was offered on the UCLA campus in the Fall of 2001. The event also explored his response, and that of other scientists, to the extraordinary political and social forces of the 1930s to the 1950s. It was a historically rich part of the 20th century when democracies were engaged in a dramatic conflict with fascism and communism that led to World War II and then to the Cold War. At the same time, scientists were revolutionizing the world through nuclear and high-energy physics, enabling human capacity in ways that at once improved and threatened its very existence. Topics offered by the two-day symposium included the development of nuclear weaponry from Enrico Fermi's perspective and experience, as well as from the viewpoint of other important intellectuals of the period. The symposium offered lectures from an international faculty, in addition to roundtable and panel discussions. Admission was free and open to the public. UCLA organizers from the Department of Physics and Astronomy, the Department of Italian, and the Center for Modern and Contemporary Studies were joined by representatives from the Instituto Italiano di cultura, Los Angeles, under the auspices of the Consul General of Italy.

"Whatever nature has in store for mankind, unpleasant as it may be, men must accept, for ignorance is never better than knowledge." Enrico Fermi

Per Kraus, Assistant Professor in elementary particle theory

Roberto Peccei with his birthday present – the first Italian book on electromagnetism

Jean Turner (Vice Chair) and Claudio Pellegrini at Graduation 2002

Graduates

Bachelor of Science Degrees Awarded

Astronomy

Michele Carpenter
Lorien Friesen
Jon A. Frigulti
Adrian Head
Kwang Ho Kim
Louis Levenson
- Departmental fellowship to pursue graduate studies in astrophysics at UCLA

Angel Marquez
Eric Mittlestaedt
- Fellowship to pursue graduate studies in geophysics at the University of Hawaii

Sabrina Pakzad
Priscilla Payan
(double major in astrophysics and mathematics)
- Departmental fellowship to pursue graduate studies in physics at UCLA

Maria Perelli
Pheng Rathana
Joshua Scherbenski
(double major in astrophysics and mathematics)
Kiyomi Tsuruta
Jun Uehara
Joaquin Vieira
- Departmental fellowship to pursue graduate studies in astrophysics at the University of Chicago

Physics

Shimul Akhanjee
- Departmental fellowship to pursue graduate studies in physics at UCLA

Arsho Azadian
Antonia Chimonidou
- E. Lee Kinsey Award

David L. Emerson
Arshak Gharibjanyan
(double major in physics and mathematics)
- Departmental fellowship to pursue graduate studies in mathematics at UCLA

Albert Hahn
Maurio Holston
- Fellowship to pursue graduate studies in physics at the University of California, Irvine

Mollie Ireson
Tyrell Johnson-Miles (double major in physics and mathematics)
Dai Katagiri
Priscilla Kurnadi
Chi Wai Lam
- Departmental fellowship to pursue graduate studies in physics at UCLA
- E. Lee Kinsey Award

Spencer McLemore
Benny C. Lee
Sinh Quang Ly
Alex Manasson
Charan Mellor
Shawn Pollock
- Departmental fellowship to pursue graduate studies in physics at UCLA

Ren Ritsuno
- E. Lee Kinsey Award

Mankei Tsang
(double major in physics and electrical engineering)
- Fellowship to pursue graduate studies in electrical engineering at the California Institute of Technology
- E. Lee Kinsey Award

Elbert Wu
Sina Zareian
Jeff Sylverwind
(Bachelor of Arts)

Doctoral Degrees Awarded

Astronomy
Lucian P. Crosthwaite
David Stuart Meier
• PAAL Outstanding Graduate Student Award 2001–2002 (Physics and Astronomy Alumni Alliance)

Condensed Matter Physics
Pierre-Anthony Lemieux
Vadim Oganesyan
Verner Kristian Thorsmoll
Roya Zandi
• Graduate Opportunity Fellowship 1994–1995
• Research Mentorship 1999–2000
• Dissertation Year Fellowship 2000–2001

Elementary Particle Physics
Marieke Postma
• Dissertation Year Fellowship 2001–2002

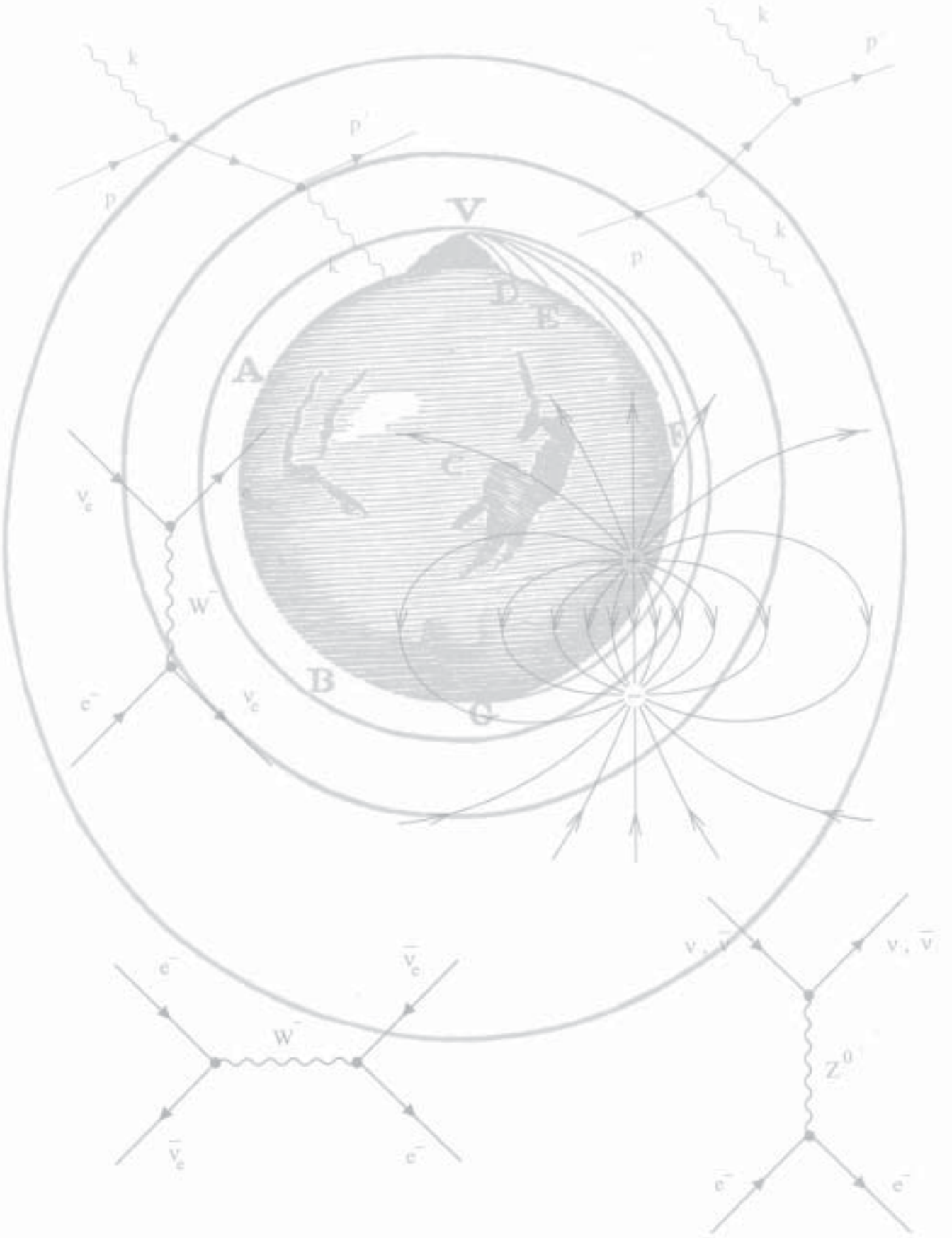
High Energy Physics
Patrick Boykin
• Alyne and Leon Camp Fellowship 1996–1997
Youngho Seo

Nuclear Physics
Hui Long
Nakorn Phaisangittisakul
Eugene Yamamoto

Plasma and Advanced Accelerator Physics
Scott Anderson
Matthew Charles Griskey
• Alyne and Leon Camp Fellowship 1994–1995
Lukas Mandrake
Lance Robert Menthe
• PAAL Outstanding Graduate Student Award 1998–1999(Physics and Astronomy Alumni Alliance)
Alex Murokh
John Tonge

Graduates

Francoise Queval, Undergraduate Advisor, and graduates celebrating


k
p'
p
V
A
B
C
D
E
ν_e
W^-
e^-
ν_e
$\bar{\nu}_e$
W^-
e^-
$\bar{\nu}_e$
e^-
$\nu, \bar{\nu}$
$\nu, \bar{\nu}$
Z^0
e^-
e^-