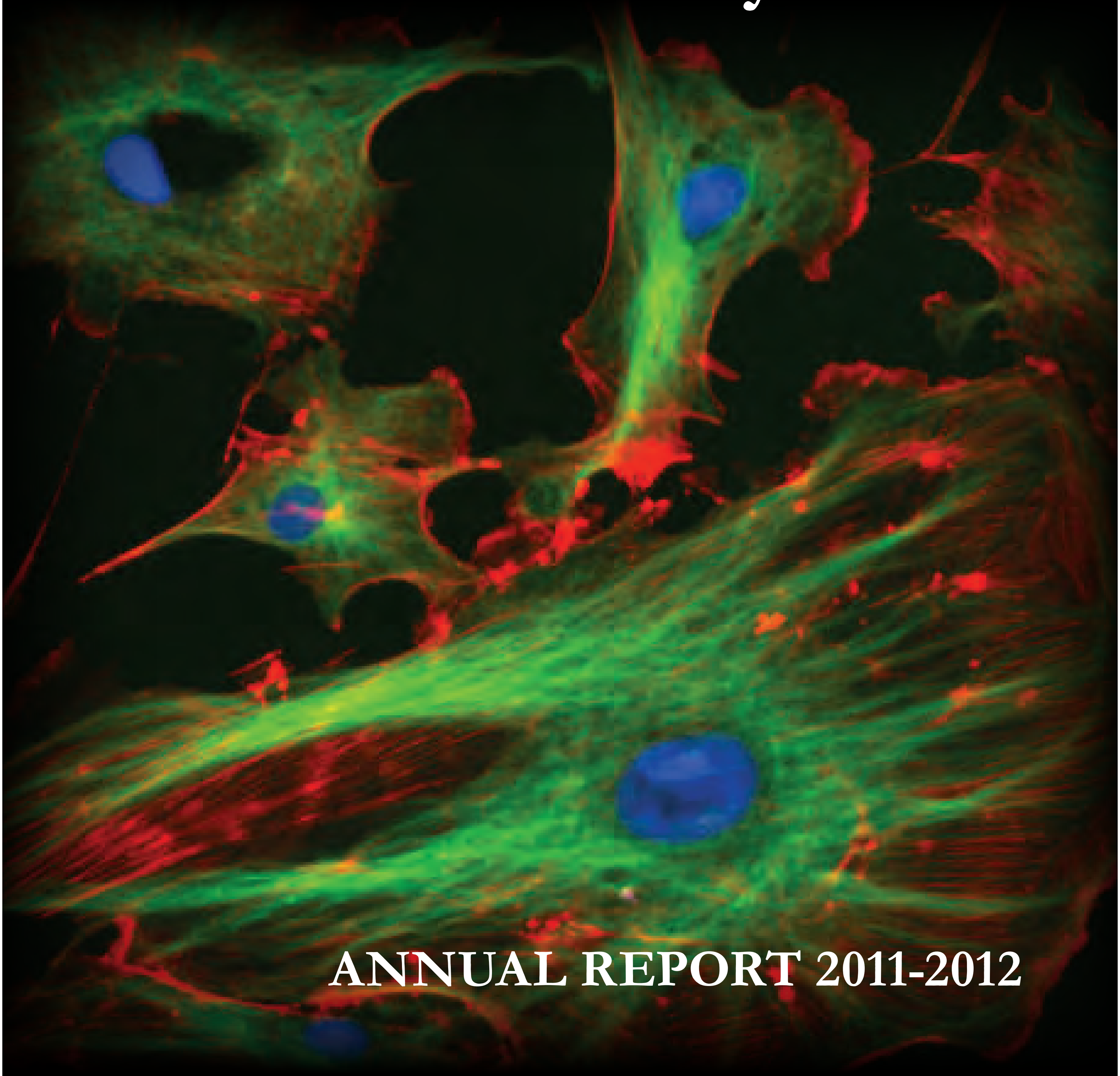
UCLA

Department of Physics & Astronomy



ANNUAL REPORT 2011-2012

UCLA Physics and Astronomy Department
2011-2012
Chair
James Rosenzweig

Chief Administrative Officer
Will Spencer

Feature Article
Alex Levine

Design
Mary Jo Robertson

Requests for additional copies of the publication
UCLA Department of Physics and Astronomy
2011-2012 Annual Report may be sent to:

Office of the Chair
UCLA Department of Physics and Astronomy
430 Portola Plaza
Box 951547

For more information on the Department see our website:
http://www.pa.ucla.edu/

Los Angeles California 90095-1547

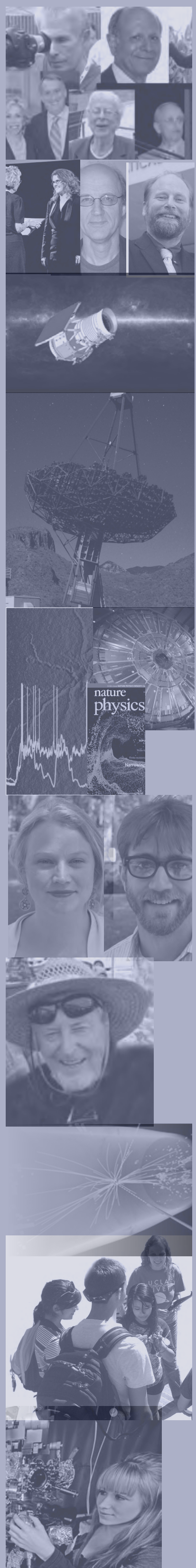
Annual Report 2011-12-Final-.indd 2 11/30/12 3:23 PM

Department of Physics & Astronomy

2011-2012 Annual Report

University of California, Los Angeles

CONTENTS



Message from the Chair


James (Jamie) Rosenzweig, Chair

As Chair of the UCLA Department of Physics and Astronomy, it is with pleasure that I present to you our 2011-12 Annual Report. This communication is intended to document the highlights of departmental experience in the last year, from news about research achievements, to faculty hiring and advancement, and to special recognitions of excellence within our ranks. I intend this report to provide a clear overview of the kaleidoscope of exciting activities during the year, in the hope of stimulating further interest. I hope that reading it proves a gateway to a need to know further about our first-rate education and truly innovative research programs. This information can be obtained through the recently redesigned departmental web site. I encourage you to explore this site in detail, as it offers considerable resources for informing students, colleagues, potential benefactors, and the public at large, about our department.

As scientists, we are driven towards quantitative descriptions of phenomena. In the case of an academic department, a quite complex system, it is a challenge to reduce our current status to numbers. Nonetheless, the numbers are promising indeed. The UCLA Department of Physics and Astronomy is clearly approaching top-10 status nationally — in the last National Research Council Rankings, our research program was measured to be as high as eighth in the nation. This excellence is to be expected in the context of the UCLA Division of Physical Sciences, as in a recent Times of London rating, UCLA physical sciences was listed as eighth in the US and ninth in the world. These impressive achievements in graduate education are mirrored by incredible growth in popularity of the undergraduate major: in physics, biophysics and astrophysics, major enrollment is up by over 50% in the past four years. UCLA produces over 1% of the annual crop of physics bachelors in the US at present.

It is traditional in our annual report to provide, in addition to summaries of research highlights from across the department, an in-depth look at one particular area in the departmental portfolio, in our feature article.

This year we feature the exciting work of the biophysics area, a diverse group of physicists who are exploring the fundamental attributes of biological systems using physics techniques in both their theoretical and experimental embodiments. The UCLA group is strengthened greatly by the presence on campus of the world class UCLA Medical School and the California NanoSystems Institute (CNSI). To exploit the possibilities for cross-disciplinary cooperation in biophysics, in the last year the UCLA Center for Biological Physics was formed. Indeed, the unique collaborative environment here allows investigations into topics ranging from the macroscopic systems level — e.g. neurophysics, the physics of brain function— to the molecular level, in which deduction of structure of, for example, DNA or protein molecules, gives rise to a deep understanding of molecular function. Applications of such knowledge are obvious, and contribute to our well being through improved understanding of pathologies and pathways to their cure. This potential is well recognized, drawing support from sources ranging from the National Institutes of Health to the Keck Foundation. The feature article, entitled Center for Biological Physics: Exploring The Physical Foundations of Emergent Phenomena, provides an excellent introduction to our burgeoning program in biophysics.

Beyond the focus of the feature article, this report gives snapshots of the compelling variety of recent research results obtained by departmental faculty. From biology, it is a long conceptual leap to fundamental particle physics, yet one that keeps you inside our department. The UCLA group at the CERN collider is an integral part of the team that found the long-sought Higgs boson, with new discoveries certain to emerge. To aid this search UCLA physicists provide essential theoretical support, ranging from direct support for LHC experiments, to frontier work in string theory and super gravity. In a heavy ion collider at Brookhaven Lab in New York, the UCLA group plays a leading role in experiments that shed light on an extreme state of the sub-nuclear matter termed the quark-gluon plasma.

At UCLA, particle physics is found in astronomical approaches as well, with questions concerning the structure and composition of the universe investigated by our high energy cosmic ray and dark-matter groups. The skies are also searched by UCLA teams at the Keck telescope, with its capabilities enhanced by state-of-the-art "eyes" such as Prof. Ian McLean's MOSFIRE infrared detector. Fascinating objects such as exoplanets and the violent neighborhood of the galactic center are brought into view.

UCLA physics is also home to unique programs in plasma and beam physics. This research holds the promise of applications such as future energy sources based on magnetic and inertial confinement fusion, and ultra-small accelerators that would permit CERN-like experiments on the UCLA campus. These efforts have given rise to one-of-a-kind, internationally renowned laboratory facilities.

The nascent atomic-molecular-optical group grapples with physics underlying quantum computers and precision systems measuring time beyond atomic-clock-resolution. Experiments are performed by UCLA physicists that explore, using the advanced capabilities of the CNSI, the boundary between classical and quantum systems. Novel X-ray sources based on systems such as collapsing bubbles and the simple tearing of Scotch tape have emerged from departmental labs.

The faculty in our department has undergone a number of notable transitions in the past year: both Profs. Christoph Niemann and B. Christopher Regan have been advanced to the tenured ranks as associate professors. We heartily congratulate the two Chris's on this achievement. To replenish the assistant professor cohort, and to strengthen and expand our research programs, the Department has in the last year made some remarkable hires. Specifically, we have recruited three assistant professors, all at the very top of their fields: Lindley Winslow, an expert in neutrino physics; Wes Campbell, a rising star in atomic-molecular-optical physics; and Ni Ni, a skilled practitioner of experiments in quantum materials. This impressive incoming "class" of new faculty illustrates that UCLA is a highly attractive place to do physics, with the best and brightest willing to throw their lot in with our high-achieving yet collegial community of scholars.

These impressive numbers are validated at the personal level by faculty recognition, in the form of awards and prizes bestowed by the scientific community. In the last year, our faculty members have reaped a considerable number of such honors. Prof. Andrea Ghez was awarded the 2012 Crafoord Prize in Astronomy, the first female recipient of the prize. Prof. Edward (Ned) Wright was named a recipient of the 2012 Gruber Cosmology Prize, and David Jewitt (of ESS and Physics & Astronomy) was awarded two prizes during the same week: the 2012 Shaw Prize in Astronomy, and the Kavli Prize in Astrophysics. Prof. Eric Hudson was recognized as a Cottrell Scholar in 2012, and Prof. Yaroslav Tserkovnyak was named a Simons Fellow in Theoretical Physics, in the inaugural year of the program. Professor C. Kumar Patel has been inducted into the National Inventors Hall of Fame for his invention of the carbon dioxide laser. Finally, it has been announced that Prof. Roberto Peccei will receive the 2013 J.J. Sakurai prize in Elementary Particle Theory from the American Physical Society. This prize is named for a distinguished UCLA physicist, but this represents the first time it has been awarded to a UCLA faculty member. We are delighted to welcome it home.

The department has shown renewed commitment to widening participation in science by historically underrepresented groups. In this regard, we note that a new group has been organized in the department termed "Women in Physics and Astronomy"; it was brought into existence by two graduate students, and aims to foster the community of female students, post-docs and faculty within the department.

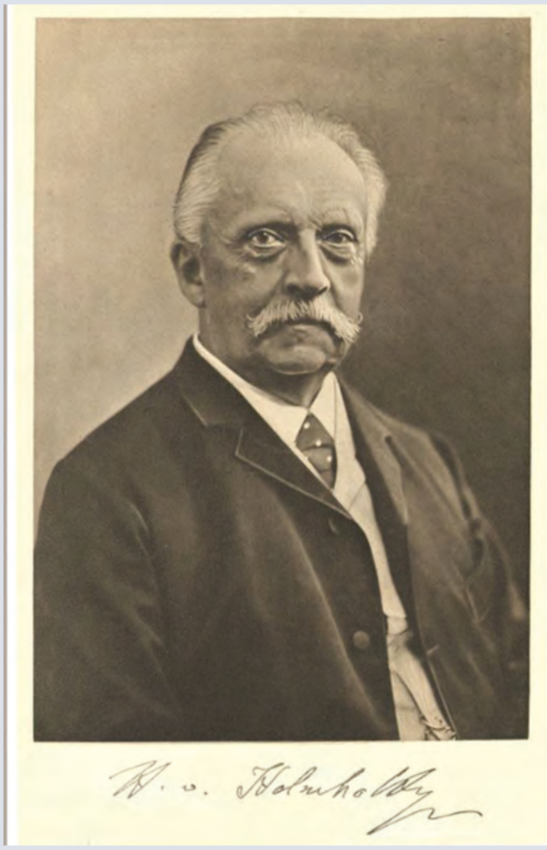
This message offers an introduction and orientation to the academic community that is our department. This community obviously extends to the alumni and valued benefactors, whose generosity is also spotlighted in this report. Whether you are interested in the UCLA Department of Physics and Astronomy 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. We hope your interest extends further still, and you will come to visit us on campus, during stimulating events such as the Bruin Heroes Award-winning Astronomy Live! outreach. Our doors will be open to all who have an abiding interest in the science that ignites our deepest curiosity.

Ian McLean, Vice Chair, Astronomy

James (Jamie) Rosenzweig, Chair

Physics provides the theoretical foundation for explaining the workings of nature in the broadest sense.

Exploring how this foundation informs our understanding of the living world may appear to be a new direction in modern physics, but actually it dates back to the foundations of physics and the birth of modern science. The development of the life sciences and the physical sciences has been intertwined for centuries. A quick glance at the work of famous physicists makes that point clear. It is no accident that Galileo's studies of the pendulum and mechanics led him to speculate on the physical constraints imposed by nature on the structure of animal skeletons. Further, Robert Hooke, who reported to the Royal Society on elasticity and gravitation, published *Micrographia* on his microscopic observations of the living world and first coined the term "cell" in its biological context. This trend continued through Maxwell and Helmholtz in the nineteenth century; Erwin Schrödinger, Francis Crick, and Max Delbrück in the twentieth; and through to the present day.



Hermann von Helmholtz (1821-1894) Pioneer in the study of electricity and magnetism, acoustics, nerve physiology, and vision.

If the 20th century was the century of physics, the 21st will be the century of biology.

New Perspectives Quarterly 21 (4), 73—77 (2004)

We are privileged to live in an age where fundamental workings of life at the molecular level are being understood for the first time in a quantitative manner. From these studies, new insights into the complexity of living systems are coming fast, one upon the next, from our colleagues in chemistry, biology, and a wide variety of related fields. It is likely that a biologist of the nineteenth century would be bewildered by today's first-year biology textbook. If this is a golden age for the life sciences, does physics have a new role to play? What can physics do for biology, and, perhaps more interestingly, what can biology do for physics?

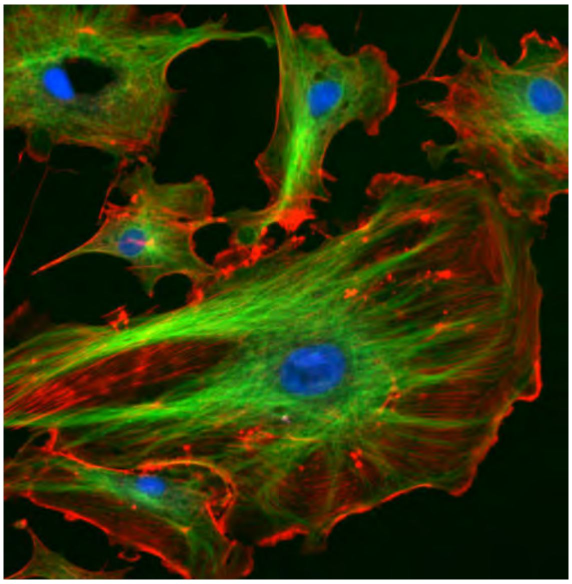
Dr. Craig Venter, who made key contributions to sequencing the human genome and who first used a synthetic genome to create cells, suggested that we indeed live in the golden age of biology. He speculated that the romance and intellectual ferment of revolutionary scientific advances will pass from physics to biology.

The existence of the field of biophysics provides a counter argument. Precisely because of the remarkable flood of new information coming from the mapping of genomes, a better understanding of the biochemical inventory of living cells, and new quantitative techniques allowing us to probe, for the first time, single molecules, there is a new role for physics, functioning productively at the boundaries of the traditional disciplines. Just as the tools developed by experimental physicists have opened new windows on the structure and dynamics of cells, understanding the formation of these structures, their mechanics and complex, dynamic interactions provides new opportunities for theoretical physicists interested in the fundamental exploration of complex non-equilibrium systems. It may be a new golden age for biology, but exciting new horizons beckon for physicists as well.

Physics or Biology?
Science in an interdisciplinary world

Physicists turning to studying living things soon realize that their ideas of fundamental physics confront a powerful, and perhaps disturbing, problem that is uncommon in physics: historical contingency. This feature alone gives one pause in considering the application of basic physics to these problems. For example, the fact that you are reading this with two eyes and turning the pages with five-fingered hands is not the logically required outcome of physical law, but the result of complex and stochastic events in our distant past. The mathematician D'Arcy Wentworth Thompson addressed this issue in his monumental work *On Growth and Form:*

"We want to see how, in some cases at least, the forms of living things, and of the parts of living things, can be explained by physical considerations, and to realize that in general no organic forms exit save such as are in conformity with physical and mathematical laws."



Cells are complex mechanical entities. In this image of the dynamic scaffolding, the cytoskeleton of endothelial cells, microtubules are stained green and actin filaments are stained red. The nuclei are blue. This complex network coupled to molecular motors controls cell shape, allows cells to exert forces on their environment, and even to measure the elasticity of their surroundings.

In short, all observable properties of the living world must conform to physical law and some, such as the graceful logarithmic spiral of the nautilus shell (studied by Thompson), can be directly understood in terms of such principles. While this is certainly true, there is another lure that biology provides the physicist. The living world creates previously unimagined dynamic organizations of matter with great complexity. Our experience with condensed matter physics does not yet provide us with sufficient tools to understand the relation of these complex structures and non-equilibrium dynamics to their collective properties. We have much to learn. For example, the cytoskeleton of living cells is a polymer network driven out of equilibrium by molecular motors, and the details of this non equilibrium state control its mechanics. Understanding how that works remains mysterious since such problems were not previously encountered in traditional polymer physics that explored synthetic systems in thermal equilibrium. Life presents an entirely new frontier.

IS THIS REALLY PHYSICS?

This question is endemic in interdisciplinary science. The distinguished physicist Prof. Michael Fisher (University of Maryland) said, "There is no interdisciplinary science without the disciplines." We take this to mean that the key to keeping the physics in biological physics is to approach questions regarding living systems in a new light based on our background as physicists. **Consequently, we do not necessarily intend to answer questions posed by our colleagues in the life sciences differently, but rather to ask different questions.**

The UCLA Center for Biological Physics

FACULTY

David Bensimon
Chemistry & Biochemistry

Dolores Bozovic
Physics & Astronomy

Robijn Bruinsma
Physics & Astronomy

Tom Chou
Biomathematics & Mathematics

William Gelbart
Chemistry & Biochemistry

William Klug
Mechanical and Aerospace Engineering

Charles Knobler
Chemistry & Biochemistry

Thomas Mason
Chemistry & Physics

Mayank Mehta
Physics & Astronomy, Neurology, Neurobiology

Jianwei (John) Miao
Physics & Astronomy

Amy Rowat
Integrative Biology and Physiology

Yaroslav Tserkovnyak
Physics & Astronomy

Shimon Weiss
Chemistry & Physiology
California NanoSystems Institute

Gerard Wong
Bioengineering

Giovanni Zocchi
Physics & Astronomy

The UCLA Center for Biological Physics applies and adapts the methods of fundamental physics and mathematics to study basic questions of biology. Eventually, we hope to better understand the answers to such questions as these: What are the minimum molecular components required for the assembly of a functioning cell? Under what conditions will self-replicating and error-correcting molecular machines evolve from simpler molecular components? How does the cellular replication control fail in the context of cancer? What are the physical mechanisms of sensory detection and what are the fundamental limitations on detecting sound or light?

The Center is supported by both the Department of Physics and Astronomy and Joseph Rudnick, Dean, Division of Physical Sciences. Currently, we are a group of seventeen faculty, most with appointments in the Department of Physics & Astronomy, but also including faculty from Chemistry, Engineering, Mathematics, and Physiology. Combining our expertise into a cohesive group will raise the visibility of UCLA's contributions to this field and enable us to play a leadership role in the future course of biological physics.

While we work together to perform research that simply cannot be undertaken by any one person, no matter how talented, we also work together to provide resources for the department, its alumni, and the campus. In the spring, we host a yearly public lecture to which a top physicist is invited to report about work conducted at the frontiers. We also sponsor "Evening in the Labs," where one can learn first-hand how biological physics research is conducted at UCLA. I strongly encourage you to join us for these events. Discussed on the following pages are examples of research going on in the Center. I am looking forward to hearing from you.

Sincerely,

Alex J. Levine
Director, Center for Biological Physics.

For more information please see our website http://cbp.physics.ucla.edu.

If you have any questions or comments,
please contact me at: cbpdirector@physics.ucla.edu.

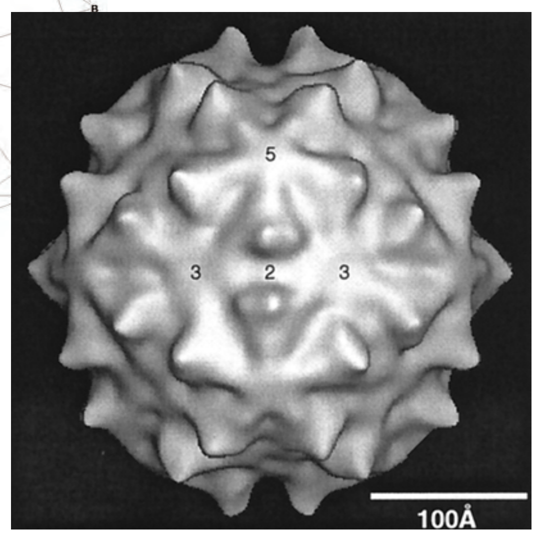
Viruses: Geometry at the edge of life

Science fiction writers have explored an end-of-the-world scenario that announces itself not with the violence of an asteroid impact, but by the subtle and initially unnoticed spread of microscopic self-replicating machines, like those originally envisioned by John von Neumann, Freeman Dyson, and others. These hypothetical devices involving molecular scale nanotechnology are imagined to consume our environment for raw materials, reducing the world to a "grey goo" of the exponentially growing number of replicators. While certainly less lurid and apocalyptic, we live in a world already densely populated by nanoscale machines that replicate by highjacking the molecular machinery of living cells—viruses.

In addition to their implications for human health, the structural simplicity of viruses, coupled with the fact that they reside at the boundary of living and nonliving matter, has long attracted physicists to their study.

Viruses are the ultimate parasites: Composed of a nanoscale protein shell and containing all the genetic instructions to make their component parts, they rely on the infected host for the entire replication process. But the genetic information encoded in DNA or RNA takes up physical space. Watson and Crick reasoned that, based on the size of viruses, that space was at a premium. Typical viruses contain enough space for encoding only a couple of proteins.

The Flock-House virus shown here can hold the instructions for only two. So, how can a virus build its shell (capsid) from such a small instruction set? The answer is geometric symmetry. Long before the Pythagoreans, viruses "discovered" the Platonic solids, polyhedra composed of identical polygonal faces. Each corner must have an identical environment so it is possible to design one protein to have its minimum energy configuration when surrounded by that set of identical neighbors. Such proteins may then self-assemble inside the infected cell to form new viral shells solely by processes occurring in thermal equilibrium. No special assembly required! Of the five Platonic solids, the icosahedron, with twenty triangular faces, is the closest to a sphere and thus has the greatest interior volume for a given surface area. It is the shape of choice for small viruses. Bigger viruses have explored more complex shapes having, for example, two different local environments. With this innovation, they can make more spherical structures composed of hexagons and pentagons like the geodesic domes of Buckminster Fuller—or, more simply, the panels of a soccer ball.



A cryo-TEM (transmission electron microscope) picture of the Flock-House Virus. Pictured above is the electron density of the capsid, a protein shell that, in this case, houses two RNA molecules that encode the information for only two genes. These RNA molecules provide a sufficient instruction set to make copies.

QUESTIONS REMAIN

Some viruses, like HIV, undergo geometric transition as part of a maturation process.

- How does that happen?
- How do the genes pack inside a virus?
- What are the elastic properties of their shells?
- How does the assembling shell know how to pack the right number of genes?

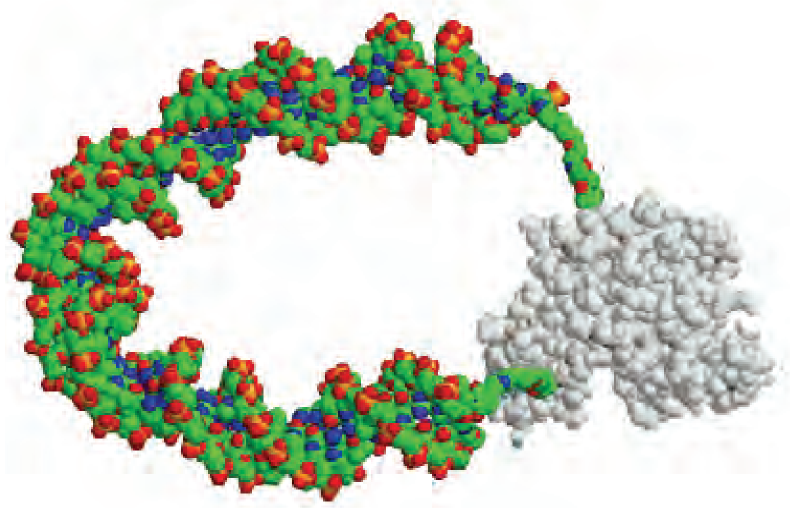
DNA and the mechanics of inheritance

For the last three billion years, life on earth has been in a continuous state of reading, copying, miscopying, correcting, swapping and mixing genes. In the computer age, it is tempting to think about information solely in the abstract, but even data in “the cloud” has a physical manifestation. Life’s genetic information storage and processing capabilities are built upon a plethora of physical processes acting on DNA, a remarkable polymer strand about two billionths of meter in width, but about a meter long if fully stretched out. These processes are carried out by a variety of molecular motors physically manipulating the DNA strand. Understanding the mechanics of DNA and the forces produced by the molecular motors acting on it continues to be a forefront problem in biological physics.

One study in the Center examines how a specialized molecule called a “helicase” consumes fuel (ATP) and unwinds the double-stranded helix of DNA as a prelude to copying this molecule. Together with a number of other proteins, it forms the complex machinery by which DNA is copied. Other studies explore the mechanics of DNA. How hard is it to stretch a DNA strand? How much torque is required to twist it up or to bend it? These questions, which can be explored by a variety of single-molecule manipulation experiments, have deep implications for understanding information processing in cells.

Understanding the mechanics of DNA has other implications as well. Center faculty have explored how one can use short (tens of billionths of a meter) pieces of DNA to exert subtle and precisely controlled forces on other nanoscale biological constructs, e.g., individuals proteins. By exploiting the specific bonding scheme of complementary DNA strands, one can design new molecular-scale experiments to probe the mechanics of proteins.

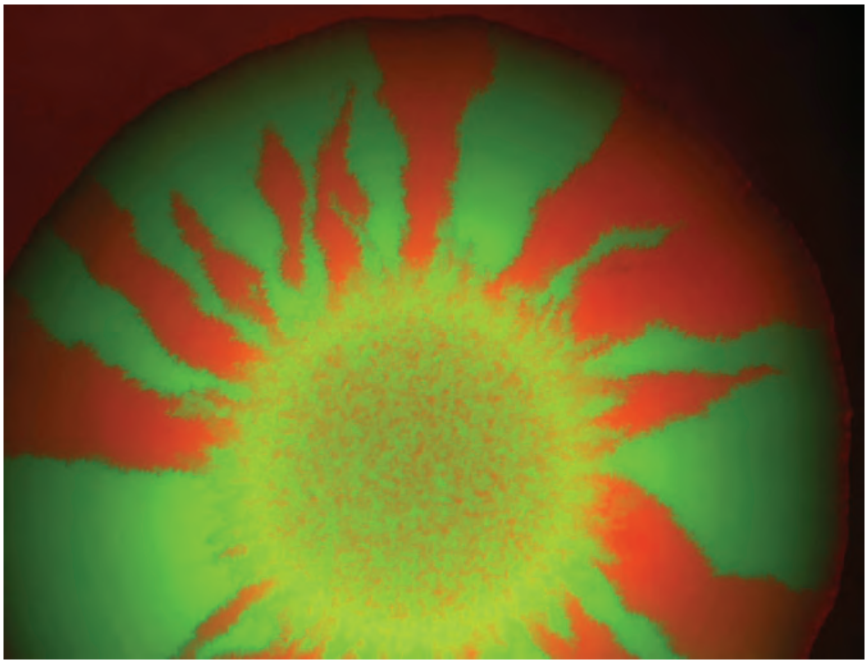
Researchers have long inferred that proteins must be able to change shape and thus their chemistry in response to specific cues, a processes termed allostery. One classic example is found in our blood. Oxygen is carried by hemoglobin molecules, a protein that holds an iron atom in such a way that it can bind oxygen and, in a sense, rust. To be a good collector of oxygen in your lungs, this protein has to be very “sticky” for oxygen, but that stickiness would inhibit the release of that same oxygen in your tissues. The resolution of this problem is to build into this carrier a simple program: in oxygen-rich environments, be sticky to load the cargo. In oxygen-poor ones, be less sticky to unload it. This program is effected by allowing the hemoglobin to change shape in the presence



A protein-DNA chimera designed to measure the work required to deform the protein. A short and stiff double stranded piece of DNA (color) is bound to specific sites on a protein (grey). The bent DNA exerts a weak force that stretches the protein. One can observe how that deformation changes its chemical activity.

of sufficient oxygen—an allosteric change that makes our high energy lifestyle possible.

So, what are the mechanics of a protein and how does it deform? By using DNA attached to a protein, one can build a type of archery bow in which the DNA is bent like the wooden bow and the protein is pulled like the tensed bowstring. Using equilibrium statistical mechanics, one can then measure with high precision the work of allostery. Using different recently developed frequency-dependent forcing methods, one can actually explore the mechanics of proteins over a range of timescales.



Two types of microorganisms (red and green) spread from the center the white circle in a single layer. Their progeny appear on the outer rim of the colony and stay there, so by reading radially inward we travel back in time tracing the changing composition of the ancestral population. From a mixed starting state, one type or the other successfully surfs the expanding population wave to take over. Courtesy David Nelson

How can you take part?

If you want to learn more about the frontiers of biological physics, we hope you will attend the programs we offer. The Center sponsors two public events: a public lecture in the spring where we invite a thoughtful and distinguished speaker to present his/her work in a public forum. On June 13, 2012 Professor David Nelson, the Arthur K. Solomon Professor of Biophysics and professor of physics at Harvard University spoke to a packed auditorium in PAB on "Gene surfing and the survival of the luckiest." While it may appear from the preceding that biological physics deals solely with the microscopic, interesting questions in population biology and the spread of particular genes in space and time are amenable to study using the methods of physics. Professor Nelson presented his work on how neutral mutations (ones that confer no selective advantage to the organism) can spread by surfing a population wave of organisms expanding their range. Such occurrences are common in life's evolution, and one example is the spread of humanity in the "out-of-Africa" hypothesis of our ancestry. One can turn powerful tools from statistical mechanics loose on such problems and even explore them experimentally using rapidly reproducing bacteria. Mathematical insights into evolutionary dynamics like these may help us better understand our own history. Such insights made by physicists into the microevolution of HIV in a host have already revolutionized treatments by demonstrating the need for multi-drug "cocktails."

In January 2013 we will hold our second yearly event—An Evening In The Labs— where we will highlight work going on at UCLA and where you will get a chance to hear a presentation, ask questions, and visit the laboratories. This year, we will feature research on viruses, hearing presentations from Professors Bruinsma (Physics) and Gelbart (Chemistry) on their theoretical and experimental studies.

Space is limited, so please make a reservation by contacting the Center. We hope you will join us. WEBSITE: http://cbp.physics.ucla.edu. **E-MAIL:** cbpdirector@physics.ucla.edu.

We hope you will join us. With your support, we will promote our university's presence in one of the rapidly growing areas of physics of the twenty-first century. You can also help us by supporting our biological physics lecture series, including our annual public lecture and the evenings in the labs. Finally, your support will contribute to the education of the next generation of physicists and enable the growth of the Center's educational outreach to local universities and community colleges.

DONORS 2011 - 2012

Robert L. & Jane Schneider
Physics & Astronomy
Graduate Award

Michael & Gretchen Kriss
Teaching Assistant Award
Physics and Astronomy
Capital Support

Janet Marott
Andrea Ghez Research Fund
Janet Marott Student Travel Awards

Richard B. Kaplan
Endowed Graduate
Award in Astrophysics

Maha Abdalla
Ernest S. Abers & Sylvia Snowiss
The Ahmanson Foundation
John A., Jr .& Joan Carethers-Allen
Robert J. Altizer
Dennis R. Anthony
Michael W. Arenton
Arete Associates
Asylum Research
AT&T Foundation
Robert Baker
Harold Baran & Romelia De Baran
Francisco M. Bernal
Lara Bernini & Brian Derro
Robert S. Bessin
The Boeing Company
Nicholas Bottka & Lieselotte Bottka
Jacqueline & Dr. Rubin Braunstein
Jack C. Brostrom
Kenneth N. Brown
Kirk C. Brown
James P. Brugger
Brian Brugman & Golnar Nassiri
Jessi R. Bustos
David O. Caldwell
Richard & Sheila Campbell
The Capital Group Companies Charitable Foundation
Ralph & Ute Chamberlin
Manuel Chaves, III & Sara Chaves
Robin E. Chin
Howard & Erma Christensen
Cisco Systems Foundation Matching Gift Program
W. Gilbert Clark & Eva S. Clark
Coroniti Family Trust
Steven W. Crowe
James I. Davis
Viktor K. Decyk
Eric D'Hoker
The DIRECTV Group Program Giving
Weijiang Dong
Steven T. Donovan
Debi A. Drayer
Ian S. Drayer
David M. Dreisbach
Justin Ducote
James Kenneth Dunn
Harold B. Eaton
James Enright & Mary A. Enright
Exxon Mobil Foundation
Kirill Fayerman
John R. Ferron
Fidelity Investments Scheifele-Holmes Family Foundation
Ivan L. Finkle
Christopher N. Folley
Frank S. Fontanella
Richard Forber & Sharon Forber
Albert J. Franco
Allan & Donna Frandsen
Francis & Patricia Freyne
Nicholas J. Frontiere
Anthony & Beverly A. Gangi
H. Douglas Garbin
Stephen Gayer
John Giang
Steven C. Gillespie
Charles Glashausser
David A. Gollom
Judith Ann Gordon
Alexander & Deborah A. Grigorian
Steven M. Guertin
Stephen L. & Elaine C. Guice
Eben Gunadi
Kenneth J. Harker
Sara R. Heap
Charles Michael Heard
Aaron & Jo-Ann Heick
Eileen W. Hinkes
Takeo T. Hirai
Christian M. Ho
Kenneth A. Hood
Julie J. Hsieh & David T. Chang
Linden Hsu
Patrick H. Hu & Susan Shen
Byron A. Iijima
Institute for Advanced Study
Donald M. Jacobs
Marilyn & Bill Jennings
Hai Jiang
James Jiang
Thomas E. Jones
Jura Family Living Trust
Andrew G. & Rachel Kadar
Reynold S. & Harriet Kagiwada
Richard B. Kaplan & Rosamond Westmoreland
Allen E. & Lynn A. Karz
Iltcho Kerelsky
Debbie M. Kern & Glen Roycroft
Sahak Khacheryan
Robert Iwao Koda
Robert P. Korechoff
Michael A. Kriss & Heather K. Kriss
William F. Krupke
E. C. Krupp
Mark J. Kushner
Clayton La Baw
Perry E. Lanaro
Brian L. Le
Arthur Levine & Lauren Leichtman
David P. Levine
Ren-Jang & Chi-Hsiang Lin
Hue B. Loo
Eduardo Limon Lugo
Jo-Ann Lung & David Schwartz
Costas & Dionisia Lymberis
William, III & Karla MacCary
James Makris
Demetrius J. & Valerie Margaziotis
Janet E. Marott
Timothy & Margaret Martin
Richard A. Mc Cray
Paul & Margaret McManigal
John A. Mc Neil
Tim & Patricia McDonald
Razvan Melen
Carl A. Melis
Osborne K. & Mildred M. Moe
John T. & Michelle Montroy
The Morris Foundation, Inc.
Bernard M. & Helen Nefkens
Xuan V. Nguyen
Oracle Corporation
Evelyn & Hsin-Chiao Ou-Yang
Timothy Pope
Martin & Thao Posner
Farhad & Berta Pourhamzeh
Howard J. & Astrid D. Preston
Julie Quaal
Lawrence S. Quimby
Ralph M. & Carmen V. Wilcox Revocable Living Trust
Raytheon Systems Company
Fred B. Reimer Research Corporation
Richard B. Kaplan Living Trust
Maria & Hans G. Ritter
Christopher C. Rodriguez
Bill & Sue Roen
Erno H. & Charlotte S. Ross
Barbara & Herbert Royden, III
Rhonda M. Sakaida
Shirley G. Saxon
Steven B. &. Frances T. Schiff
Judith E. Schrier
Gregory R. Schultz
Michael Schulz
Chu-Chih & Mrs. Li-Li Sheng
Ernst P. Sichtermann
Murray D. Silverstone
Randy W. Simon & Rachel Cohon
The Simons Foundation
Celestine Star & Grady Smith
John Soltis
David-Douglas Staszak & Kendal Busse
Ronald C. & Patricia G. Stearns
Dean M. & Lisa M. Sumi
Maria Tajeda
Diana R. Thatcher
Michael W. Thompson
Jeffrey Topper & Izumi Kobayashi
Andrew M. Torricelli
Thomas G. Tripppe
Egbert S. & Betty C. Tse
Susan E. Turnbach
Shiro A. Uchizono
Martin Villegas
W. M. Keck Foundation
Aileen Wang
Eric H. Wang
Jeremy S. & Vanessa Werner
Brice C. Weyer
Anne E. White & David C. Pace
Gordon R. White
Whitehall Foundation Inc.
Joan E. Whitten
Madeleine & Gary Williams
Dorothy P. Wong
Byron T. Wright
Wenqin Xu
Sung S. & Un J. Yoon
Faramarz Zarinshenas
J. William Zink

Ron Abelmann
Rudnick-Abelmann Endowed Fund

Shirley Saxon
David Saxon Physics Graduate Fellowship Fund

Ben & Carol Holmes
Physics and Astronomy Capital Support

Enrichetta, Beverly, & Anthony
Gangi Endowed Scholarship Fund

Dear Friends and Alumni:

As Chair, I am continuously inspired by the quality and breadth of research conducted by our scientists in the UCLA Department of Physics & Astronomy. Their work, initially concentrated on fundamental investigations, has life-changing, real-world applications and potential for future development that extend well beyond their original scope - in medicine, alternative energy, environmental preservation, defense, and more. For example, the cutting edge search for new biological imaging methods at the nanoscale, conducted by Professor John Miao, is leading directly to new, lower risk tomographic imaging systems for advanced medical diagnostics. The world-class experimental work in fusion plasmas, led by Professor Walter Gekelman, is being adapted to new methods for processing semiconductors - the raw materials of modern electronics.

Beyond its obvious, compelling benefits for the human condition, the quest for scientific discovery holds immense fascination for scientists and non-scientists alike - from the enormous potential of biophysics to revolutionize our understanding of living beings, to the intellectual adventure of particle physics, with its frontiers in new particles, and string theory/dark matter. Because of this, research in physics and astronomy attracts some of the best and brightest students - our research enterprise is, at its core, all about education and about creating the next generation of academics and teachers, national laboratory scientists, and industrial innovators. However, it is no surprise that creating the conditions for an education-centered, ground breaking research program necessitates a committed investment.

As you are no doubt aware, there has been a steady and recently dramatic erosion of state support for the university. Although UCLA physicists and astronomers have been phenomenally successful in securing funds from federal agencies that aid in funding our mission, it is not enough. Indeed, it is clear that we can no longer rely solely on state and federal outlays to sustain our truly outstanding program. The fact is that we simply cannot hope to reach extraordinary heights of discovery, nor educate our future scientific thinkers and leaders, without private philanthropy.

Over the years, we have sought to build partnerships with visionary philanthropists who share our passion for scientific research and education. I have witnessed the huge impact that their generosity has had, and continues to have, on our research enterprise. It is not only the large gifts that matter: every dollar of private support makes a difference and helps us compete with private universities and their historic advantage of large endowments. We can work with you to determine where your gift will have the greatest impact, channeling your interest with our current needs. Here are just a few areas to consider:

Graduate/Post-doctoral Fellowships help recruit elite young scientific minds to the Department, attracted by financial incentives that alleviate teaching responsibilities (so that students can focus on their research) and the prestige associated with a named fellowship.

Undergraduate Scholarships are awarded to students based on academic merit, financial need, or diversity. Many of the Department's scholarships give students the opportunity to conduct research or gain lab experience during the year or over the course of the summer – a unique opportunity for undergraduates.

Named Endowed Chairs for Faculty ensure that the Department can recruit and retain top faculty; these chairs are considered the most highly prized honors among scientists in the academic world. Recruitment and retention are indeed critically hampered by the drop in state funding, and funds for these needs are nearly impossible to augment without private investment.

Discretionary Funds enrich the Department's scientific community and ensure that the Department has sufficient resources for its most pressing needs, ranging from aiding under-represented groups in science, to making sure UCLA teaching labs are state-of-the-art.

Lab naming is a targeted way to support individual research groups, and ensure that labs have the most cutting-edge equipment and technology.

I urge you to contact **Kerri Yoder, Director of Development, at (310) 794-9045** or **kyoder@support.ucla.edu** if you have any questions about giving to the Department, and I extend my gratitude to all of you who support our teaching and research.

Regards,

James Rosenzweig
Chair

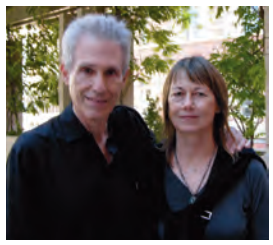
Eugene Y. Wong Physics Graduate Fellowship

Arthur Levine &
Lauren Leichtman

Arthur Levine &
Lauren Leichtman
Andrea Ghez Research Fund

Arthur E. Levine & Lauren B. Leichtman Fund in Astrophysics

Lauren B. Leichtman & Arthur E. Levine Astrophysics Endowed Chair



Howard & Astrid Preston
Graduate Colloquium Fund

Howard Preston Fund
Physics and Astronomy Capital Support

Preston Family Endowed Graduate Fellowship in Astrophysics

'BRILLIANT' SUPERSTAR ASTRONOMERS

Andrea Ghez First Woman to win the Crafoord Prize in Astronomy

The 2012 Crafoord Prize in Astronomy was awarded to Andrea Ghez and Reinhard Genzel for having found the most reliable evidence to date that supermassive black holes really exist. For decades the Crafoord Laureates, with their research teams, have tracked stars around the center of the Milky Way galaxy. Separately, they both arrived at the same conclusion: in our home galaxy resides a giant black hole called Sagittarius A*. Black holes are impossible to observe directly—everything in their vicinity vanishes into them, virtually nothing is let out. The only way of exploring black holes is to investigate the effects their gravitation has on the surroundings. From the motions of stars around the center of the Milky Way, Reinhard Genzel and Andrea Ghez, and their colleagues, estimated the mass of Sagittarius A* at nearly four million times solar masses. Sagittarius A* is our closest supermassive black hole. It allows astronomers to better investigate gravity and explore the limitations of the theory of relativity.

The Crafoord Prize is awarded annually by the Royal Swedish Academy of Sciences to promote international basic research in the astronomy and mathematics, biosciences, geosciences or polyarthritis according to a rotating scheme. These disciplines were chosen so as to complement those for which the Nobel prizes are awarded by the same organization. Andrea Ghez is the first woman to be awarded this prize in any field in its 30-year history.

This year Ghez was also honored with Caltech's Distinguished Alumni Award, the highest honor Caltech bestows on its graduates, and election to the American Philosophical Society, the country's oldest learnedsociety, which was founded by Benjamin Franklin in 1743.

David Jewitt was awarded the Shaw Prize in astronomy the same week as he won the 2012 Kavli Prize in astrophysics

Prof. David Jewitt of the UCLA Departments of Physics and Astronomy, and Earth and Space Sciences, has been awarded the Shaw Prize in astronomy and, remarkably, in the same week, won the 2012 Kavli Prize in astrophysics for his role in the 1993 discovery of the Kuiper Belt beyond Neptune. That the Shaw and Kavli prize committees independently made the same choice in the same week is "pretty excellent", stated Jewitt.

The Shaw prize, widely regarded as the "Nobel of the East", is named after Sir Run Run Shaw, a leader in the Hong Kong media industry and a long-time philanthropist. The prize is for recent achievements in the fields of astronomy, life science and medicine, and mathematical sciences; it is not awarded posthumously.

The Kavli Prize in Astrophysics is awarded for outstanding achievement in advancing our knowledge and understanding of the origin, evolution, and properties of the universe, including the fields of cosmology, astrophysics, astronomy, planetary science, solar physics, space science, astrobiology, astronomical and astrophysical instrumentation, and particle astrophysics. The Kavli Prize consists of USD 1,000,000 in each of the scientific fields. In addition to the prize money the laureates receive a scroll and a gold medal.

Edward (Ned) Wright wins Gruber Cosmology Prize

Edward L. (Ned) Wright, a professor of physics and astronomy and principal investigator of NASA's Wide-field Infrared Survey Explorer (WISE) mission, was named a recipient of the 2012 Gruber Cosmology Prize, along with other scientists who made major contributions to the Wilkinson Microwave Anisotropy Probe (WMAP). Wright and his colleagues were honored in Beijing on August 21st for their observations and analyses that have provided rigorous measurements of the age, content, geometry and origin of the universe.

The Gruber Foundation presents the 2012 Cosmology Prize to the WMAP team for its exquisite measurements of anisotropies in the relic radiation from the Big Bang — the Cosmic Microwave Background. These measurements have helped to secure rigorous constraints on the origin, content, age and geometry of the Universe.

In May 2011, Wright was elected to the National Academy of Sciences. In 2007, he was elected to the American Academy of Arts and Sciences. Wright, who holds the UCLA's David Saxon Presidential Chair in Physics, is among the most-cited researchers in the field of cosmic microwave background radiation.

ASTRONOMY & ASTROPHYSICS

INFRARED LABORATORY GROUP 2011-12

Ian McLean, James Larkin and Michael Fitzgerald

This has been an exciting year for the Infrared (IR) Lab at UCLA and for professors McLean, Larkin and Fitzgerald. For over two decades the IR Lab has played a central role in the development of state-of-the-art instruments for astronomy, instruments that have enabled a broad range of science and supported the research of many astronomers. This year, however, was an especially busy one. In July of 2011 the IR Lab delivered an infrared camera called FLITECAM to NASA's Dryden Aircraft Operations Facility (DAOF) in Palmdale, CA and the instrument was used on four flights in October 2011 on NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA). Another powerful instrument, known as MOSFIRE, was shipped to Hawaii on February 8 and achieved "first light" on the Keck I telescope on April 4, 2012. This brings to four the number of major IR instruments provided, either wholly or in part, from the IR Lab to the Keck Observatory. Meanwhile, the integral field spectrometer(IFS) for the Gemini Planet Imager (GPI) was delivered to UC Santa Cruz in December 2011. After system integration, GPI will be delivered to the 8-m Gemini South telescope in Chile in 2013. As if all this was not enough, work also continued on the preliminary design of IRIS, the InfraRed Integral-field Spectrograph for the Thirty Meter Telescope (TMT), and during the same period, the IR Lab team also crafted upgrade proposals for the three instruments already provided to the Keck Observatory, NIRC2, OSIRIS and NIRSPEC.

Working through the past year in chronological order, we begin with FLITECAM. This instrument is both an infrared camera and a low-resolution infrared spectrometer. It was built specifically for NASA's SOFIA mission. SOFIA is a modified Boeing 747-SP that carries a 2.5-m telescope into the stratosphere for infrared astronomy. FLITECAM was developed several years ago and used eight times on the Shane 3-m telescope at Lick Observatory. Two UCLA students – Amy Mainzer (now at JPL and Deputy Project Scientist for WISE) and Erin Smith (now at NASA Ames where she is the Instrument Lead on the SOFIA project) – obtained their PhDs with professor Ian McLean, PI of FLITECAM. In October 2010 NASA accelerated the delivery of FLITECAM to SOFIA. Despite our work on other projects, FLITECAM was delivered to the Dryden Aircraft Operations Facility (DAOF) in Palmdale, CA in July 2011 and four successful

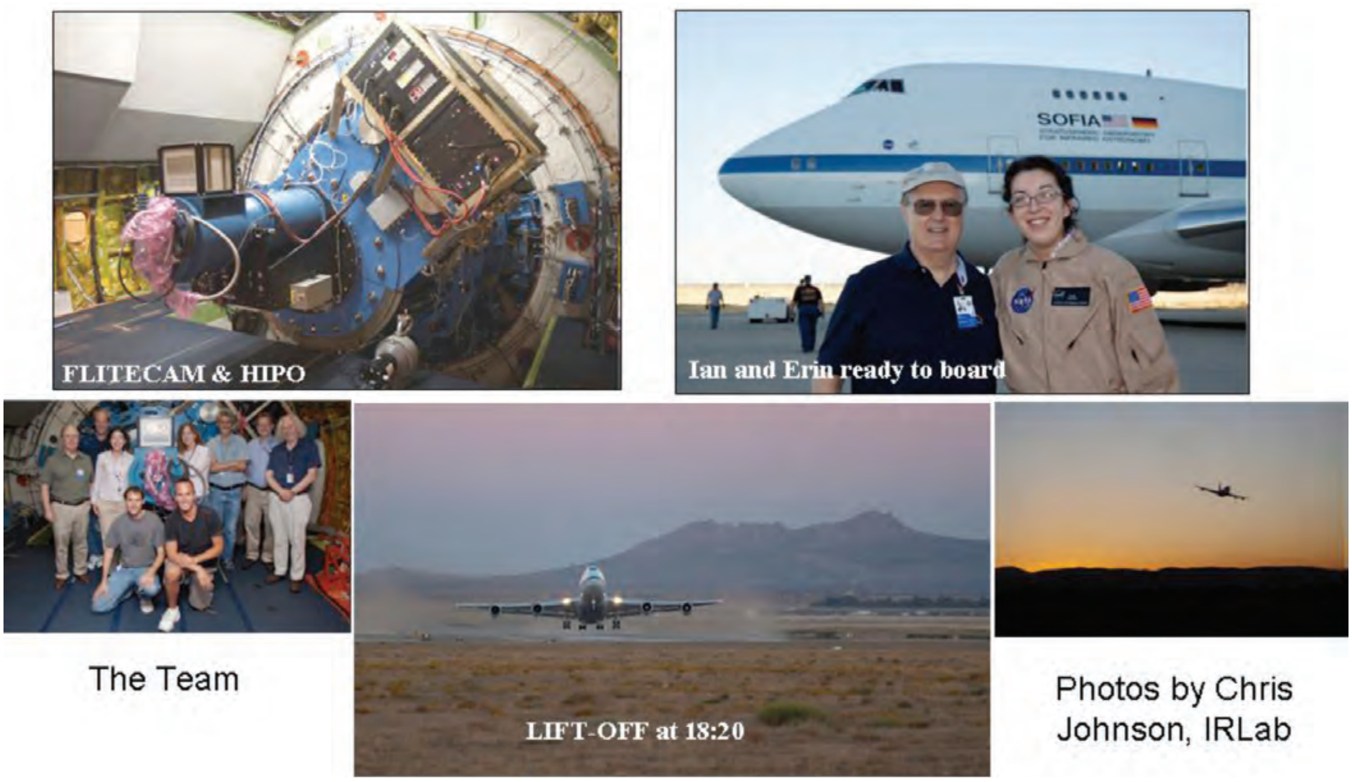


Figure 1: First Flight of FLITECAM on SOFIA at sunset on Thursday, October 13, 2011 from the Dryden Aircraft Operations Facility, Palmdale, CA. Dr. Erin Smith, shown alongside Professor Ian McLean, is a doctoral graduate from the IR Lab. She is now in charge of SOFIA instruments for the NASA Ames Research Center.

flights occurred in October 2011. For these flights, the UCLA instrument was co-mounted with HIPO, a visible light camera from the Lowell Observatory, Flagstaff. Although these flights were not part of FLITECAM's official commissioning time, that is still to come, many useful performance characteristics were determined. Figure 1 shows some images of our "first flight." The aircraft is currently receiving upgrades to its avionics system and flights will begin again in late 2012.

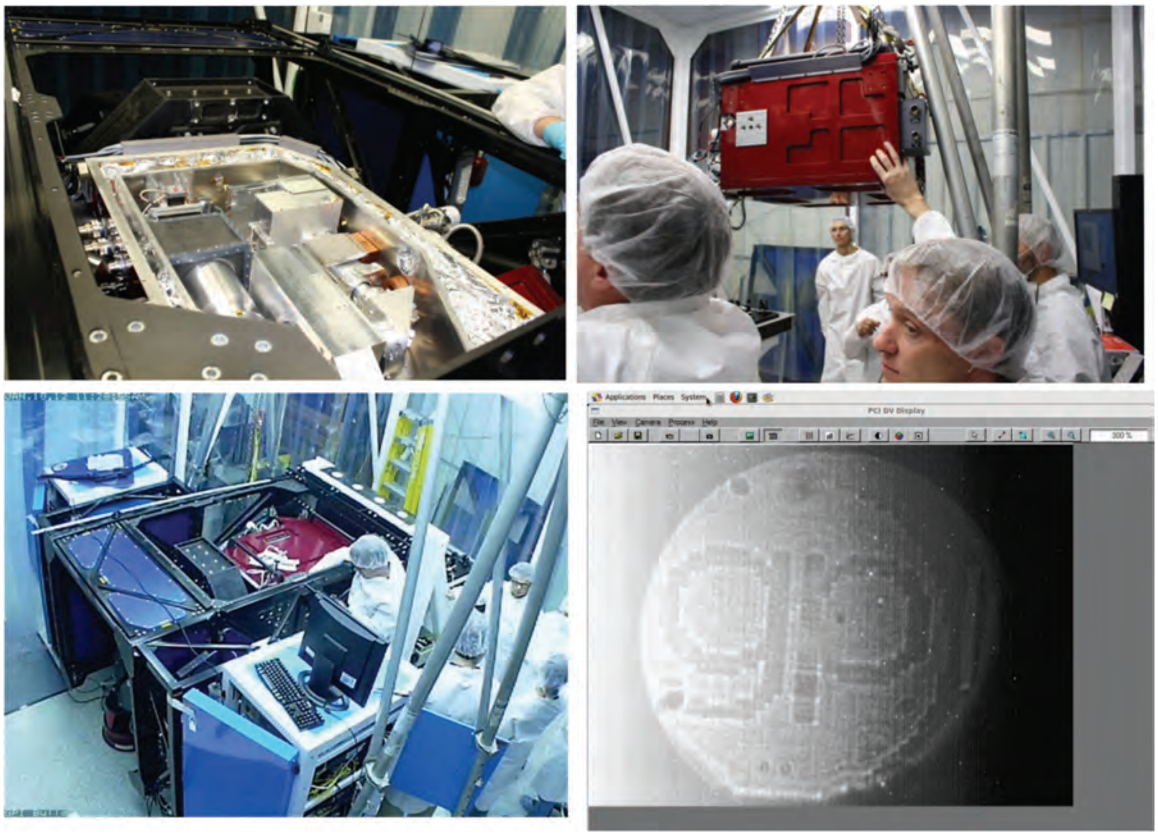


Figure 2: Upper Left: The IFS with cover removed. Upper Right: The IFS (red) is lifted into place in the clean room at UCSC. Lower Left: The entire GPI instrument under test. Lower Right: a pupil image in which the MEMS deformable mirror was actuated to produce the letters gpi.

In December 2011, UCLA delivered a critical component, called the Integral Field Spectrograph (IFS), for one of the most ambitious infrared instruments ever conceived. The Gemini Planet Imager (GPI) is a multi-institutional project to build an advanced, diffraction-limited imaging system for direct detection of Jovian planets around young nearby stars. Bruce Macintosh (LLNL) is the Principal Investigator. We are proud of the fact that Bruce received his PhD from UCLA in 1994 and was the first student through the IR Lab. To image planets more than 10 million times fainter than their host stars, GPI combines one of the most advanced adaptive optics (AO) systems, an apodized coronagraph, a shearing interferometer and an integral field spectrograph as the final science instrument. James Larkin led the design and construction of the IFS at UCLA. The special AO system and coronagraph suppresses the majority of the intense starlight, leaving a dark region or hole about two seconds of arc on a side. This region roughly matches the size of our own system of planets if placed at the distance of the target stars. The dominant noise source within this dark hole is in the form of speckles, which are diffraction-generated rainbows caused by irregularities in the optical system. Like the OSIRIS instrument delivered by James to the Keck Observatory in 2005, the IFS employs a lenslet array to dissect the image and take more than 40,000 spectra simultaneously over the full dark hole. In this spectral data cube, the speckles change position as a function of wavelength while a true planetary companion stays fixed. It is this trick that gains another factor of 10 to 100 of additional contrast against the central star, depending on the location of the planet, and should therefore allow us to see the planet directly. Figure 2 shows the initial installation of the IFS (red) in the clean room at UC Santa Cruz. System integration is currently under way and GPI will be deployed on the Gemini South 8-m telescope in Chile next year.

MOSFIRE, the Multi-Object Spectrometer For Infra-Red Exploration, was a collaboration among UCLA, UCSC, Caltech and Keck Observatory to build the most sensitive and most efficient multi-object infrared spectrometer in the world.

A very different kind of instrument was also completed this year by the IR Lab. MOSFIRE, the Multi-Object Spectrometer For Infra-Red Exploration, was a collaboration among UCLA, UCSC, Caltech and Keck Observatory to build the most sensitive and most efficient multi-object infrared spectrometer in the world. Ian McLean (UCLA) was overall PI, Project Manager and spokesperson and Chuck Steidel (Caltech) was co-PI and Project Scientist. MOSFIRE was funded by a private donation from Gordon and Betty Moore and by the NSF Telescope System Instrumentation Program. MOSFIRE achieved "first light" on April 4, 2012 on the Keck I telescope on Mauna Kea, Hawaii. Figure 3 shows McLean with MOSFIRE just prior to "first light" on April 4, 2012.

spectra. MOSFIRE will be used for a wide range of projects but most especially for studies of faint galaxies at high redshifts. Figure 5 shows the "first light" image. The official UCLA press release can be found at: http://newsroom.ucla.edu/portal/ucla/time-machine-will-study-the-early-231810.aspx

Optical design and acquisition of all the lenses and mirrors was handled by Harland Epps at UC Santa Cruz. Measurements of throughput and efficiency confirm that the optical quality is excellent and transmission is even better than predicted. At the time of writing, MOSFIRE is now in regular use by the Keck community.

Figure 3: Professor McLean in front of the MOSFIRE instrument just before its installation into the Keck I telescope on the 14,000 ft summit of Mauna Kea, Hawaii.

MOSFIRE is unique because it is a wide-field infrared camera with a special device that enables up to 46 objects in the field to be selected for infrared spectroscopy, all at the same time. A cryogenic robotic mechanism, consisting of 46 pairs of opposable bars, can deploy a pattern of short slits across the field of view, and then reconfigure the pattern for some other part of the sky in less than six minutes. Other instruments in this class typically use metal masks that are pre-cut with a pattern of slits and pre-installed inside the vacuum-cryogenic instrument. Consequently, such instruments must be warmed up and opened from time to time in order to change masks. MOSFIRE avoids these limitations and adds flexibility because adjustments to the pattern can be made on-the-fly by the computer. The configurable slit unit was developed in collaboration with the Swiss Center for Electronics and Microtechnology (Neuchatel). The science detector is a single 2K x 2K array of HgCdTe from Teledyne Imaging Sensors (Camarillo, CA). The IR Lab was responsible for project leadership, systems design, electronics, detectors, software, filter wheel, pupil mechanism, focus mechanism, lens mounting and bonding, and optical metrology. UCLA graduate students Kristin Kulas and Gregory Mace worked on the development of MOSFIRE with Professor McLean and participated in commissioning observations. Figure 4 shows the basic layout for imaging, a pattern of slit bars for multi-object spectroscopy and the resulting infrared

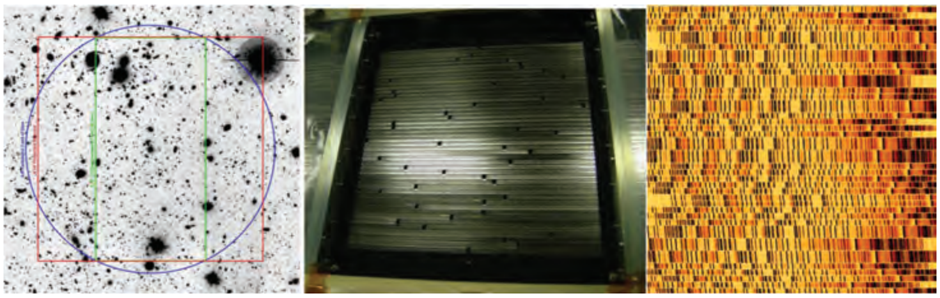


Figure 4: MOSFIRE's field of view on the sky is the intersection of the blue circle and red square. The configurable slit unit mechanism can place up to 46 slits anywhere in the field but optimally within the green rectangle. The detector records up to 46 spectra simultaneously as shown on the right.

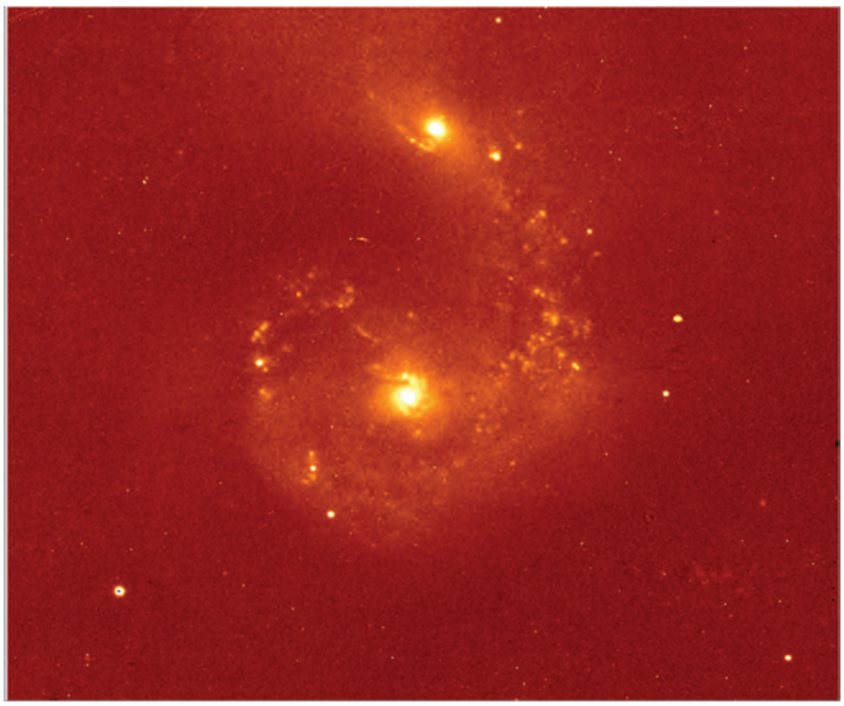
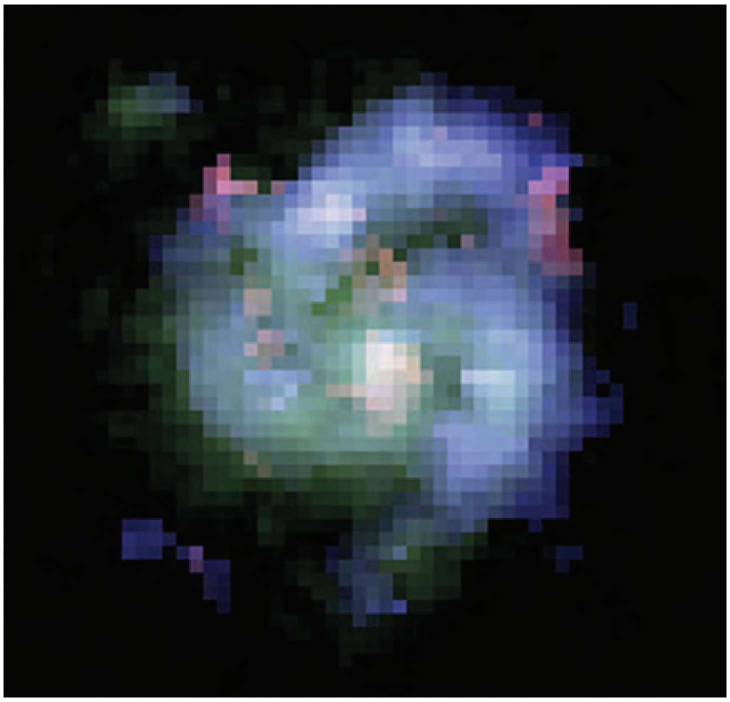


Figure 5: The "first light" image obtained by MOSFIRE on April 4, 2012. The object is called the Antennae, a pair of galaxies in collision, and this infrared picture reveals numerous compact star-forming regions. Image quality is excellent.

HIGH-REDSHIFT GALAXIES

Alice Shapley



HST/Keck false color composite image of galaxy BX442. "Grand-design" spiral structure is evident in the image, with three striking spiral arms. Additionally, a low-mass companion galaxy appears at the upper left of the image. A map of the kinematics of BX442 demonstrates that it rotates at roughly the same speed as our own Milky Way galaxy, but is much more turbulent.
(Credit: David Law/ Dunlap Institute for Astronomy & Astrophysics)

Alice Shapley, her graduate students and postdocs continue to study the formation and evolution of galaxies, and their impact on the evolution of the intergalactic medium. One of the most important goals in the study of galaxy evolution is to explain the origin of the rich diversity of galaxy structures that we observe today, ranging from spiral disk galaxies to ellipticals to irregulars. This year, with collaborator Dr. David Law (a former Hubble Postdoctoral Fellow at UCLA and current Dunlap Fellow at the University of Toronto), Shapley reported the discovery of a "grand-design" spiral galaxy, observed when the Universe was only a few billion years old. This object, despite its rather nondescript name ("BX442") boasts a spectacular morphology, with three well-formed spiral arms. The structure of BX442 stands in stark contrast with those of other galaxies ~11 billion light years away (and observed as they existed ~11 billion years ago). Most galaxies at this distant cosmic epoch are characterized by irregular, clumpy morphologies, reflecting the conditions of the early universe. Something about the nature of BX442 causes it display a beautiful spiral pattern, similar to the ones observed in disk galaxies in our local universe. Law and Shapley first noticed the grand-design spiral pattern in a Hubble Space Telescope image of the starlight from BX442. They then used the OSIRIS integral field unit spectrograph on the Keck I telescope, built by colleague Professor James Larkin, in order to probe the dynamic motions of the gas in BX442. The OSIRIS map of BX442 demonstrated that the galaxy rotates at roughly the same speed as the Milky Way galaxy, but is much more turbulent. Furthermore, BX442 appears to be interacting with a small nearby companion galaxy. The gravitational interaction between BX442 and its companion may be the cause of the striking spiral pattern, in analogy with the beautiful local galaxy known as the Whirlpool, whose spiral structure appears to be excited by a merger event with a neighboring galaxy. BX442 therefore contains important clues to the formation of spiral patterns in galaxies. The discovery of BX442 was reported in the journal Nature, and also appeared in such popular news outlets as the LA Times, NPR, Scientific American, and the CBS Evening News.

THEORY

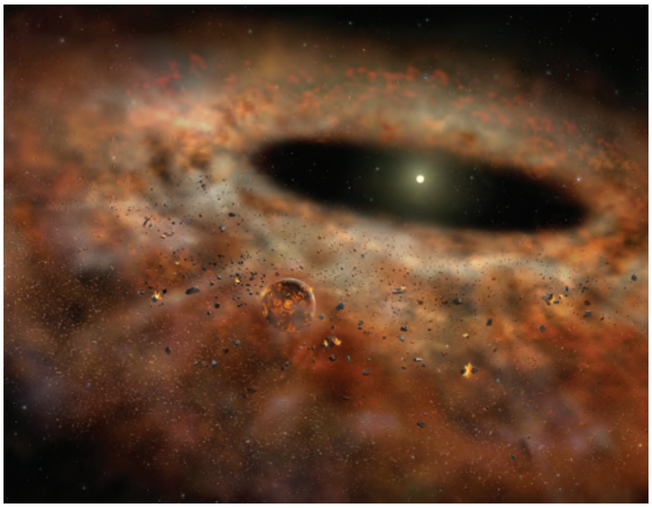
William I. Newman

My research is germane to condensed matter and statistical physics, published in Physical Review E and in review elsewhere, focused on "Pattern in Randomness." Employing methods originally developed in particle physics, I was able to sum over all possible graphs for any probability distribution function describing uncorrelated events and obtained a closed form expression for the distribution of peak-to-peak sequences. I was also able to extend in closed form the theory to Brownian random walks, and using numerical simulations was able to extend these results to a wide family of random probabilistic models. Applications to great earthquakes, solar substorms, biological populations, and other sequences observed in nature and in the financial world (Standard and Poors 500 Index) were considered. More recently, my work has focused on the presentation seen in deterministic chaos, as in the logistic map due to Ulam and Von Neumann, and issues relevant to randomness in Monte Carlo simulations in contrast with "ideal," i.e. mathematical, random sequences.

In applications to plasma physics and astrophysics, working with my Physics and Astronomy graduate student Nathaniel Hamlin (who was awarded the PhD this summer), we investigated the Kelvin-Helmholtz instability for magnetized plasmas using analytical and numerical methods. This work is presently in preparation for publication, and Nat was awarded a Division on Dynamical Astronomy of the American Astronomical Society student stipend to present his work at the Division's annual meeting, which convened in Mt. Hood, Oregon in May.

STELLAR ASTRONOMY

Benjamin Zuckerman



Dusty disc surrounding star. Dust today, gone tomorrow. An artist's conceptualization of the dusty TYC 8241 2652 system as it may have appeared several years ago, when it was emitting large amounts of excess infrared radiation. (Credit: Gemini Observatory/AURA artwork by Lynette Cook)

Researchers have reported a baffling discovery never seen before: An extraordinary amount of dust around a nearby star has mysteriously disappeared. "It's as if the rings around Saturn had disappeared," said co-author Benjamin Zuckerman. "This is even more shocking because the dusty disc of rocky debris was bigger and much more massive than Saturn's rings. The disc around this star, if it were in our solar system, would have extended from the sun halfway out to Earth, near the orbit of Mercury."

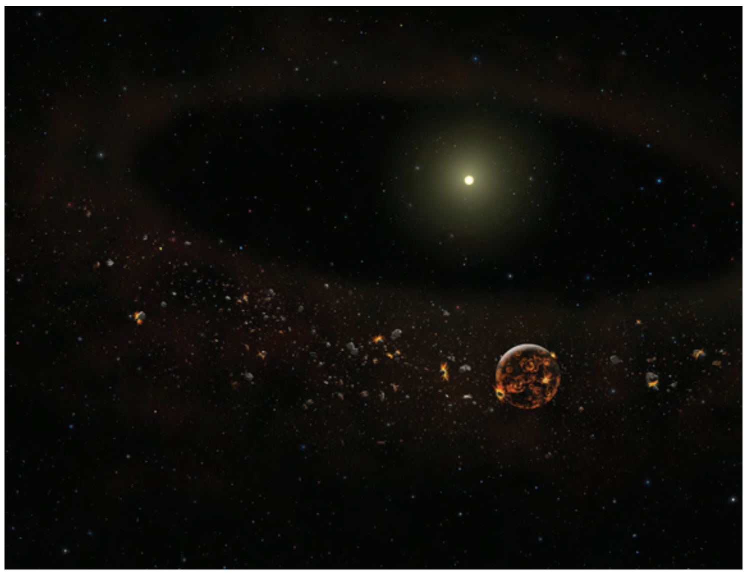
The dust had been present around the star since at least 1983 (no one had observed the star in the infrared before then), and it continued to glow brightly in the infrared for 25 years. In 2009, it started to dim. By 2010, the dust emission was gone; the astronomers observed the star twice that year from the Gemini Observatory in Chile, six months apart. An infrared image obtained by the Gemini telescope as recently as May 1 of this year confirmed that the warm dust has now been gone for two-and-a-half years. Like Earth, warm dust absorbs the energy of sunlight and re-radiates that heat energy as infrared radiation. Because so much dust had been orbiting around the star, planets very likely are forming there, said Zuckerman, whose research is funded by NASA.

The lack of an existing model for what is going on around this star is forcing astronomers to rethink what happens within young solar systems in the making. The dust likely resulted from a violent collision — but that would not explain where it went. The research is based on multiple sets of observations of TYC 8241 2652 obtained with the Thermal-Region Camera Spectrograph on the Gemini South telescope in Chile, the IRAS, NASA's Wide-field Infrared Survey Explorer (WISE) satellite, NASA's Infrared Telescope on Mauna Kea in Hawaii, the Herschel Space Telescope of the European Space Agency (ESA), and AKARI (a Japanese/ESA infrared satellite).

"We were lucky to catch this disappearing act," Zuckerman said. "Such events could be relatively common, without our knowing it."

The research on this cosmic vanishing act, which occurred around a star some 450 light years from Earth, in the direction of the constellation Centaurus, was reported by Carl Melis, lead author of the research and co-author Benjamin Zuckerman in the journal Nature July 5,2012. Other co-authors of the Nature paper are Joseph Rhee, a former UCLA postdoctoral scholar in astronomy, who is now an astronomer at California State Polytechnic University in Pomona; Inseok Song, an assistant professor of physics and astronomy at the University of Georgia who also was a postdoctoral researcher at UCLA; and astronomers Simon Murphy and Michael Bessell at the Australian National University.

The full article of this discovery can be read at
http://newsroom.ucla.edu/portal/ucla/astronomers-discover-a-houdini-235572.aspx



Where did it all go?
An artist's conception of the TYC 8241 2652 system as it might appear now after most of the surrounding dust has disappeared --based on observations by the Gemini Observatory and other ground and space-based observatories.
(Credit: Gemini Observatory/AURA artwork by Lynette Cook))

EXTRASOLAR PLANETARY SYSTEMS

Michael Jura

Jura has continued to study white dwarf stars to measure the elemental composition of extrasolar minor planets. Graduate student Siyi Xu and Professor Ben Zuckerman also are working on these projects. Three results were reported.

1. We have argued that water is less than 1% of the mass of most observed extrasolar asteroids. Therefore, these objects are relatively dry and resemble Earth where water (both in the oceans and stored internally)is much less than 1% of the total mass.

2. We have found that carbon and nitrogen only compose a small fraction of the total mass of two extrasolar asteroids. This result is similar to what is measured for Earth. (see figure 1)

3. Two new dust disks orbiting white dwarfs were discovered; the total number is now 30. Astronomers at UCLA have participated in the discovery of about 50% of all known systems.

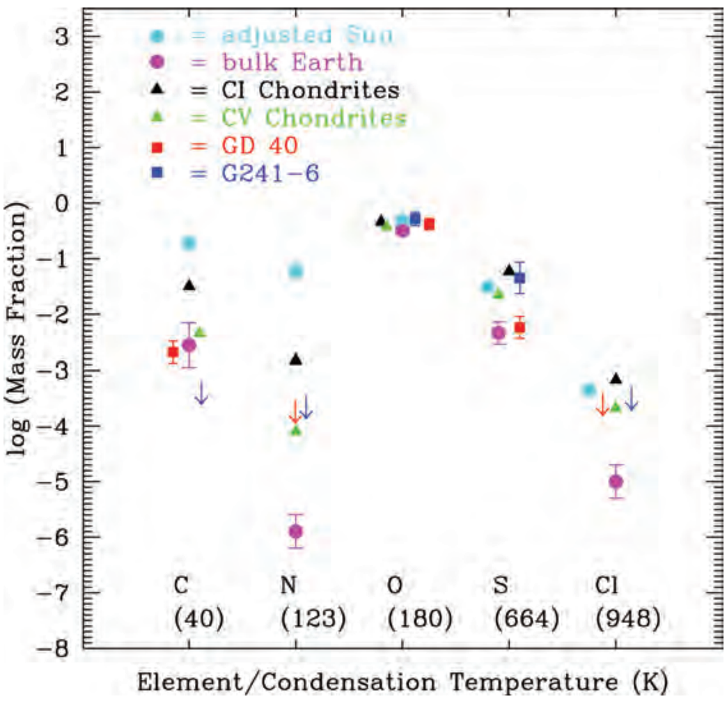
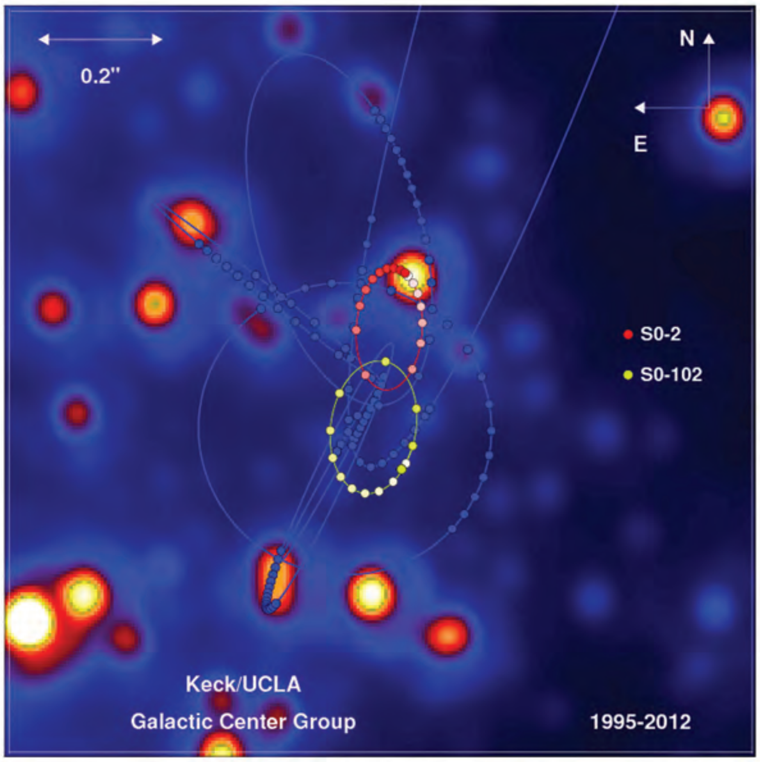


Figure 1

GALACTIC CENTER

Andrea Ghez

This fall, Ghez and her team reported the discovered a star, S0-102, which is orbiting the Milky Way's supermassive black hole in 11.5 years, the shortest known orbit near the black hole. This discovery will allow Ghez and her Galactic Center group to determine the geometry of space and time near the black hole, testing Einstein's theory of General Relativity. This discovery was enabled through the development of a new algorithm, which provided a ten-fold enhancement of the sensitivity of her first decade of high resolution data, which was obtained with speckle imaging from the Keck Telescopes, and thereby allowed her team to track stars that they have discovered with the more advance technology of adaptive optics over a much longer time baseline. At last count, this has been covered in over 100 media outlets and in at least 10 countries, including the following few fun examples:



Slate News: http://www.slate.com/blogs/trending/2012/10/08/speeding_star_near_milky_way_black_hole_tests_einstein_s_relativity_.html
The BBC World news: http://www.bbc.co.uk/programmes/p00yk1pw
LA Times: http://www.latimes.com/news/science/sciencenow/la-sci-sn-closest-star-black-hole-milky-way-20121004,0,4129357.story

Other group news: Gunther Witzel joined the group in May as a postdoc after completing his PhD at the University of Koeln, and Sylvana Yelda defended her PhD at the end of summer 2012 and then remained as a postdoc within the group.

Howard & Astrid Preston with Andrea at the Crafoord Days public lecture which took place prior to the award ceremon.

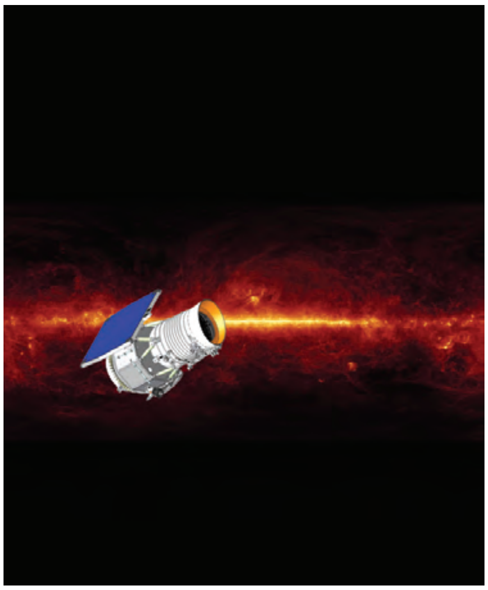
Andrea Ghez Group 2012

"Andrea Ghez was named one of the 25 most influential people in space by Time magazine"

http://issuu.com/bobjacobs/docs/timespace

COSMOLOGY

Edward (Ned) L. Wright



Wright was a repeat winner of the 2012 Gruber Prize in Cosmology as a member of the Wilkinson Microwave Anisotropy Probe science team.

Edward L. (Ned) Wright continued to lead the Wide-field Infrared Survey Explorer (WISE). WISE has finished collecting data, but the analysis continues with a grand combination of all 12.5 months of data yet to be done.

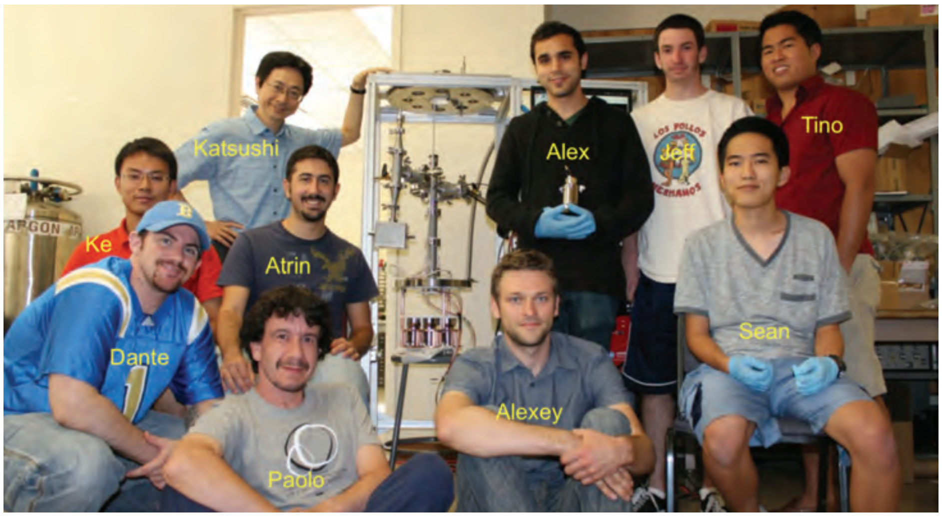
Wright also served on the Wide Field InfraRed Survey Telescope Science Definition team, and was a co-chair of the Gravitational Wave Community Science Team, both for NASA.

The Wide-field Infrared Survey Explorer mission surveys the entire sky in a portion of the electromagnetic spectrum called the mid-infrared with far greater sensitivity than any previous mission or program ever has. The mission's principal investigator, Edward Wright is at UCLA. JPL manages the Wide-Field Infrared Survey Explorer for NASA's Science Mission Directorate and California Institute of Technology manages JPL for NASA. Image Credit: - NASA/JPL

ASTROPARTICLE PHYSICS

ASTROPARTICLE PHYSICS DARK MATTER GROUP

Katsushi Arisaka, David Cline, Hanguo Wang



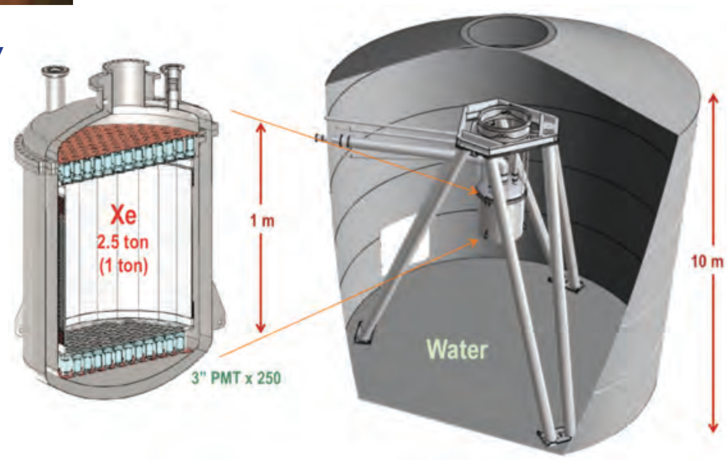
A part of UCLA dark matter team, working at the photon detector lab over summe 2012. At the center of picture, a prototype of XENON1T detector, 7 PMT array is shown, just before its operation under liquid argon.

February 2012 we held the **10th Symposium** on the **Search for the Origin of Dark Matter and Dark Energy.** There were 150 attendees from all over the world and every major dark matter experiment. This meeting was supported by the DOE and is a benchmark for the progress on the search for Dark Matter.

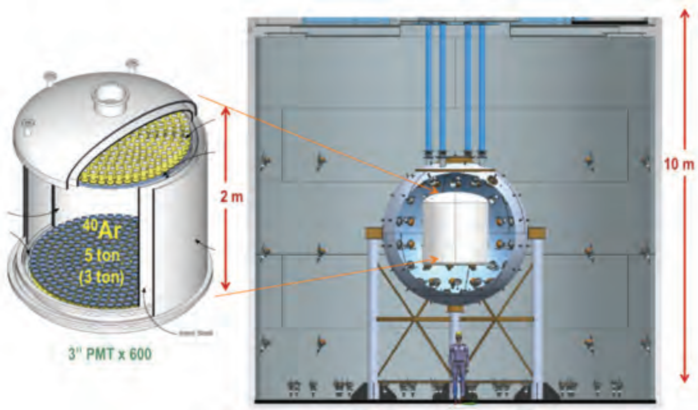
The direct detection of dark matter is recognized as one of the greatest challenges in astronomy, cosmology and particle physics altogether. Building on expertise with previous world-leading noble liquid instruments developed by David Cline and Hanguo Wang, coupled with 30 year-long photo-detector developments by Katsushi Arisaka, UCLA conducts it first in line to observe such a signal. Our primary effort has been XENON100 (100 kg), operating a liquid xenon detector under the Gran Sasso mountains in Italy for the last 5 years. We published the latest result this summer from 225 days of data taking to set the world's most sensitive limit, which has begun to exclude theorical predicitons by certain super symmetry models. We are currently actively involved in the low mass (< 10 GeV) WIMP search and Axion search. UCLA has a world class Dark Matter laboratory on campus.

Over the last two years, we designed and proposed the next generation experiment, XENON1T (1 ton). This year, this has been fully funded by NSF and the construction has begun. The UCLA group is responsible for the photon detectors and the internal detector design, such as the ultra high-voltage feed-through and distribution.

Our second project, the liquid argon program DarkSide (also at Gran Sasso, Italy) has made significant progress as well. DarkSide50 (50 kg) detector is under construction and expected to start data taking early next year. It is designed to expand to a 5 ton detector eventually. Our student X Meng is doing his PhD on this detector. We are the only instutute working on both XENON and DarkSide, thus uniquely situated to search for dark matter by combining both xenon and argon for many years to come.



The XENON1T detector under construciton at Gran Sasso Laboratory, Italy. UCLA group is in charge of the heart of the detector : Photon detectors (3" PMT) and TPC (Time Projection Chamber) in the 2.5 ton Liquid Xenon Cryostat.



The conceptual design of the DarkSide G2 (Second Generaton) detector at Gran Sasso Laboratory, Italy. It will be surrounded by the spherical liquid scintillator, then the cylindrical water tank to reduce neutron backgrounds.

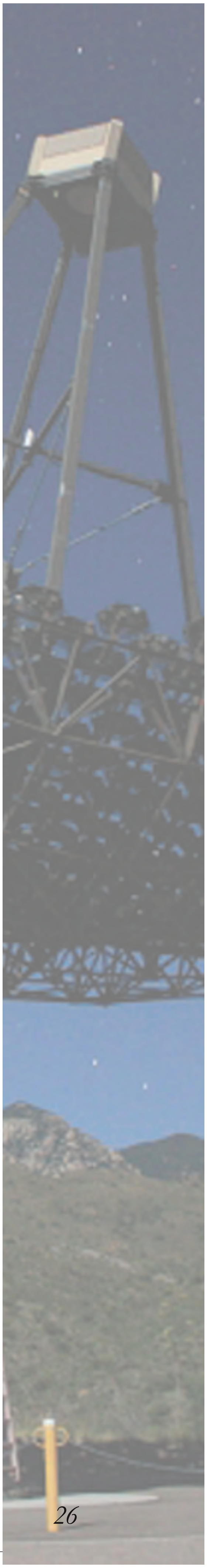
Alex Kusenko

Alexander Kusenko and collaborators have put forth some new ideas for dark matter, which makes up most of the matter in the universe. They also conducted a search for dark matter using X-ray telescopes and published new limits on the masses of relic sterile neutrinos and string/supersymmetry moduli. Furthermore, Kusenko and collaborators proposed a scenario for the formation of supermassive black holes from primordial seeds. Together with his former UCLA student Warren Essey and other collaborators, Professor Kusenko also studied the connection between gamma rays and cosmic rays produced by distant blazars. In addition, Professor Kusenko chaired the Summer Program Committee for Aspen Center for Physics, as well as the organizing committees for two international conferences. He received an APS Outstanding Referee Award this year. A graduate student Lauren Pearce working with Professor Kusenko published her first, single-author paper in Physical Reviews.

VERY HIGH-ENERGY (VHE) ASTROPHYSICS GROUP

Rene Ong and Vladimir Vassiliev

The very high-energy (VHE) astrophysics group carries out a broad range of research focused on the study of non-thermal and violent phenomena in the Universe in which extreme physical conditions can generate photons with energies exceeding energy of visible photons by nine to thirteen orders of magnitude. Such unusual environments typically occur during or after explosions of supernovae, during interaction of rapidly spinning pulsars with the surrounding matter or radiation, or during accretion of matter onto supermassive black holes residing in the centers of active galaxies, which are called sometime active galactic nuclei (AGN).



The VHE photons can also be produced if mysterious dark matter in the Universe is composed of elementary weakly interacting particles which self annihilate or decay, or, perhaps, when collapse of massive stars or coalescence of neutron stars and/or black holes occur causing phenomena known as gamma-ray bursts. The extremely energetic photons created in these processes provide us also with the unique opportunity to probe properties of space-time at high energies and very large cosmological distances. In addition, when VHE photons propagate from fierce environments in which they were created to Earth they interact with intergalactic radiation, such as visible and infrared diffuse photon fields, causing cascading in the presence of surrounding magnetic fields and consequent production of the secondary particles. Observing absorption of VHE photons allows us to learn the properties of diffuse radiation, the history of its evolution, and ultimately the history of nuclear synthesis in the Universe. Detection of secondary gamma rays would provide insight into the origins of magnetic fields in the Universe and their role in large scale structure formation.

Studying these fascinating astrophysical phenomena has become possible with the use of the atmospheric Cherenkov technique, which is capable of detecting very weak gamma-ray fluxes from cosmologically distant sources. The VHE astrophysics group conducts intensive research through observations and analysis of the data obtained with the Very Energetic Radiation Imaging Telescope Array System (VERITAS) - an array of four 12m diameter telescopes utilizing this technique. The UCLA group has taken an active role in the planning, construction and operation of this observatory, which since 2007 has been remarkably successful, and has produced dozens of discoveries published in leading astronomy and astrophysics journals.

The scientific success of VERITAS and the other ground-based gamma-ray observatories has motivated the development of the ambitious major international worldwide observatory called the Cherenkov Telescope Array (CTA). This instrument is planned to have 50-75 atmospheric Cherenkov telescopes covering an area greater than 1 square kilometer. The UCLA VHE astrophysics group has pioneered the development of a novel Schwarzschild-Couder Telescope (SCT) for CTA to achieve superior angular resolution and significantly wider field of view relative to the existing telescope designs. In 2012 the UCLA group together with several other US institutions received a multimillion-dollar grant from the National Science Foundation to construct a prototype SCT at the VERITAS site location during the next three years and demonstrate its performance capabilities for CTA. With the initiation of this project, the development of innovative instrumentation for VHE astrophysics continues and promises exciting scientific opportunities for incoming graduate and undergraduate students.

Currently, the VHE astrophysics group consists of two professors-Vladimir Vassiliev and Rene Ong, three postdoctoral researchers- Julien Rousselle, Isaac Mognet and Taylor Aune, two graduate students- Timothy Arlen and Alexis Popkow, and several undergraduate students.

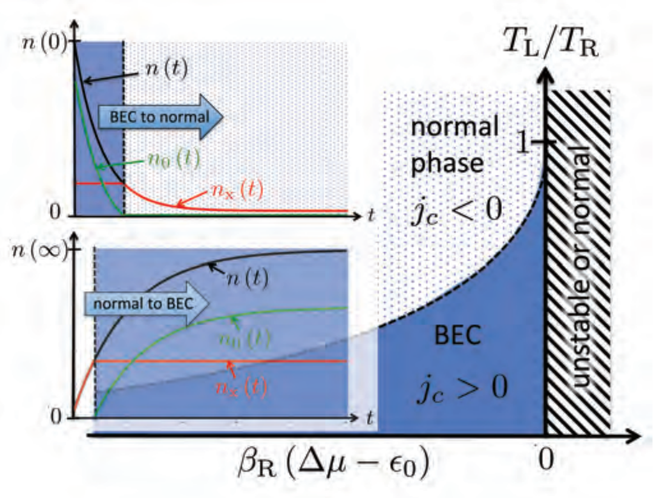
PHYSICS RESEARCH

Hard Condensed Matter

Yaroslav Tserkovnyak

Bose-Einstein condensation of a dilute bosonic gas, one of the most basic and fascinating macroscopic quantum phenomena, has eluded solid-state realization, barring transient phenomena in pump-probe experiments on trapped photons, excitons, or magnons.

Professor Tserkovnyak et al, theoretically propose a new route towards realization of a steady-state quasi equilibrium condensate of magnons, fomented and controlled by a simultaneous application of a temperature bias normal to a conventional magnetic heterostructure and electric current tangentially to it.



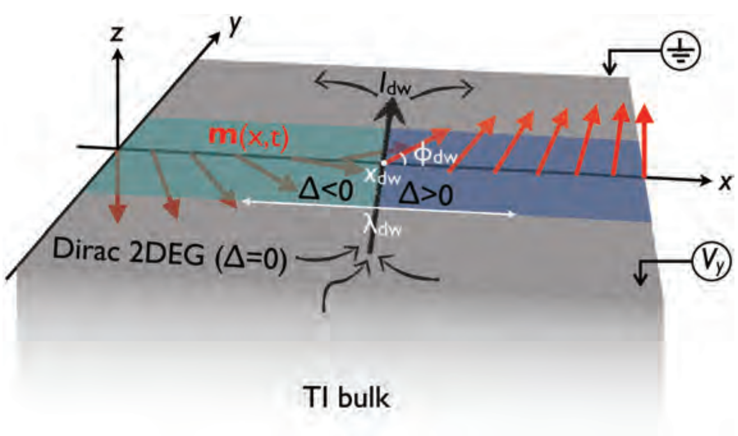
Dynamic phase diagram, as a function of temperature bias (vertical axis) and tangential current bias (horizontal axis) applied to platinum/magnetic insulator bilayer.

If realized, this opens a possibility of inducing magnon superfluidity in spintronic devices based on magnetic insulators, which may in principle be achieved even at room temperature.

Following theoretical predictions and experimental realizations of three dimensional topological insulators, vigorous ongoing activities in this burgeoning field are aimed at introducing spontaneous symmetry breaking mechanisms into the system.

Study of the magnetization dynamics of a thin ferromagnetic film exchange coupled with a strong three-dimensional topological insulator surface, focusing on the role of electronic zero modes engendered by magnetic domain walls. The coupled topological/magnetic insulators structure yields rich nonequilibrium phenomenology, with magnetic domain-wall motion pumping electric current and, reciprocally, electric currents strongly affecting the magnetic dynamics.

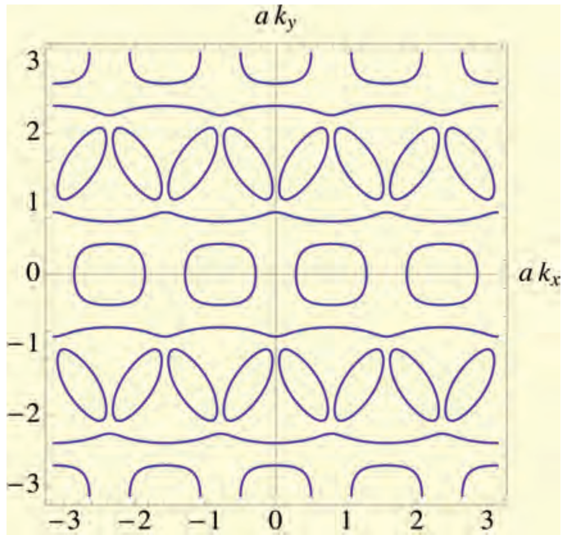
This heterostructure points towards complex electric circuitry that may be imprinted and controlled by the magnetic spin texture and its dynamics.



Domain wall in a ferromagnetic strip deposited on the surface of a topological insulator. A chiral electron mode formed under the domain wall can ballistically carry current governed by the fictitious electromotive force generated by the domain-wall dynamics.

Sudip Chakravarty

Professor Sudip Chakravarty has carried out research in a variety of new directions during the past year. He currently mentors four graduate students and two postdocs, one co-supervised with Professor Rahul Roy. In the past year one graduate student received his Ph. D. Out of the four current graduate students two have advanced to candidacy. He will therefore be looking for new students in the near future. Here is a brief highlight of his research in the past year.



Reconstructed Fermi surfaces from period-8 density wave state. There are electron pockets, hole pockets and open orbits. For more information see the reference above in Proc. Natl. Acad. Sci. USA.

Toplogical states of matter

In this subject he has worked in a large collaboration on the model of a spin chain with longer-range interaction, as is likely to occur in a realistic system, which goes beyond the Kitaev model and has shown that it possesses a richer phase diagram and has several quantum phase transitions. From an exact solution of the model these phases can be classified according to the number of Majorana zero modes of an open chain: 0, 1, or 2 at each end. The number of Majorana modes at each end of the chain is identical to the topological winding number of Anderson's pseudospin vector that describes the BCS Hamiltonian. The topological classification of the phases requires an unitary time-reversal symmetry to be present. When this symmetry is broken, only the number of Majorana end modes modulo 2 can be used to distinguish two phases, as in the original Kitaev model. He has also considered a possible connection of the pseudogap phase of high temperature superconductors and a topological state with quantized Hall effect. Current efforts are under way to apply such ideas to the enigmatic hidden order state in a heavy fermion material. [Yuezhen Niu, Suk Bum Chung, Chen-Hsuan Hsu, Ipsita Mandal, S. Raghu, Sudip Chakravarty, Phys. Rev. B 85, 035110 (2012).]

High temperature superconductivity

He continues to investigate the unusual quantum oscillations in this material and has made considerable progress in understanding experiments in both electron and hole doped superconductors. In the electron doped a complete understanding was provided using a two-fold commensurate density wave order, even quantitatively, including magnetic breakdown effects. At this time, in hole doped cuprates, there appears to be no general agreement about the precise nature of the translational symmetry breaking. His group has found that using a very specific density wave order of period-8, one can explain much of the data and provide a very precise prediction that can be tested in future experiments in even higher magnetic field than currently pursued. [Jonghyoun Eun and Sudip Chakravarty, Phys. Rev. B 84, 094506 (2011); Jonghyoun Eun, Zhiqiang Wang, Sudip Chakravarty, Proc. Natl. Acad. Sci. USA 109, 13198-13203 (2012).]

Rounding due to disorder of first order phase transition to critical points

Rounding of the first order transition due to disorder is an important problem because such transitions are ubiquitous in both classical and quantum systems. In contrast to the effect of disorder on continuous transitions much less is known about its effect on first order transitions. An important question that remains unanswered is what is the universality class of such transitions. In a recent work, his group addresses the criticality of the bond disordered classical three-color Ashkin-Teller model as a non-trivial example and derive striking results from a powerful Monte Carlo simulation that the emergent criticality due to disorder belongs to hitherto unknown universality class , which unambiguously rules out the Ising universality class, as was previously suggested. This problem is a part of long term plan in which they want to extend the simulations to quantum phase transitions. *[Arash Bellafard, Helmut G. Katzgraber, Matthias Troyer, Sudip Chakravarty, Phys. Rev. Lett. 109, 155701 (2012)]*

Quantum criticality between topological and band insulators

Four-component massive and massless Dirac fermions in the presence of long range Coulomb interaction and chemical potential disorder exhibit striking fermionic quantum criticality. For an odd number of flavors of Dirac fermions, the sign of the Dirac mass distinguishes the topological and the trivial band insulator phases, and the gapless semi-metallic phase corresponds to the quantum critical point that separates the two. Up to a critical strength of disorder, the semi-metallic phase remains stable, and the universality class of the direct phase transition between two insulating phases is unchanged. Beyond the critical strength of disorder the semi-metallic phase undergoes a phase transition into a disorder controlled diffusive metallic phase, and there is no longer a direct phase transition between the two types of insulating phases. The results are also applicable to an even number of flavors of Dirac fermions, and the band inversion transition in various non-topological narrow gap semiconductors. This work can easily be and has been extended to Weyl fermions that are currently widely discussed. *[Pallab Goswami and Sudip Chakravarty, Phys. Rev. Lett. 107, 196803 (2011)]*.

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 pnictide and oxychalcogenide superconductors and on the heavy-fermion metals. In 2011-2012, the following results were obtained and published:

In a "Topical Review," Abrahams [with co-author Qimiao Si (Rice) in *J. Phys.: Condens. Matter 23, 223201 (2011)]* reviewed the theory and the experimental evidence for a new type of quantum criticality. Here, a magnetic quantum critical point arises out of competition between electron localization and itinerancy. This competition is a central feature in much of the physics of strongly-correlated materials. The theory, by Abrahams and coworkers that led to this discussion is based on treating the pnictides and oxychalcogenides as being close to a correlation-induced metal insulator transition, thus from a strong-coupling perspective.

Two other papers on the iron pnictide superconductors involved collaborations with researchers from Iowa State, Rice and Florida State: *[Phys. Rev. B 84, 155108 (2011)]; [Phys. Rev. Lett. 107, 217002 (2011)]*

Quantum criticality found in many rare-earth and actinide based "heavy-fermion" metals is at the forefront of condensed matter research. There are competing theories for the behavior in the neighborhood of the quantum critical points. Abrahams has collaborated with Peter Wölfle (Karlsruhe) in developing a new theory of how quantum critical fluctuations in these materials affect the electronic properties. It is an extension of the traditional Landau Fermi-liquid picture that goes beyond the usual theory of weakly-coupled critical fluctuations. This "critical quasiparticle theory" *[Phys. Rev. B 84, 041110 (2011)]* is used to calculate a number of the observed properties of the prototypical heavy-fermion metal, Yb2Rh2S2. The agreement with experiment is remarkable. In subsequent work *[Proc. Nat. Aca. Sci. 109, 3238 (2012)],* the critical quasiparticle theory was extended to a scaling analysis of the free energy and various thermodynamic quantities for which agreement with experiment was again remarkable.

In a collaboration with experimentalists from Dresden and elsewhere, Abrahams discussed the new observation of a breakdown of the Wiedemann-Franz relation in Yb2Rh2S2 at very low temperature and its implication for the nature of quantum criticality in this material *[Nature 484, 493 (2012)*

Soft Condensed Matter

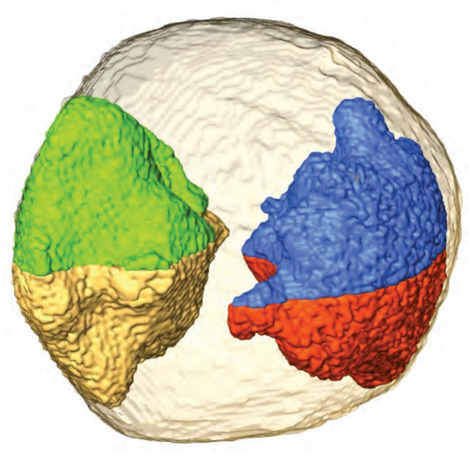
COHERENT IMAGING GROUP

Jianwei (John) Miao

Visualizing the arrangement of atoms has played an important role in the evolution of modern science and technology. Crystallography has long been used to reveal globally averaged 3D atomic structures. Scanning probe microscopes can determine surface or sub-surface structures at atomic resolution. Electron microscopes can resolve atoms in 2D projections of 3D crystalline samples. The Miao group and collaborators have recently reported the experimental demonstration of a general electron tomography method that achieves atomic scale resolution in three dimensions. By combining a novel projection alignment and tomographic reconstruction method, known as equally sloped tomography (EST), with scanning transmission electron microscopy, they have determined the 3D structure of a ~10 nm gold nanoparticle at 2.4 Å resolution. Individual atoms are observed in some regions of the particle and several grains are identified at three dimensions. The 3D surface morphology and internal lattice structure revealed are consistent with a distorted icosahedral multiply-twinned particle. It is anticipate that this general approach can be broadly applied to determine the 3D structure of crystalline, polycrystalline and potentially disordered materials at atomic scale resolution. This work is published in Nature this year (*http://newsroom.ucla.edu/portal/ucla/ucla-physicists-peer-within-gold-230808.aspx)*. Graduate students Mary Scott, Chien-Chun Chen, Chun Zhu and postdoc Rui Xu have participated in this work. Other collaborators include Matt Mecklenburg, Chris Regan of UCLA, Peter Ercius and Ulrich Dahmen of LBNL.

Mammography is the primary imaging tool for screening and diagnosis of human breast cancers, but approximately

10-20% of palpable tumors are not detectable on mammograms and only about 40% of biopsied lesions are malignant. By combining phase contrast x-ray imaging with the EST method, the Miao group and European colleagues have recently performed high resolution, low dose phase contrast x-ray tomography for 3D diagnosis of human breast cancers. They imaged a human breast in three dimensions and identified a malignant cancer with a pixel size of 92 μm and a radiation dose less than that of dual-view mammography. According to a blind evaluation by five independent radiologists, their method can reduce the radiation dose and acquisition time by ~74% relative to conventional phase contrast x-ray tomography, while maintaining high image resolution and image contrast. These results demonstrate that high resolution 3D diagnostic imaging of human breast cancers can, in principle, be performed at clinical compatible doses. This work is published in Proceedings of the National Academy of Sciences USA (*newsroom.ucla.edu/portal/ucla/breakthrough-technique-can-see-239762.aspx*) Graduate student Yunzhe Zhao and postdoc Zhifeng Huang have participated in this work. Other main collaborators include Emmanuel Brun, Alberto Bravin of ESRF in France, and Paola Coan of Ludwig-Maximilians University in Germany.



Inside a gold nanoparticle

Jianwei Miao and colleagues have developed an electron tomography method to image the 3-D structure of a gold nanoparticle at a resolution of 2.4 angstroms. Individual atoms are observed in some regions of the particle and several grains are identified in three dimensions. In the figure, the four three-dimensional grains (green and gold; blue and red) form two pairs of twin boundaries inside the nanoparticle.
(Credit: Jianwei Miao/UCLA Physics & Astronomy, CNSI)

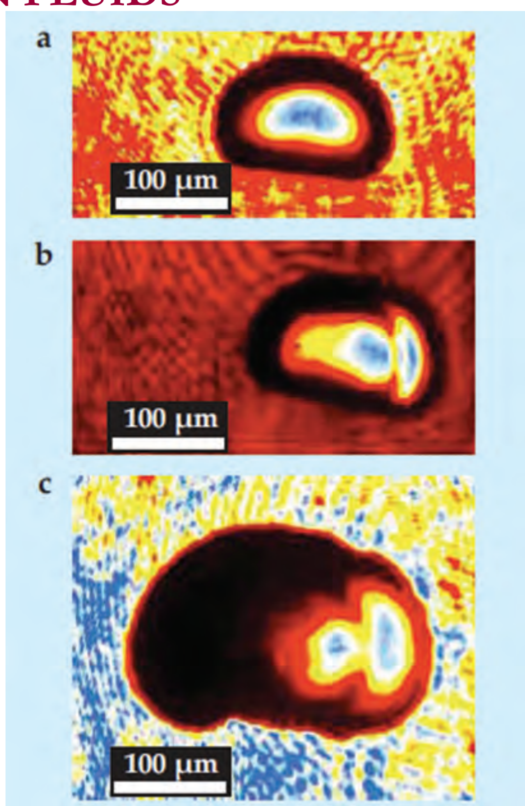
SPONTANEOUS ENERGY FOCUSING IN FLUIDS

Seth Putterman

Researchers led by Seth Putterman have administered the most direct test yet of a sonoluminescing bubble's ionic makeup: They observed its response to a laser pulse. Their finding, that even a relatively cool bubble becomes opaque during sonoluminescence, is one that even they themselves can't fully explain.

They have discovered a new phase of matter which is a dense cold plasma that is highly ionized. The April Issue of Physics Today of 2012 ran a Search and Discovery story on this work. This work is widely seen as a promising technical breakthrough: In a field that has long relied on passive observation, one can now give a sonoluminescing bubble laser nudges to find out what it's made of.

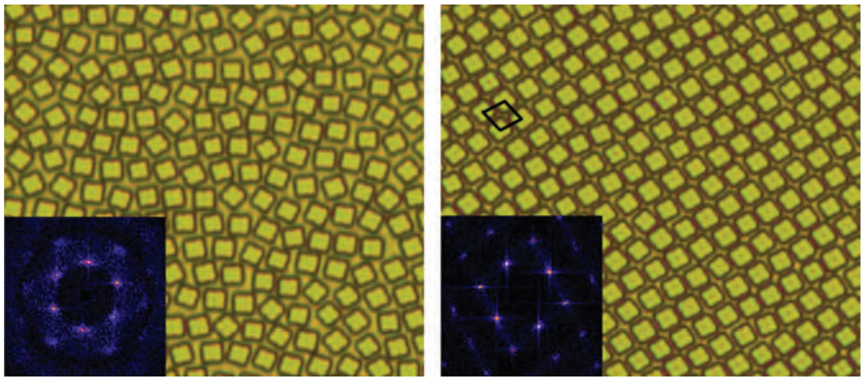
In May 2011 Nature ran a news story on how the Putterman group got xrays from slapping surfaces together. In September 2012 the Telemedecine and Advanced Technology Research Center {TATRC} based on the info in the Nature 2011 news story gave a grant to the Putterman group to build a field portable xray source for use by medics.



A sonoluminescing bubble is shown (a) before (b) 60 ns after, and (c) 360 ns after the arrival of a 10-ns laser pulse. (Blue depicts brighter regions; black depicts darker ones.) The bright spot at right in the bottom two images suggests that the laser pulse, which arrives from the right, is absorbed before it can deeply penetrate the bubble.

SELF-ORGANIZED COLLOIDAL SYSTEMS

Thomas G. Mason



Optical microscope images of a self-organized hexagonal rotator crystal (left) and a rhombic crystal (right) of hard Brownian squares that diffuse in a plane (insets show corresponding Fourier transforms). The hexagonal rotator crystal has a lower particle area fraction than the rhombic crystal. Differences in rotational entropy in different particle configurations are key to understanding this entropic crystal-crystal transition. *Image copyright 2011 by Thomas G. Mason and Kun Zhao, used with permission.*

The principles of directing the self-organization of many complex mobile structures at the colloidal scale are still being elucidated. Many milestones in condensed matter physics have revolved around understanding the structure and dynamics of many-body systems that are driven and interact at high densities. Work in Mason's lab is revealing the fundamental physics of phase transitions and jamming in Brownian systems of hard microscale particles that have shapes controlled by the same lithography methods used to print circuits on computer chips. These tiny microscale particles diffuse in a liquid and collide with each other. The fluctuating structural patterns that these particles form depend on the underlying shapes and the particle density; these patterns can be easily observed using optical video microscopy. When the particles are confined, so that they diffuse in two dimensions, they can self-organize into different shapes. In particular, postdoctoral fellow Dr. Kun Zhao and Prof. Mason have found that hard Brownian squares undergo an entropic crystal-crystal transition between a hexagonal lattice structure known as a rotator crystal and a rhombic lattice structure (*Proc. Natl. Acad. Sci. USA 108 2684, 2011*). Surprisingly, neither of these lattice structures directly corresponds to the square shape of the particle. Their experimental work and the corresponding rotational cage theory developed by Prof. Robijn Bruinsma have demonstrated the importance of rotational entropy in determining the surprising self-organized structures emerging from thermally driven systems of these very simple shapes.

In a different area of complex soft matter, yet involving isolated custom-shaped particles, postdoc Dr. Clayton Lapointe has observed and explained an unexpected multi axis rotational dynamics of colloidal platelets in nematic liquid crystals when an electric field is applied (*Phys. Rev. Lett. 105 178301, 2010*). In addition, Lapointe has used holographic optical tweezers to create vortex beams that manipulate custom-shaped colloids dispersed in nematic liquid crystals (*Optics Express 19 18182, 2011).*

In the area of fundamental mechanics of soft materials, Mason has collaborated with Prof. Todd Squires of UCSB to develop a full tensorial theory of microrheology of custom-shaped anisotropic colloidal particles (Rheol. Acta 49 1165, 2010). In addition, Mason has been highly involved in writing a major invited review article on microrheology with Prof. Squires published in Annual Reviews (*"Fluid Mechanics of Microrheology" Annu. Rev. Fluid Mech. 42 413, 2010*).

MOLECULAR BIOPHYSICS LAB

Giovanni Zocchi

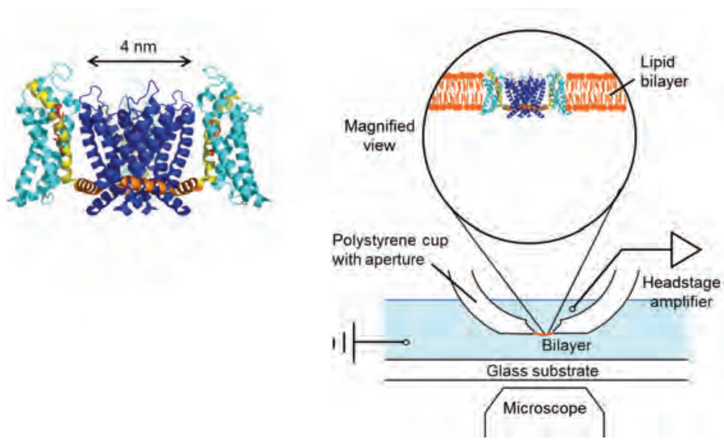


Fig. 1. Electrophysiology setup to measure ion channel currents while shearing the voltage gating domain (yellow in the structure) with an AC electric field. The molecule is a voltage gated potassium channel (KvAP).

Enzymes are molecules in motion: catalysis is associated with large conformational motion of the enzyme, itself responsible for virtually all aspects of the molecular machinery of the cell. Research in the Zocchi Lab is focused on probing this mechano-chemical coupling, using forces and elastic energies to control chemical reactions ("mechano-chemistry"). Thus we are generally interested in molecules under stress.

Voltage gated ion channels enable electrical signal propagation along the axon in nerve cells. These transmembrane proteins operate by coupling the motion of a charged group of aminoacids (the "gate") to the opening of a pore permeable to ions. We have performed a rheology experiment on the KvAP voltage gated potassium channel. We shake the gate through an AC electric field and observe the ionic current. We discovered a fundamental nonlinearity in the response, not known before, where the current saturates and even decreases for increasing voltage. A simple mechanical model leads us to a force dependent internal viscosity for the conformational motion of the channel. In essence, the harder you squeeze, the stiffer the molecule becomes. [A. Ariyaratne and G. Zocchi, to appear in Phys. Rev. X (2012)].

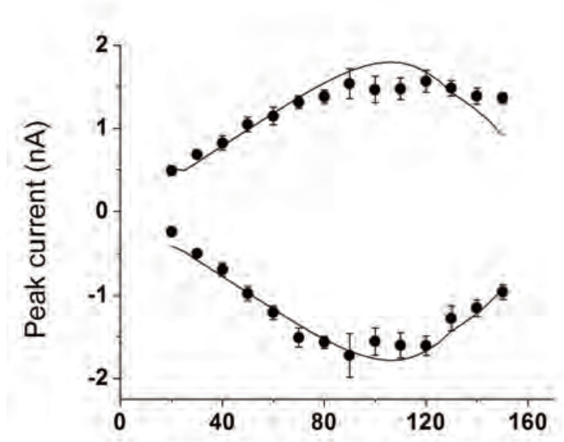
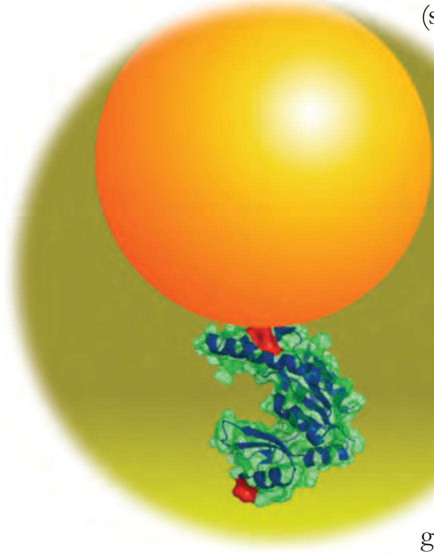


Fig. 2 Peak ionic current (multichannel recording) measured at 100 Hz excitation. The current saturates and even decreases for increasing voltage. Lines represent the model with force dependent internal friction of the molecule.

Cracking the phase diagram for enzyme dynamics.

We have obtained extraordinarily high resolution (sub-Å) nano-mechanical measurements on the conformational motion of an enzyme, using a nanorheology setup where the enzyme is stressed by an oscillatory force. We find that the mechanical susceptibility diverges as $1/\omega$ for the frequency $\omega \rightarrow 0$ and obtain experimentally from these plots a non-equlibrium phase diagram for the dynamics of this enzyme. In the frequency – force plane, a phase line separates linear elastic from softer, viscoelastic dynamics. Enzyme action involves crossing this phase line. The existence of this phase line, which was unknown before, provides a new physical insight on the ensemble averaged dynamics of the conformational motion of enzymes. *[Y. Wang and G. Zocchi, EPL 96, 18003 (2011) ; Y. Wang and G. Zocchi, PLoS ONE 6(12), e28097 (2011); H. Qu, J. Landy, and G. Zocchi, PRE 86, 041915 (2012)].*



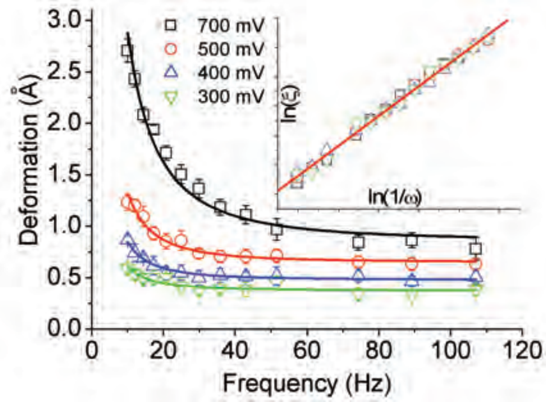


Fig. 4. The ensemble averaged amplitude of the enzyme's deformation vs. frequency for different driving forces, showing the low frequency divergence of the mechanical susceptibility.

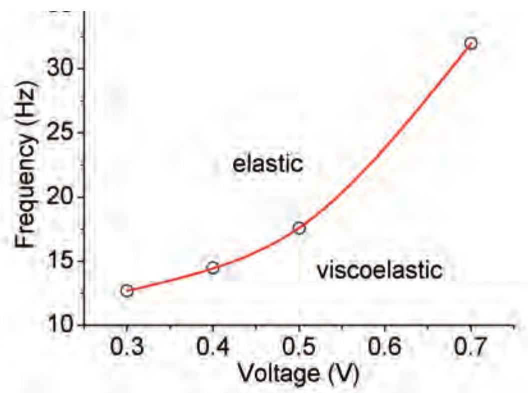


Fig. 5 The phase line in the frequency – force plane which separates elastic from viscoelastic mechanical response of the enzyme.

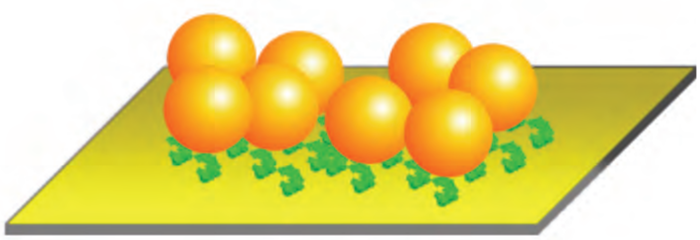


Fig. 3. Geometry of the nano-rheology setup, where gold nanoparticles (GNPs) tether the enzyme to a gold surface. The GNPs are driven by an electric field, while the displacement is read optically.

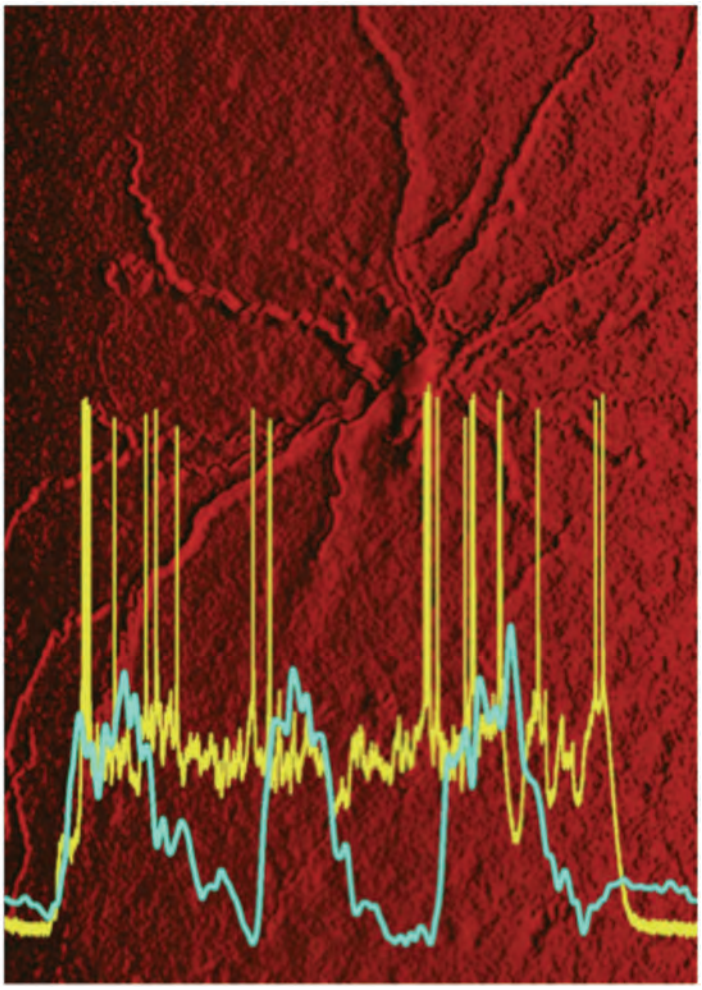
NEUROPHYSICS GROUP

Mayank Mehta

The Neurophysics laboratory published five papers during the last academic year. Of these, two are discussed here.

In one study they investigated how the brain encodes running speed of a subject. While plenty of evidence exists that neurons represent physical entities such as color, smell, objects etc., little is known about how the brain represents and perceives speed of movement. The position of a stimulus and its speed are orthogonal variables and hence they should be represented by independent neural parameters. In particular, they theorized that the position can be represented by the average neural activity while the speed can be represented by individual frequencies or Fourier components. Their subsequent experiments of measuring neural activity during natural behavior validated this theory. They found that the frequency of brain rhythms increased reliably with increasing running speed. This was the first evidence of a frequency-modulated (FM) neural code in any brain area. The results appeared in the journal of neuroscience.

In another study, they investigated the pattern of neural activity when there is no stimulus at all, when the subjects are either sleeping or anesthetized, which could be treated as the ground state of the brain. Remarkably, even when there is no stimulus the neural activity is only about 20% less than during alert behavior, even in brain areas involved in vision while the eyes are closed, the room is dark, and there is no visual perception. Not only that, the neural activity is not random during these quiescent states but acts like a two state system, fluctuating between the more active Up state and less active Down state. They investigated the interaction between different brain areas during this Up-Down state oscillations. Remarkably, they found that a brain region that is critically involved in learning and memory shows hysteresis during these Up-Down state oscillations: This brain region makes a transition to the Up state along with the rest of the brain, but then it remains in the Up state even when the rest of the brain makes a transition to the Down state. This hysteresis, or persistent activity is stochastic. It plays a crucial role in learning and memory during alert and attentive behavior. The surprising finding is that this occurs spontaneously during the entire period of sleep or anesthesia. Further, this persistent activity has a profound impact on the downstream neural circuits. The results were published in nature neuroscience and received extensive media coverage. http://newsroom.ucla.edu/portal/ucla/ucla-scientists-discover-that-239347.aspx



Background shows the image of a neuron that showed hysteresis or persistent activity. Cyan trace shows the activity of the visual cortex, fluctuating between active and inactive states. Yellow trace shows the activity of the red neuron that persists in the active estate while the rest of the brain shuts down.

Experimental Elementary Particles and Nuclear Experimental Physics

NUCLEAR PHYSICS GROUP

Huan Huang et al

The UCLA nuclear physics group has research programs focusing on studies of Quantum ChromoDynamics (QCD) in the extremely high temperature and density environment at the Relativistic Heavy Ion Collider (RHIC), and on neutrino physics for the mixing angle θ13 measurement and the neutrinoless double beta decay search. We have made major advances in all these research frontiers.

One of the major scientific goals in heavy ion collision physics is to search for a critical point in the QCD phase diagram. *Figure 1* shows a schematic diagram for QCD phases and recent theoretical calculations expect a critical point at finite temperature and chemical potential. In the last two years the STAR collaboration at Brookhaven National Laboratory has carried out a beam energy scan program by taking data for Au+Au collisions at 62.4, 39.0, 27.0, 19.6, 11.5 and 7.7 GeV energies. Preliminary results indicate that there may be a transition from partonic matter to hadronic matter between 19.6 and 11.5 GeV beam energy at RHIC. In order to scan the interesting beam energy region with more statistics, both an electron cooling system for the low energy beams and an upgrade of the Time-Projection Chamber readout system for broad pseudo-rapidity coverage will be needed. We will continue to analyze the phase I beam energy scan data to quantify properties of QCD matter created in these collisions while pursuing both the accelerator and detector upgrades in the coming years for a possible Phase II beam energy scan program starting 2017.

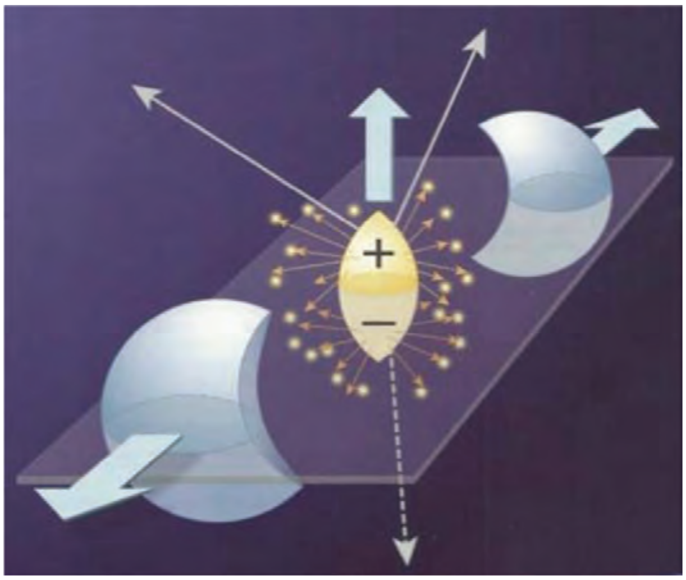


Figure 1

QCD is the underlying theory for nuclear collisions at RHIC. The theory has distinct topological excitations for underlying quantum fields that describe the vacuum structure. Calculations by Kharzeev et al [e.g., *Phys. Lett. B633, 260 (2006); Nucl. Phys. A803, 227 (2008)*] predicted a Chiral Magnetic Effect (CME) due to the coupling of a strong magnetic field generated by spectator protons and quantum (sphaleron) excitations in the Quark-Gluon Plasma (QGP) created in the nucleus-nucleus collisions. As a result, there is a charge separation across the reaction plane for particles produced in heavy ion collisions. *Figure 2* shows a schematic diagram for the charge separation which violates local parity symmetry.

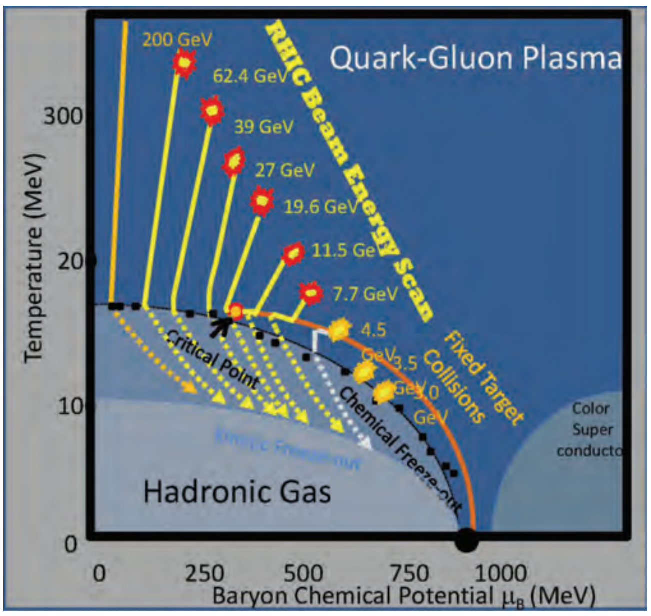


Figure 2

We have used a reaction plane-dependent two-particle correlation measurement to search for a possible CME in heavy ion collisions. The correlation measurement is sensitive to fluctuations in charge separation. By studying the difference between same-sign and opposite-sign charged particle correlations we can systematically examine the fluctuations in charge separation with possible contributions from the CME. In particular, we have studied the charge separation effect from the beam energy scan data. We found that the charge separation effect disappears at the lowest RHIC beam energy, presumably due to the fact that the QGP is not formed in these low energy collisions.

Several theoretical calculations attributed the measured reaction plane-dependent charge correlation to several common effects such as the coupling to elliptic flow, the balance function from charge conservation and momentum conservation. These background correlations are predicted to sensitively depend on the magnitude of the elliptic flow. In order to test these calculations we have taken U+U data in 2012. Because of the deformation in the Uranium nucleus, the elliptic flow of particles will be finite, even in most central U+U collisions. *Figure 3* shows the measured correlation difference between opposite-sign and same-sign charged particles as a function of elliptic flow. The measured correlation approaches zero in the most central collisions, even when the elliptic flow is finite. The new results indicate that our measured correlation cannot be entirely due to the background from elliptic flow coupling to charge balance and/or momentum conservation. Dr. Gang Wang from UCLA gave a highlight talk on these results at the Quark Matter 2012 conference at Washington D.C. in August 2012 [http://qm2012.bnl.gov/]. The results have also generated significant interest in the general press [http://www.bnl.gov/newsroom/news.php?a=11446].

The UCLA group is also a member of the Daya Bay Collaboration. This experiment measures neutrinos from reactors at a power plant near Daya Bay in southern China. A significant depletion of neutrinos has been observed at a baseline a few kilometers from the reactors, indicating a new oscillation of neutrinos from $\nu 1$ to $\nu 3$. The Daya Bay experiment announced the first measurement of the $\theta 13$ neutrino mixing angle in March 2012 and published the result in a paper in Physical Review Letters 108, 171803 (2012).

The CUORE experiment at Gran Sasso searches for neutrinoless double beta decays from Te isotope, and is still in the construction phase. We have completed the testing of preamplifier boards for the experiment, which is the first milestone for the CUORE electronics project. The experiment is expected to complete the construction phase in 2014 and data-taking is to commence in early 2015. Professor Lindley Winslow has joined the CUORE collaboration and will develop her own neutrino research group at UCLA. The UCLA group will host a CUORE collaboration meeting in October 2012.

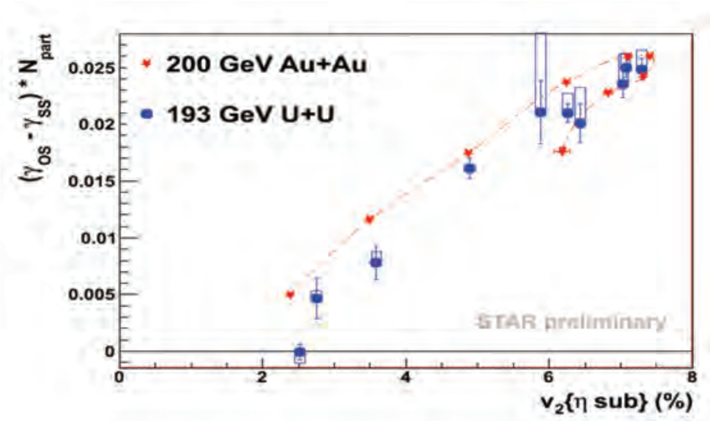


Figure 3

COMPACT MUON SOLENOID (CMS) EXPERIMENT

Katsushi Arisaka, David Cline, Bob Cousins, Jay Hauser, David Saltzberg

This was a great year for the LHC, CMS and Atlas with the discovery on July 4 of a new particle that appears to be the Higgs Boson. This is the first fundamental scalar particle ever discovered (the W and Z particles are vector particles responsible for the weak force). A key part of the discovery relied on the CSC chambers built in Westwood and Florida. (Figure 1) The CMS detector with these chambers is shown in Figure 1. The UCLA team of K Arisaka, R Cousins, D Cline, and J Hauser with others at UCLA signed the discovery paper. In Figure 2 we show the cover of the Physics Letters edition where the discovery was published.

Some of the highlights of the year for the UCLA team were:

- Cousins' service as chair of the CMS statistics committee lead to his involvement in the Higgs search, as well as searches in many other areas such as for Supersymmetry.
- Hauser's service as project manager of the CMS endcap muon system while resident at CERN; his term as project manager was recently extended to 2012-2013.
- Research physicist Greg Rakness' service as operations manager for the CMS endcap muon system; he was appointed to deputy run coordinator for all of CMS for 2012-2013, and research physicist Mikhael Ignatenko will be assuming his current responsibilities.
- Staff scientist Viatcheslav Valuev served another year as co-convenor of the muon physics object group.

Figure 1: The CMS detector at CERN.

The UCLA research team has been meanwhile busy with analyzing the flood of new data, especially:

- A search for heavy partners of the Z boson particle resulted in a publication in Physical Review Letters (graduate student Jordan Tucker, together with Valuev and Cousins).
- Staff scientist Valery Andreev working with one of the UCLA analysis teams has helped produce one of the first CMS papers on Beauty quark production, which is also a test of QCD corrections.
- Valery Andreev and D Cline have studied more than 40,000 3b quark events looking for new physics.
- A search is ongoing for charged particles that are heavy, yet anomalously stable so that they are directly visible in the detector (graduate student Chris Farrell, together with Rakness and Hauser).

New activities have begun with new faces in the UCLA team. Another line of data analysis has begun with the addition of postdoctoral researcher Pieter Everearts, who has begun refining the search for multiple leptons due to Supersymmetry. Meanwhile, under Saltzberg's supervision, new postdoctoral researcher Matthias Weber will create a test station at CERN for new muon detectors that are being built to allow the muon system to keep pace with the ever-increasing rate of proton-proton collisions. Electronics are to be built in the UCLA laboratory for the new chambers and other upgrades under Hauser's supervision. X Yang from the Cline group is also working on these chambers.

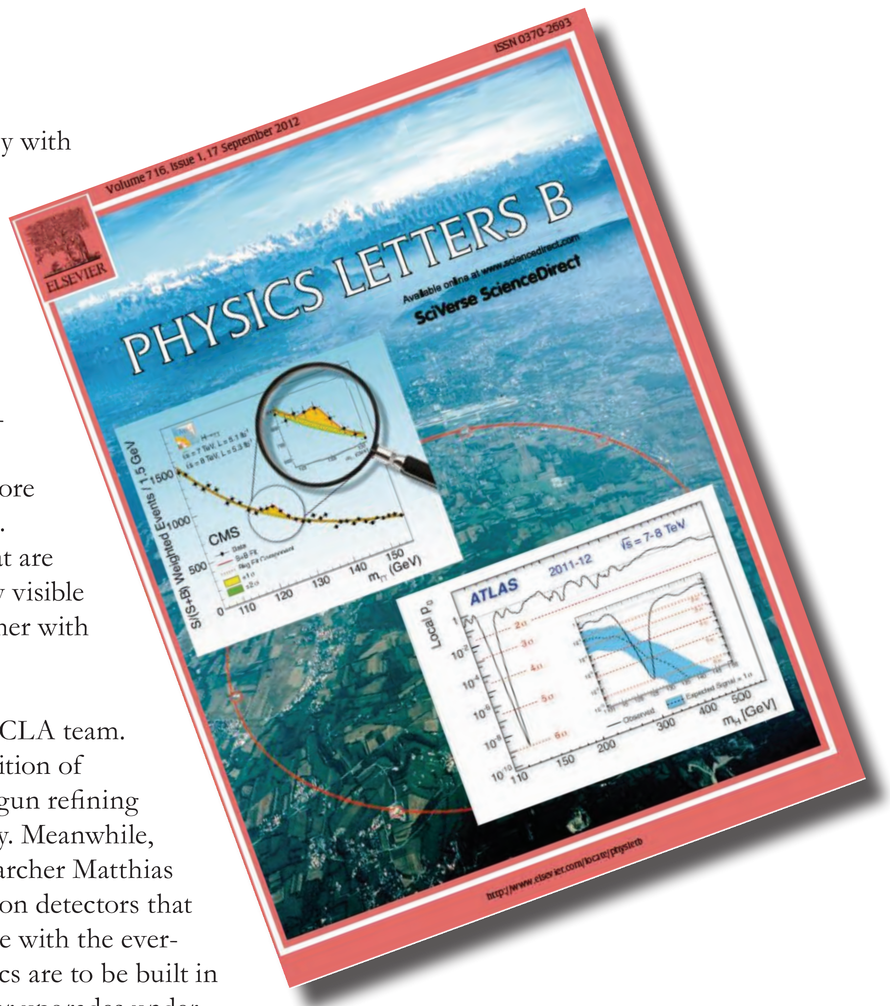


Figure 2: The cover of the Physics Letters B edition in which the Higgs Boson discovery was published. (The CMS result is on the upper left)

THEORETICAL ELEMENTARY PHYSICS

John M. Cornwall

Cornwall continues his work in non-perturbative Quantum Chromodynamics (QCD). He has published an invited review of the role of entropy in QCD (*Mod. Phys. Lett. A27, 123011 [2012]*), covering not only the familiar topic of the role of entropy in disordering the vortex vacuum of QCD but newer ideas, introduced by him, on how the entropy of massless-quark world lines is critical in understanding chiral symmetry breaking. He gave an invited talk at the workshop *Quantum Chromodynamics: History and Prospects* (Oberwoelz, Austria, September 2012) showing, from a gauge-invariant formulation of the field equations of QCD, how to generalize the usual running charge to a new and in principle more accurate formulation. With colleagues Roberto Peccei, Alex Kusenko, and Kusenko's graduate student Lauren Pearce, he is finishing the initial stages of a project to look for Higgs-boson-like bound states in the minimal supersymmetric version of the standard model

Christian Fronsdal

Fronsdal has been fully engaged, these last 5 years, on a revision of thermodynamics of heterogeneous substances, that is mixed fluids.

This project began with some work on stellar structure that led to the realization that procedures that have been followed almost universally are flawed. More precisely, a set of equations for the interaction of gravitation with matter are very unsatisfactory. Let us mention only the fact that the continuity relation that is a central part of classical hydrodynamics is abandoned in this theory. Only Weinberg seems to have been disturbed by this; to overcome the difficulty he introduced an extra scalar field to be interpreted as baryon number. This theory is reported in textbooks but it has not been put to use.

It turned out that this defect of the standard approach could be easily fixed (Fronsdal 2007), but there were objections to the effect that thermodynamics was not properly respected in this work. This prompted Fronsdal to review the foundations of thermodynamics. This turned out to validate his work in stellar structure and led to a full integration of General Relativity with Thermodynamics.

What most poignantly characterizes the new approach is the insistence of an action principle formulation. In the case of simple system this does not bring anything new, but when applied to heterogeneous systems it is quite revolutionary.

Difficulties with referees has led Fronsdal to undertake the writing of a monograph. This is already quite advanced and interested persons may ask Fronsdal for an advance copy. So far the following topics have been treated:

Simple phase transitions.

- The formulation of mixtures by Lagrangian methods.
- A new treatment of entropy of mixtures.
- A new understanding of the meaning of the Gibbs Dalton hypothesis
- A derivation of Saha's equation within thermodynamics.
- A new treatment of immiscible fluids that is a departure from the tradition.
- An account of the velocity of sound in mixtures.
- A theory of atmospheres with controversial elements.

Planned:

- A new version of Landau's two-fluid theory of liquid helium.
- Thermodynamics of Dark Matter.
- Alternatives to Black Holes.

Plasma and Beam Physics

THEORETICAL PLASMA PHYSICS

George Morales

Origin of broadband spectrum of deterministic chaos

In a recent publication [Phys. Rev. E 86, 015401 (2012)] Dr. James Maggs and Prof. George Morales have provided the solution to a long-standing question associated with the characteristic broadband frequency spectrum of fluctuating quantities (e.g., temperature, density) in general systems whose dynamics is governed by “deterministic chaos”. The concept of “deterministic chaos” refers to solutions to the behavior of a system that is governed by a known set of differential equations that can, in principle, be solved exactly. Yet the solutions in chaotic systems are very sensitive to initial conditions. A given known solution for one starting point is not predictive of the behavior of solutions starting in the immediate vicinity of that point. Although it has been long recognized by the nonlinear dynamics and fluid turbulence communities that chaotic systems display a characteristic spectrum that has an exponential frequency dependence, the origin of such behavior remained unexplained. Maggs and Morales, in collaboration with their students, identified from controlled plasma experiments in the LAPD device at UCLA that the origin of the exponential dependence could be traced to the appearance of pulses having a unique temporal Lorentzian shape.

The connection established by the plasma experiments ruled out that the exponential feature is a statistical property (e.g., a canonical distribution), but, rather, that it is the imprint of individual intermittent events with a unique shape. But it is natural to question why pulses emerging from a chaotic system should have a Lorentzian shape. In fact, some researchers expect that such pulses should more closely follow a Gaussian form or other distorted shapes determined by random events. The recent paper by Maggs and Morales answers this question by illustrating explicitly the origin of Lorentzian pulses as chaotic dynamics near the separatrix boundaries of elliptic regions in flow fields, or, more generally, near the limit cycles of attractors in nonlinear dynamics models. Two explicit examples are considered, a bifurcation given by a potential field appropriate for drift waves in a plasma, and a case from the classic example of deterministic chaos, the Lorenz model, illustrated in Fig.1.

The width of the Lorentzians is determined by the imaginary part of the complex eigenvalues of the underlying Jacobian matrix. These Lorentzian pulses are responsible for the exponential power spectra that characterize deterministic chaos and that are observed in a wide class of physical systems. The importance being that since deterministic chaos is irreversible, the phenomenon leads to strong transport that does not follow Fick’s law.

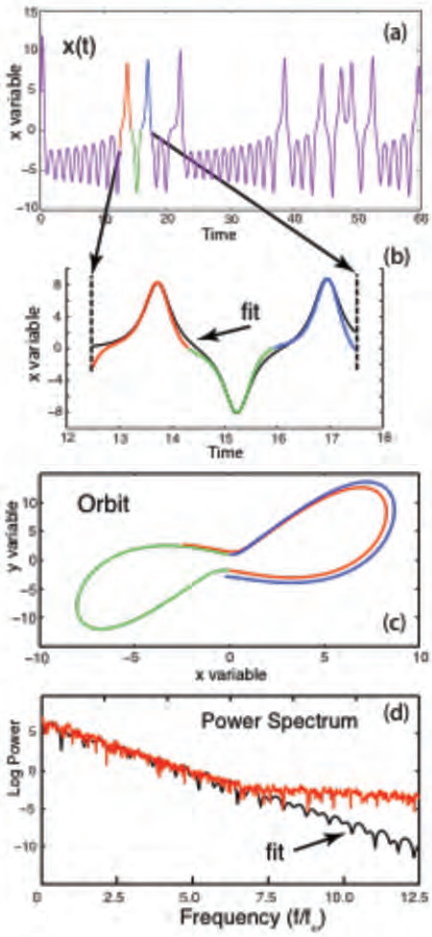


Fig 1. (a) Time series for Lorenz model variable x shows intermittent pulses. (b) Color-coded time series is fit by a sum of three Lorentzian functions (black curve). (c) Phase-space trajectory of variables (y, x) is near the limit cycle of the attractor. (d) Frequency power spectrum of time series (red) compared to spectrum (black) of the sum of three Lorentzians.

These results have been applied to the extensive worldwide data base of fluctuations measured at the edge of fusion devices of varying size and geometry. It is concluded that the anomalous transport observed at the edge of these devices results from a deterministic and not a stochastic process.

This work is part of a broader DOE-funded program, lead by Maggs and Morales, that studies the basic properties of non-diffusive transport. An issue of current attention is the connection between deterministic chaos and fractional diffusion formulations. Collaborations with groups at U. of Alberta in Canada, University of Warwick in the U.K., and Oak Ridge National Laboratory complement the efforts at UCLA.

THE COMPUTER SIMULATIONS OF PLASMA GROUP

Warren Mori

The Computer Simulations of Plasma Group (http://plasmasim.physics.ucla.edu) under the leadership of Professor Warren B. Mori, and Adjunct Professors Viktor Decyk, and Phil Pritchett continues to do pioneering work in high-performance computing of complex plasma phenomena. The group also currently includes four research physicists (Dr. Tsung, Tzoufras, Lu, and Tonge), a post-doctoral researcher, and six PhD students. Its research remains focused on the use of fully parallelized particle based simulation models to study laser and beam plasma interactions, plasma based accelerator and light sources, space plasmas, Alfvenic plasmas, inertial fusion energy plasmas, and high-energy density science. The group specializes in fully kinetic simulation of plasmas using particle-in-cell (PIC) and Vlasov Fokker Planck (VFP) techniques It continues to develop and maintain over five separate state-of-the-art PIC simulation codes, OSIRIS, PARSEC, Magtail, QuickPIC, and the UPIC Framework and a new VFP code, OSHUN. 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 is also home to the DAWSON2 computer which is has 1152 CPUs and 288 General Purpose Graphics Processing (GPGPU) units. This was funded through a National Science Foundation (NSF) Major Research Instrumentation (MRI) Award. It is a leader in developing algorithms for kinetic simulation codes to run a GPU and other many core systems.

The group is engaged on several grand challenge research topics. These include attempting to design next generation accelerators at the energy frontier and for x-ray free electron lasers based on particles surfing on plasma waves. This includes carrying out three-dimensional simulations with the full temporal and spatial scale of both ongoing experiments as well as conceptual designs that are well beyond the reach and cost of existing experiments. It also includes developing the physics and simulation models necessary to positively impact the National Ignition Facility (NIF) and Inertial Fusion Energy (IFE). NIF is the world's largest and most powerful laser. It is the also the largest and most expensive science project inside the US. A grand challenge in NIF and IFE research is to unravel the complicated physics behind how a multitude of overlapping high-power laser beams are absorbed, scattered, and deflected as they propagate through centimeters of high-energy density plasmas.

The group is part of several interdisciplinary research teams. It is part of a team that was recently funded by the Scientific Discovery through Advanced Computing (SciDAC) program within the Department of Energy(DOE). The team is focused on developing and using state-of-the-

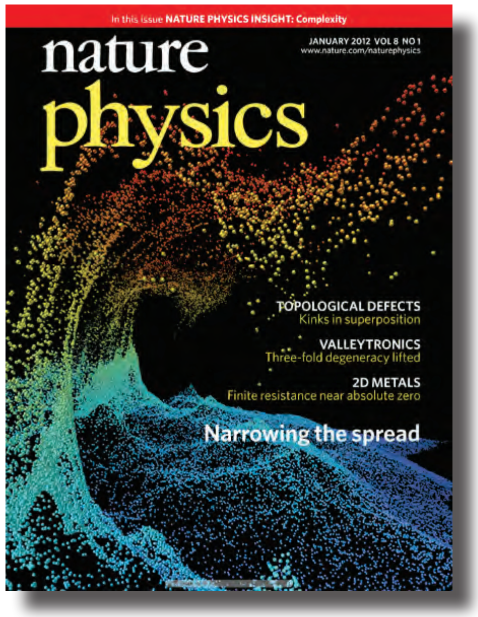


Figure 1: A cover from a recent Nature Physics issue that highlights results from the code OSIRIS. The cover shows the phase space of ions that are interacting with a collisionless shock launched by an intense laser impinging on dense plasma. The shock generated a monoenergetic beam of protons. The simulations modeled an experiment carried out a the UCLA Neptune Laboratory.

artsimulation tools for helping to develop next generation accelerators for use in high energy physics. The title of the grant is called "Community Project for Accelerator Science and Simulation" (COMPASS). It also was recently funded by a new DOE program in High Energy Density Laboratory Plasmas to study laser and electron beam transport in high energy density plasmas that are found in inertial fusion energy experiments. The group also was recently funded by the joint DOE/NSF program in basic plasma science to study the feasibility of using plasma waves to generate electron beams that could drive a x-ray free electron laser. The group is remains part of a recently 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 Laser-plasma coupling for inertial fusion energy. The group also continues to be affiliated with a DOE Fusion Science Center (FSC) on "Extreme states of matter and fast ignition physics".

The group continues to make great strides in its research. It has published widely in high impact journals such as in Nature Physics and Physical Review Letters, sample shown in figure 1. See:(http://plasmasim.physics.ucla.edu)

BASIC PLASMA SCIENCE FACILITY (BAPSF)

Walter Gekelman

This was another productive year for the Basic Plasma Science Facility. The BaPSF provides frontier level plasma devices and diagnostics to plasma physicists in the US and abroad. It is funded by the Department of Energy and National Science Foundation. So far this year 8 peer reviewed papers on work done at BaPSF were published in scientific journals and 12 invited talks and colloquia given by its scientists. Publications may be downloaded from *http:/plasma.physics.ucla.edu/bapsf.* Faculty associated with the facility are George Morales, Walter Gekelman and Troy Carter. Research Scientists are Stephen Vincena, Bart Van Compernolle, Shreekrishna Tripathi and Patrick Pribyl. Experiments at the facility change every few weeks and it is not possible to list or describe them all in this short section. Instead we briefly outline three.

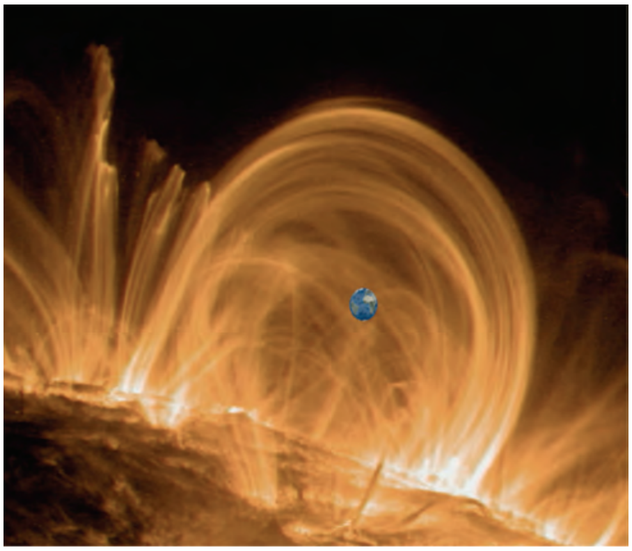


Figure 1. Xray photograph of the sun with a scaled earth inserted for size perspective. The light is generated when electrons moving along the arched solar magnetic fields strike H atoms and excite them.The picture is therefore thought to reflect a map of the magnetic field.The field occurs in bundles which upon close inspection write about themselves and twist about one another. These objects are called magnetic flux ropes. We have been able to create single or multiple magnetic ropes of various sizes in the laboratory and study them in great detail.

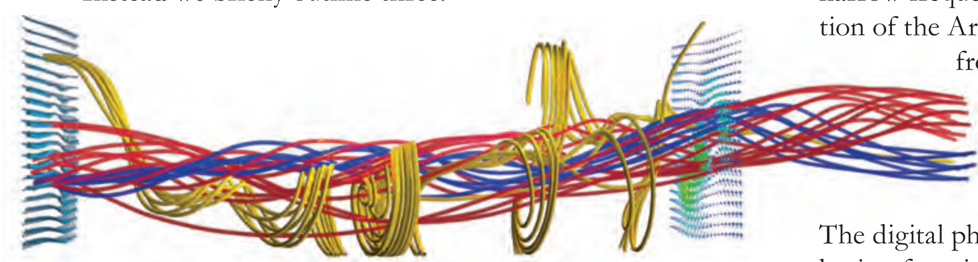


Figure 2. Field lines of two magnetic ropes shown in red and blue. Also shown are lines of three dimensional plasma flow measured with Mach probes. Two planes with arrow maps of the transverse flow are superimposed. The data set is highly compressed. It is 10 m from left to right and 24 cm in the vertical direction.

Magnetic flux ropes are twisted bundles of magnetic field which occur quite often in nature. For example figure 1 is a photograph of the sun taken in soft X rays by a satellite.

Figure 2 illustrates detailed data on two magnetic flux ropes embedded in a background magnetized plasma in the LAPD device. Plasma flow and magnetic field was measured with automated probes at close to 50,000 spatial positions and 16,000 time steps. The interaction between flux ropes is studied intensely by solar and astrophysics because it involves magnetic field line reconnection. In this process magnetic energy is transformed into particle energy, waves and flows. It may account for the fact that the solar corona (top of figure 1) can reach temperatures of one million degrees Celsius while the surface of the sun is a mere 8,000 degrees. Invited papers by Van Compernolle and Gekelman were presented on October 18, 2012 in Scotland on a conference on "Tangled Magnetic Fields". The graduate student currently involved on the flux rope experiment is Tim DeHaas

Plasma Processing is a multi-billion dollar industry. It produces all computer chips, transistors and a wide variety of other electronic circuit elements in what are known as plasma etch and deposition tools. The Intevac corporation donated an etch tool to UCLA and a series of experiments have been designed to measure the ion energy distribution function in space and time above a silicon wafer positioned in the tool. The experimental schematic is shown in figure 2b and some results in 2a.

The processing tool is an evacuated chamber where a background plasma is produced with a high frequency field (Inductively coupled plasma). In industry the plasma is made of highly reactive, sometimes dangerous gasses but in our device is filled with Argon and 5-10% Oxygen. To etch a wafer ions must bombard it with energetic particles directed downwards towards the wafer. The particles are produced by capacitively coupling a 2.2 MHz high voltage between a plate under the wafer and the chamber wall. The ions are tracked using a techniques called laser induced fluorescence (LIF). A narrow frequency laser beam is tuned to an optical transition of the Argon ion. If the ion is moving toward or away from the laser the color of the light has to slightly shifted (due to the Doppler effect) to allow the ions to absorb light. They the glow at a different color and using a narrowband filter and fast camera they can be photographed. The digital photographs can be used to assemble the distribution function f(E,r,y) as shown in figure 2a. It is possible to measure f(E,r,y) at different instants of the RF phase and the moment where the ions have the largest energy is shown in figure 2a. The blue surface is f(E,r,y=2.37mm) above the

Annual Report 2011-12-Final-.indd 40 11/30/12 3:25 PM

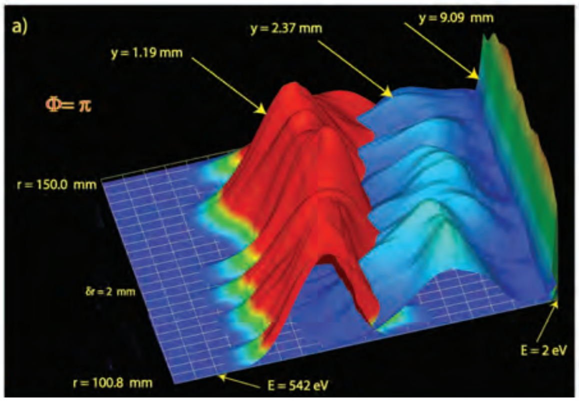


Figure 2(a) The ion distribution function FI(r,y,E,f) shown at the phase (f = p) of the 2.2 MHz ,when the ions are most energetic. RF used to bias the wafer. r is the distance along the wafer, y is height above it.

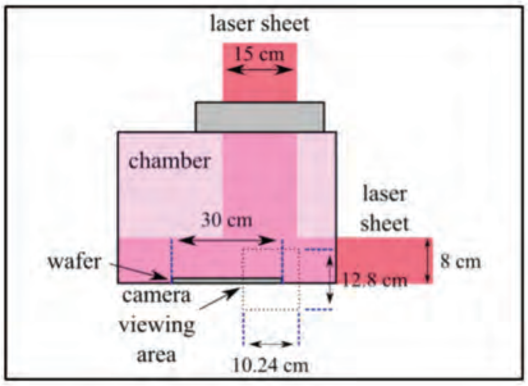


Figure 2(b) Experimental setup for LIF. Laser sheets are incident from either the side or top of the device such that ion motion perpendicular or parallel to a Si wafer can be studied

surface. Close toward the surface (y = 1.19 mm) the ions have higher energy since they are closer to the bottom of the narrow non neutral sheath near the wafer were there is a large electric field. Far above the wafer (y = 9.09 mm) there is no sheath and the ions are cold. This is the only experiment of its kind in the country and has attracted great interest from industry. One student (Brett Jacobs who finished in 2010) has a job with a large plasma processing company. Currently Nathaniel Moore is the grad student working on the project. He is about to submit a detailed publication on his work.

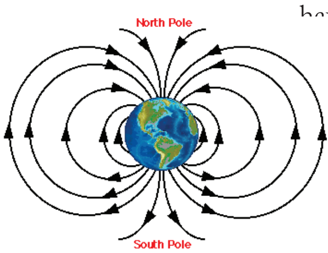


Fig 3 drawing of the magnetic field lines near the earth

A third class of experiments are on radiation belt remediation. The earth's radiation belts are a natural "magnetic mirror". Figure 3 is a cartoon showing field lines between the North and South pole.

When a large flux of particles is ejected from the sun by a coronal mass ejection or by a man-made nuclear event, these very high energy particles may be trapped for months and pose a danger to satellites orbiting at a distance of 2-3 earth radii. There is a great deal of research to find ways to mitigate this in the event it does happen. There are several experiments on the LAPD involving researchers from Los Alamos, the University of Maryland, UCLA Space Science and Stanford

Yuhou Wang who is expected to graduate this year has been studying ways to de-trap electrons from the mirror. A linear magnetic mirror is created in the LAPD by varying the magnetic field on the solenoidal coils surrounding the vessel and a high energy (100 eV-3 MeV) electron ring is formed using an intense beam of microwaves. It was discovered that a shear Alfvén wave can knock all the fast electrons out of the mirror (in the case of the earth they would be harmless lost in the atmosphere above the poles). This process is illustrated in figure 4 and was the subject of a recent Physical Review Letter. The key point of figure 4 is shown in 4b. The "spikes" are bursts of Xrays detected outside of the machine (100 kEV<E<3MeV) at various time after the electron beam is turned on. It takes nearly 20 ms for the beam to develop and no X rays are seen until then. Then when the Alfvén wave is switched on a burst of X rays is observed.

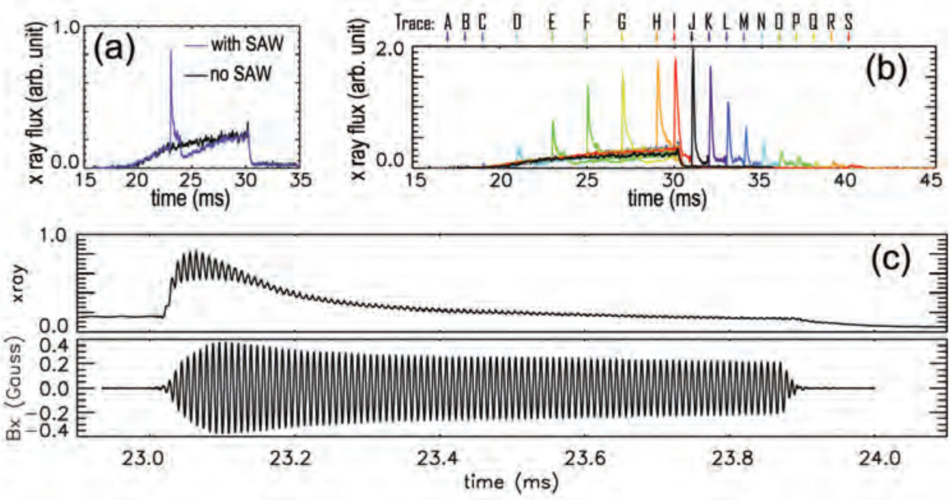


Figure 4. Time series of the x-ray flux. X-rays are generated by the fast electrons when they strike the machine wall or other metal objects in the chamber. (a) Comparison of x-ray measurement with/without the presence of a 100-cycle Shear Alfvén Wave (SAW) from t=23 ms to t=23.9ms. A burst of x-rays generated by hot electrons escaping the mirror trap appears during the Alfvén wave propagation time. (b) Overlay of 19 traces (designated A-S), each measured with a 100-cycle SAW launched at different time delays (marked by an arrow the same color of the trace of the top). A population of fast electrons persists after the termination of the ECRH at t=30ms and can be de-trapped by application of the SAW to produce x-ray bursts (traces J-S). (c) 1200 shot averaged signal of the x-ray burst during SAW propagation. The signal clearly shows a modulation at the frequency of the shear Alfvén wave Bx of the SAW measured at the center of the magnetic mirror is shown on the bottom trace.

The microwaves are switched off at t = 30 ms but the electron ring persists about 10 ms after that and when the waves are switched on the beam is destroyed the as well. An Xray tomography system was developed and using a method developed by Ms. Wang the location of the Xray source could be reconstructed . This is shown in Figure 5.

The BaPSF is doing exceptionally well. This year we have published 8 peer reviewed paper with at least 7 under review. In 2011 the lab had 17 publications. These are all available on the BaPSF website. Presently there are 14 doctoral students working on experiment and theory and since the facility stared 21 students from UCLA and other institutions have received advanced degrees. The BaPSF also has an active high school outreach program.

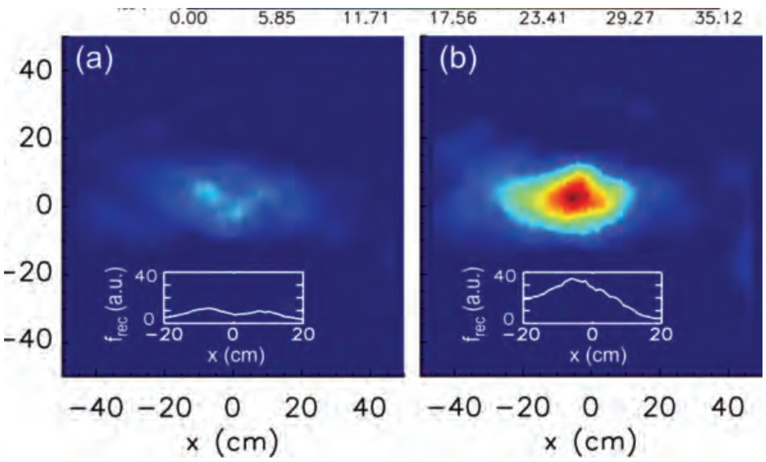


Figure 5 Tomographic reconstruction of the X ray signal on plane containing a Moly grid 12 meters away from the electron ring. Figure 5a shows the constant loss of X rays scattered from the mirror before the Alfvén wave is switched on. Fig 5b shows a distinct brightening (due to electrons striking the metallic grid) when the Alfvén wave is switched on. When there is no electron ring the signal vanishes entirely.

PARTICLE BEAM PHYSICS

James Rosenzweig, Director of the UCLA Particle Beam Physics Laboratory (PBPL)

The research of Prof. James Rosenzweig, Director of the UCLA Particle Beam Physics Laboratory (PBPL), continued to flourish last year. This research led to high profile publications printed in Physical Review Letters, and Applied Physics Letters, and Physics of Plasmas, among others, encompassing major initiatives in free-electron lasers (FELs) and other novel light sources, dielectric laser acceleration, wakefield acceleration in plasma and dielectric, and ultra-fast beam measurement techniques. The Rosenzweig group has graduated three PhDs in 2012, continuing in the tradition of placing alumni in the leading advanced accelerator and FEL research groups worldwide.

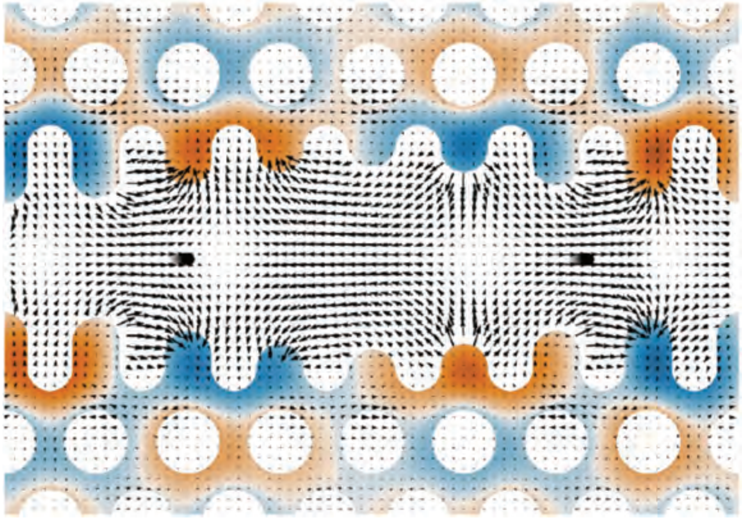


Figure 1. Cross-section of photonic dielectric laser accelerator structure for GALAXIE project (see B. Naranjo, et al, Phys. Rev. Lett. 109, 164803 (2012).

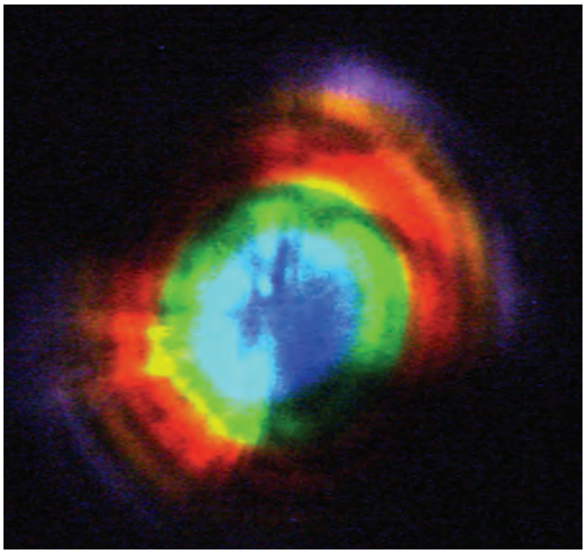


Figure 2. Far field radiation pattern in real color emitted from prebunched beam in high-field electromagnetic undulator from UCLA experiment at SLAC NLCTA facility.

Major experimental initiatives that engaged the group in the last year include above all the GALAXIE (GV-per-meter Laser Acceleration and X-ray Integrated Experiment), an ambitious consortium funded by DARPA to create a table-top X-ray FEL based on laser acceleration (see Figure 1) and optical undulators (Figure 2). The PBPL is also engaged in a number of new experiments at SLAC using the national facilities there, including the new FACET Wakefield Facility, where UCLA is leading the E-201 Dielectric Wakefield Acceleration experiment, and the E-210 Trojan Horse Plasma Wakefield Injection experiment.

OPTICAL-SCALE PARTICLE ACCELERATORS

Gil Travish

The promise of optical-scale particle accelerators is to make the availability of relativistic electron beams, and their many uses, ubiquitous. By scaling down to microchip size the structures which transfer energy from an electromagnetic field to a particle beam, formerly laboratory sized accelerators transform into bread box sized machines.

These new devices, collectively referred to as Dielectric Laser Accelerators (DLAs), benefit from advances in nanofabrication, lasers and simulations. Dr. Travish, his long time collaborator Prof. Rodney Yoder (now at Goucher College), and their team have been working to translate these concepts into reality. This past year new pioneering work continues: devices have been fabricated using the on-campus foundries, and testing has been performed at SLAC's E-163 facility. Despite possessing only an 800nm high gap for the electrons to pass through, beams have been transmitted through these structures and laser power has been applied. Particle acceleration has yet to be detected, and finding this elusive proof of acceleration is an area of intensive ongoing work.

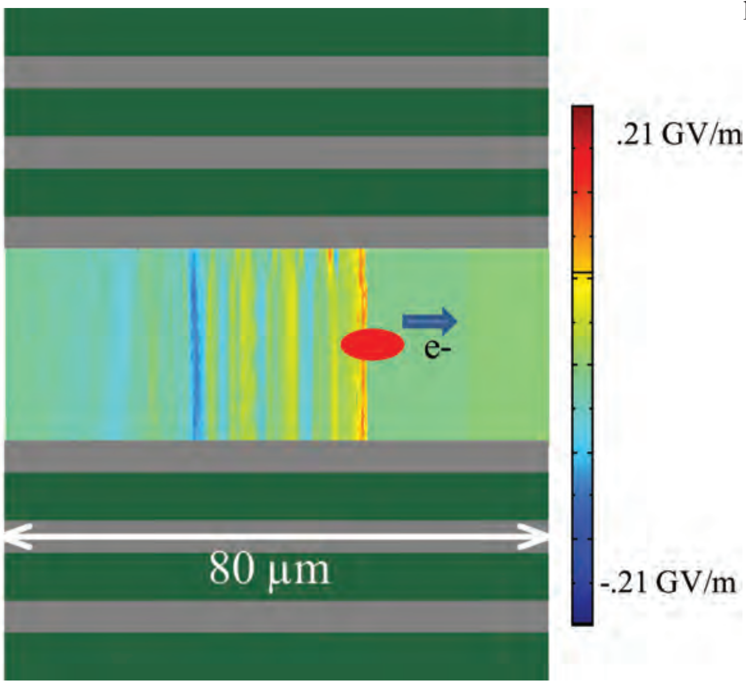


Figure 1: Simulation results for the fields excited within the MAP structure by the passage of a relativistic electron beam (shown in red). These so-called wakefields can act back on subsequent beam bunches and are therefore important to model.

With new group members Dr. Kiran Hazra and Dr. Esin Sozer joining the effort as postdocs, and Dr. Hairong Yin visiting from UESTC (China), new ideas have been generated to improve both the functioning of the structure (see Figure 1) as well as improvements in fabrication methodology (see Figure 2). The group also benefited greatly from a short term staff member and his fabrication expertise: Gang Liu (now at USC, but we are still on speaking terms). Graduate student Josh McNeur, now in his third year on the research team, has advanced to candidacy. The team is also pleased to have successfully pushed out of the nest two undergraduates: James Allen has been accepted to the Stanford graduate program, and Ritika Dusad has been accepted at Cornell; both have begun their physics PhDs at the time of this writing. Continuing students Alexander Lin and Nestor Carranza are working on Free Electron Lasers and Nanoemitters, respectively.

The team has been funded primarily by grants from DTRA and NNSA, and has also received funding for industry. Continued publication and presentation by group members has increased the profile of their research, and Dr. Travish was an invited plenary speaker at the most recent Advanced Accelerator Concepts meeting, where he highlighted UCLA's results.

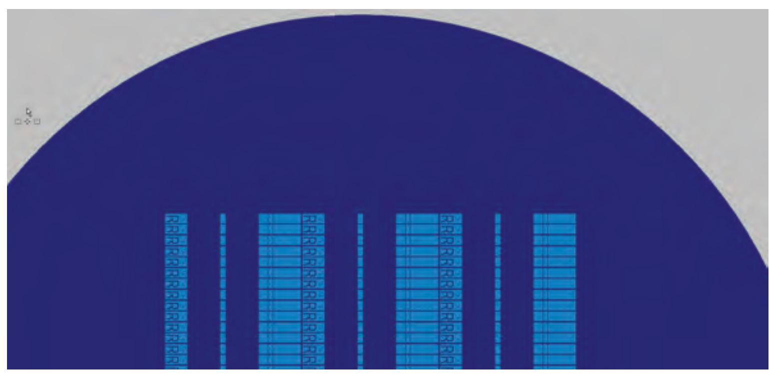


Figure 2: A portion of the new lithography mask developed for producing multiple MAP structures on a single 4" wafer.

THE PEGASUS PHOTOINJECTOR LABORATORY

Pietro Musumeci

The Pegasus photoinjector Laboratory led by P. Musumeci stays at the forefront of the generation diagnosis, manipulation and applications of high brightness ultrashort electron beams. Recent research highlights include the demonstration of ultra low emittances from RF photoinjectors (R. Li, P. Musumeci et al. Phys. Rev. STAB) which opens the way to new applications of relativistic electron beams in time-resolved diffraction and microscopy. The first workshop on Ultrafast Electron Sources for Diffraction and Microscopy has been organized by Prof. Musumeci, who is co-chairing it with Prof. X. J. Wang (an UCLA graduate) now at Brookhaven National Laboratory, and will be held at CNSI from December 12-14th. This workshop brings together for the first time accelerator physicists, microscopists and scientific users to draw a path for the ultimate electron-based instrument to observe matter at the fundamental temporal and spatial scales.

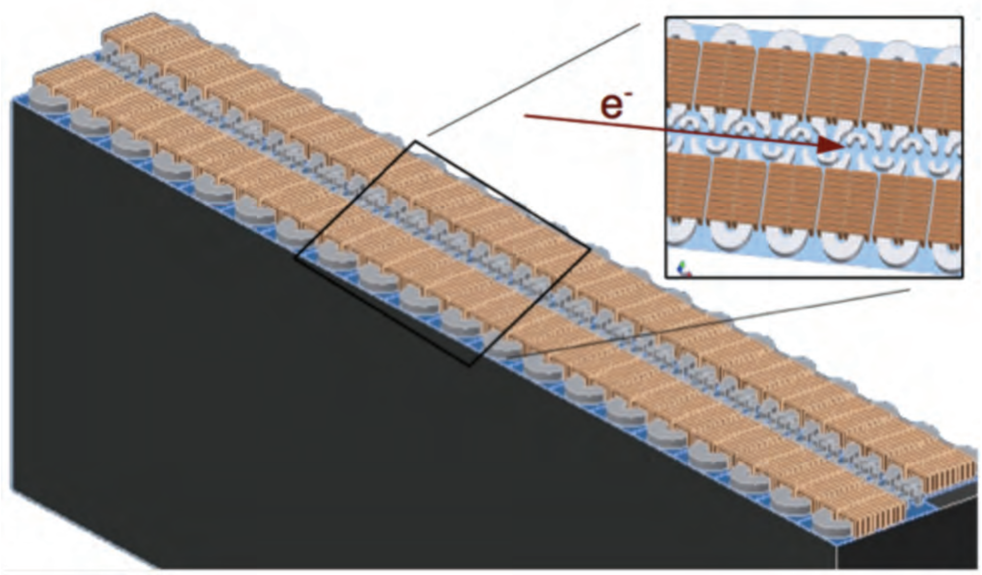
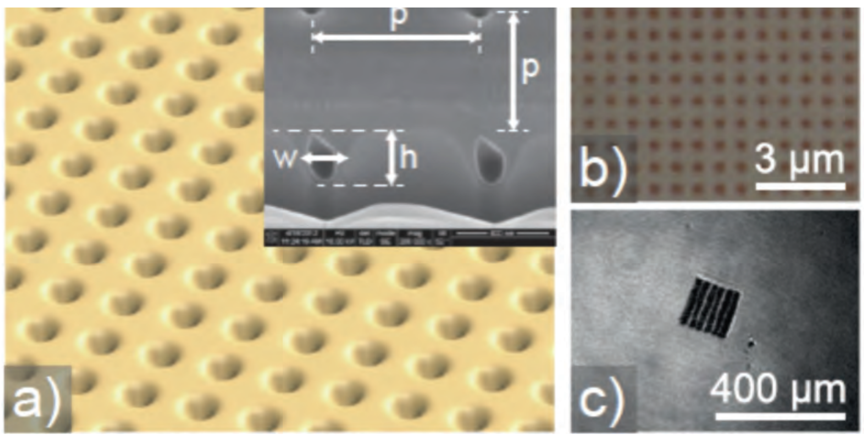


Figure 1: Illustration of a MEMS micro-undulator

Interesting developments came from the applications of nanotechnologies in the field of particle accelerators. It is known that by properly nano-pattering a metal surface it is possible to drastically change the optical response. Prof. Musumeci and collaborators have applied these nano-plasmonic concepts to solve the problem of low quantum efficiency and poor charge photoemission from metal cathodes in RF photoguns. By using an array of nano-holes drilled in a copper surface by Focused Ion Beam Technique they have observed orders-of-magnitude increase in charge yield compared to flat metal surface. In collaboration with Prof. Candler's group in EE, the Pegasus laboratory will also be the first test bed for novel electromagnetic micro-undulators nano-fabricated at UCLA. With a wiggling period of 400 um these wafer-size structures will enable the generation of short wavelength radiation using modest energy and more compact accelerators.



(a) SEM images of the nanohole array structure fabricated on a single crystal copper surface. Inset: the zoomed-in cut view of the nanoholes. (b) The nanostructured surface under an optical microscopy (c)

Faculty, 2011-12

Professors

Elihu Abrahams (Adjunct)
Katsushi Arisaka
Maha Ashour-Abdalla
William Barletta (Adjunct)
Zvi Bern
Stuart Brown
Robijn Bruinsma
Troy Carter
Sudip Chakravarty
David Cline
Ferdinand V. Coroniti - Associate Dean of Physical Sciences
Robert Cousins
Eric D'Hoker - Vice Chair of Academic Affairs
Sergio Ferrara
Christian Fronsdal
Walter Gekelman
Graciela Gelmini
Andrea Ghez
George Grüner
Michael Gutperle
Brad Hansen
Jay Hauser
Kàroly Holczer
Huan Huang
David Jewitt
Hong-Wen Jiang
Michael Jura
Per Kraus
Alexander Kusenko
James Larkin
Alexander Levine
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
Seth J. Putterman
James Rosenzweig – Department Chair
Joseph A. Rudnick - Dean of Physical Sciences
David Saltzberg – Vice Chair of Resources
Reiner Stenzel
Terry Tomboulis
Jean Turner
Rainer Wallny
Gary A. Williams
Edward Wright
Giovanni Zocchi

Associate Professors

Dolores Bozovic
Steven Furlanetto
Jean-Luc Margot
Mayank Mehta
Pietro Musumeci
Alice Shapley
Yaroslav Tserkovnyak
Vladimir Vassiliev

Assistant Professors

Michael Fitzgerald
Eric Hudson
Christoph Niemann
B. Chris Regan
Rahul Roy
Martin Simon (Adjunct)

Professors Emeriti

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

Researchers, 2011-12

Researchers

Jean Berchem
Viktor Decyk
Weixing Ding
Mostafa El Alaoui
Samim Erhan
Gregory Kallemeyn
James Maggs
William Peebles
Vahe Peroomian
Terry Rhodes
R. Michael Rich
Robert Richard
Lothar Schmitz
David Schriver
Gil Travish
Steven Trentalange
Stephen Vincena
Hanguo Wang

Associate Researchers

Neal Crocker
Mikhail Ignatenko
Frank Tsung

Assistant Researchers

Gerard Andonian
William F. Bergerson
Carlos Camara
Carmen Constantin
Xiaoping Ding
Atsushi Fukasawa
Bernhard Hidding
Renkai Li
Zhiyuan Li
Liang Lin
Wei Lu
Sebastiaan Meenderink
Leonhard Meyer
Brian Naranjo
Emilija Pantic
Gregory Rakness
Wade Rellergert
Shoko Sakai
John Tonge
Shreekrishna Tripathi
Michail Tzoufras
Bart Van Compernolle
Gang Wang
Jeffrey Zweerink

NEW FACULTY

The department has recruited three assistant professors, all at the very top of their fields: Lindley Winslow, an expert in neutrino physics; Wes Campbell, a rising star in atomic-molecular-optical physics; and Ni Ni (starting July 2013), a skilled practitioner of experiments in quantum materials.

Wesley Campbell
Quantum Physics with Atoms and Molecules Group

Wes received his PhD in physics from Harvard in 2008 for his work on magnetic trapping of neutral molecules. After a brief postdoc term on the ACME collaboration experiment at Harvard to search for the possible electric dipole moment of the electron, he moved to the Joint Quantum Institute at the University of Maryland where he was a postdoc and assistant research scientist in Chris Monroe's trapped ion quantum information group. Wes joined the UCLA Physics and Astronomy faculty this summer and is setting up experiments with ultracold molecules and trapped ion quantum information processing.

Lindley Winslow
Neutrinos @ UCLA

Lindley received her PhD in physics from Berkeley in 2008. She worked with Stuart Freedman on the KamLAND neutrino experiment which provides one of the definitive measurements that neutrinos oscillate and therefore have mass. As a postdoc, she moved to MIT to work on the Double Chooz experiment with Janet Conrad. This experiment is one of three reactor neutrino experiments to release results in the last year on the last unknown parameter governing neutrino oscillations. She joined the faculty this summer and is pursuing a program of experiments to determine the Majorana nature of the neutrino. These experiments include CUORE with Prof. Huan Huang, KamLAND-Zen and an R&D effort to make quantum-dot-doped liquid scintillator.

Ralph Wuerker summer 2012

Dr. Ralph Wuerker
1929 - 2012

Dr. Ralph F. Wuerker, a pioneer in laser physics and holography, died on Monday, October 29, 2012, of multiple myeloma. He was 83.

A workbench physicist for nearly 50 years, his love of science led him from work with the first lasers and early holography in Southern California, to research using LIDAR and liquid mirror telescopes, to the study of the ionosphere and the aurora borealis in Alaska.

A graduate of Occidental College, Dr. Wuerker received his PhD from Stanford University in 1960. He spent 25 years working in the aerospace industry, primarily at TRW in Redondo Beach.

He continued his research as a chief investigator with UCLA's Plasma Physics Lab until his retirement in his mid-70s. His work led to more than 25 patents, most notably the patent on holographic interferometry, which he shares with two other researchers at TRW. He also did extensive research in mass spectrometry, superconducting plasma magnet systems and dust measurements in shock-wave environments, and he coauthored dozens of scientific papers.

In 1985, he built the holocamera that flew on Spacelab 3.

A longtime member of the American Physical Society and the American Optical Society, his work took him to such places as the missile test site at White Sands, N.M., the Oak Ridge National Laboratory in Tennessee, and to art restoration labs in Venice, Italy.

Born in Los Angeles in 1929, he attended L.A. High and raised a family with Joanne Scott, whom he married in 1953. They separated in 1976.

He later married Anne McCarrick and they moved to Westlake Village in 1990.

Ralph and Anne were avid backpackers, trekking the John Muir Trail, across England, through the Alps and also in Tibet.

He loved gardening, horses, history and body surfing. He was also a solar-electric enthusiast who proudly used his home photovoltaic's to charge his Gem electric car that he drove all over Westlake in his last years.

Published in Ventura County Star from November 3 to November 6, 2012

Ralph has been a great friend to the department by providing discretionary support. His generosity has allowed the Department Chair to meet financial needs as they arise to support students, faculty, and facility improvements. Ralph had an extensive career as a defense contractor working at GRW and as the Associate Director of the HIPAS (High Power Auroral Stimulation) Laboratory, a focused laser beam project within the UCLA Plasma Physics Lab. He was passionate about improving K-12 science education, and enjoyed sharing his enthusiasm for science with others. Our deepest sympathy goes out to his family.

"In spite of recent government stimulation efforts, physics has declined in popularity in our country due to a lack of job opportunities. For example, physics departments at several state colleges in Texas are in the process of closing due to low enrollments. To counteract these trends I support physics at UCLA. However, I earmark my contributions to projects that I believe are important or in need of encouragement."

Dr. Ralph Wuerker 2011

UCLA ALUMNI DAY

UCLA Alumni Day 2012 took place on campus on Saturday May 5, 2012. It was a great success! Over 1,800 UCLA alumni, their families and friends enjoyed a day of fun, tours, good food, lectures and more. We want to thank all our alumni who came and stopped by the P&A table at the Info Fair. As in the past years, our table and the hands-on experiments were a magnet for alumni and guests alike, also from other departments! You can view UCLA Alumni Day 2012 photos and past schedule at: **www.alumniday.ucla.edu/2012**

We look forward to seeing you at the next UCLA Alumni Day on **Saturday May 18, 2013**!
Save the date for another fun day and check regularly at the UCLA Alumni Day 2013 website for updates on the program:
http://alumniday.ucla.edu/2013/

STAY IN TOUCH

Our Alumni are important to us and we would like to keep in touch with you! Please update your contact and professional information here: **http://alumni.ucla.edu/physicsastroupdate**

@UCLA email for life!

As UCLA alumni you are eligible to have an @ucla.edu e-mail address forward indefinitely to another e-mail account of your choosing. Switch your e-mail accounts as many times as you want without having to send a change of address to your contacts. For more information see Free UCLA Lifetime Forwarding.

BRUINWORKS

BruinWorks is a free online networking site exclusively for UCLA alumni. It allows alumni to connect professionally and personally to a network of nearly 400,000 UCLA alumni.

- Network with other alumni from our department
- Search for jobs, résumés and other alumni
- Post a job or your own résumé
- Access a comprehensive UCLA alumni directory
- Explore a global calendar of UCLA events
- Stay in touch and network with interest and geographic alumni groups

Sign up for BruinWorks: Go to **www.bruinworks.com** and click on Log in. First-time users will be directed to sign up to establish an account. If you already have an account, you can log in with your e-mail address and password.

Professional Alumni Networking

Are you a UCLA alumnus/a in a business profession?

If you have more than seven years of experience, the Bruin Professionals UCLA alumni network is for you. With already nine regional chapters in California, BP is the premier UCLA group for well-established professionals to network and expand their business activities: bruinprofessionals.com

If you have less than seven years in business or are a recent graduate, Bruin Business Network is the alumni group for you. Check them out and join them on Facebook www.facebook.com/bruinbusinessnetwork and on their BruinWorks' group site via: **www.bruinworks.com**

Dinner for 12 Strangers

For more than 40 years this UCLA tradition has brought alumni, faculty and students from all generations together to enjoy good food and great conversation. An award-winning program, UCLA Dinners for 12 Strangers is emulated by hundreds of universities. In 2011, UCLA alumni hosted 290 dinners, involving more than 3,100 Bruins.

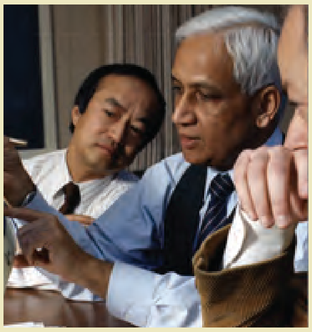
The 2013 dinners will be held on

Saturday, Feb. 23
Sunday, Feb. 24
Saturday, March 2

If you live in the Los Angeles area you can request your dinner guests to be students of our department! Please indicate so when you register online as a host. If you live anywhere in the world you can host a dinner for alumni **https://alumni.ucla.edu/events/dinners/host/signup.cfm**

DEPARTMENT NEWS

Professor Yaroslav Tserkovnyak was named a Simons Fellow in Theoretical Physics in the inaugural year of the program



Professor C. Kumar Patel has been inducted into the National Inventors Hall of Fame for his invention of the carbon dioxide laser.

Andrea Ghez, professor of Physics and Astronomy, was elected to the American Philosophical Society, the country's oldest learned society, which recognizes extraordinary achievements in science, letters and the arts. Since 1995, Ghez has used the W.M. Keck Observatory, which sits atop Hawaii's dormant Mauna Kea volcano and houses the two largest telescopes in the world, to study the rotational center of the Milky Way and the movement of hundreds of stars close to this galactic center.

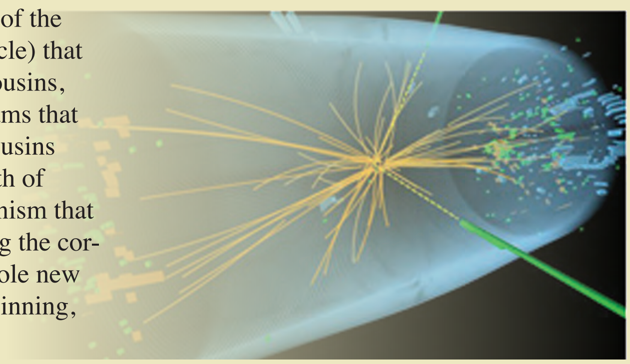
Professors Alexander Kusenko and Terry Tomboulis, each received an outstanding referee Award from American Physical Society, of which both of them are elected Fellows.

Professor Andrea Ghez received a Caltech Distinguished Alumni Award this year. The Distinguished Alumni Award is the highest honor the Institute bestows upon a graduate, and is in recognition of "a particular achievement of noteworthy value, a series of such achievements, or a career of noteworthy accomplishment."

Professor Roberto Peccei will receive the 2013 J.J. Sakurai prize in Elementary Particle Theory from the American Physical Society for the proposal of the elegant mechanism to resolve the famous problem of strong-CP violation which, in turn, led to the invention of axions, a subject of intense experimental and theoretical investigation for more than three decades. This prize is named for a distinguished UCLA physicist, but this represents the first time it has been awarded to a UCLA faculty member. We are delighted to welcome it home.

Professors Rene Ong and Vladimir Vasiliev have won a major NSF grant entitled "Development of a Novel Telescope for Very High-Energy Gamma-Ray Astrophysics." Although there are many collaborators on this project, UCLA is the lead and the telescope design comes from Vladimir's early pioneering efforts with this kind of optical design.

Physicists celebrated the almost certain detection of the Higgs subatomic particle (the so-called God particle) that existed for a fraction of a second. Prof. Robert Cousins, UCLA is a member of one of the two research teams that have been chasing the Higgs boson at CERN. Cousins stated that it also points the way toward a new path of scientific inquiry into the mass-generating mechanism that was never before possible. "I compare it to turning the corner and walking around a building -- there's a whole new set of things you can look at," he said. "It is a beginning, not an end."



DEPARTMENT NEWS

Research Corporation for Science Advancement (RCSA), America's oldest foundation devoted exclusively to science, announced that they were honoring Eric Hudson, assistant professor of physics and astronomy, UCLA, with a prestigious academic award, the Cottrell Scholar Award. The Award, one of 11 issued nationally this year, recognizes leaders in integrating science teaching and research at America's top research universities. Each recipient received a $75,000 grant and admission to an exclusive community of scholars, the Cottrell Scholars Collaborative."RCSA has named Hudson a 2012 Cottrell Scholar, based on his innovative research as well as his passion for teaching," said James M. Gentile, RCSA president and CEO. As an early-career teacher, Hudson was responsible for beginning UCLA's first course on atomic, molecular and optical physics (AMO). He has also won an undergraduate teaching award for his work. Hudson received the Cottrell Scholar Award (CSA) based on his peer-reviewed proposal that included both research and teaching projects.

Professor Steven Furlanetto was awarded the Helen B. Warner Prize from the American Astronomical Society for his theoretical work in the field of high-redshift cosmology, including groundbreaking work on the epoch of reionization and its observational signatures, and opening up new pathways to the study of reionization in the redshifted 21-cm hydrogen line. The Helen B. Warner Prize is awarded annually for a significant contribution to observational or theoretical astronomy during the five years preceding the award. It is given to an astronomer who has not attained 36 years of age in the year designated for the award or must be within eight years of receipt of their PhD degree.

"Funding Vital to U.S. Science Reputation."
UCLA Daily Bruin
by James Rosenzweig, Chair Physics & Astronomy

Professor Rosenzweig states in this article the fact that, despite bipartisan acknowledgment of the essential role of research and development, funding for physical science research in the US has remained stagnant for three decades.

UCLA has benefitted from strong growth in extramural research support with the impressive enhancement of the school's reputation. UCLA is second or third in the nation in research support received, and UCLA's physical sciences were rated ninth in the world according to an article in The Times of London. Excellence in graduate programs is directly tied to the success in obtaining research support, mainly from the federal government.

Rosenzweig states that in recent years there has been a reorganization of American science funding priorities, which has resulted in some outstanding research. On the other hand established researchers get recognition and funding, while young investigators at the start of their career struggle to get research funding.

Programs such as the Large Hadron Collider in Switzerland, and the International Thermonuclear Experimental Reactor project are both located in Europe. With U.S. support being so erratic, long term undertakings will work against this countries ability to host first class projects. Professor Rosenzweig fears with looming budget cuts that the future of U.S. science would destroy the U.S. standing in science producing lasting harm. Students and post-doctoral researchers that today throw their lot in with UCLA, will simply choose to go elsewhere to find more welcoming and stable conditions. The scientific community and concerned citizens have to stand-up to needless damage of our economic and intellectual futures.

Read full article on-line at: **http://www.dailybruin.com/article/2012/11/funding-vital-to-us-science-reputation.**

Professor William Newman has been invited to deliver the Yuval Ne'eman Distinguished Lectures in Geophysics Atmospheric and Space Sciences (Endowed by Raymond and Beverly Sackler) at Tel-Aviv University.

OUTREACH

UCLA ASTRONOMY LIFE!

"UCLA's astronomy outreach program, Astronomy Live!, has had a hugely successful third year of graduate student led community outreach, and our fourth year is continuing this success. During the 2011-2012 school year, we visited five different elementary schools throughout Los Angeles county and coordinated a visit to UCLA for ~100 students from Anatola Elementary in Van Nuys. These visits have been hugely successful, and we have been requested for more visits in the future. Outreach events are initiated by requests from the teachers, through our webpage, and from our department staff directly. We also participated in the STAR Eco Station Earth Day.

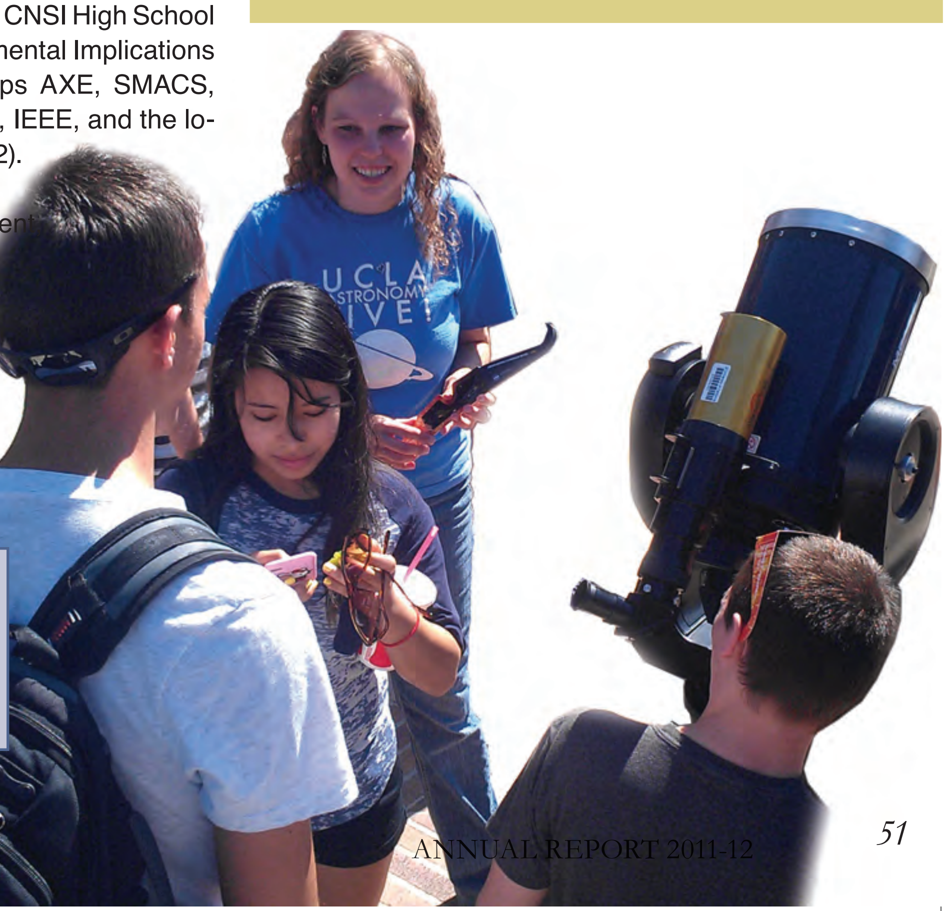
This June Astronomy Live! and the Institute for Planets and Exoplanets (iPLEX) hosted a Venus Transit Viewing on campus near Royce Hall, which attracted over 1,000 participants. Eclipse glasses and several solar telescopes were available for viewing Venus transiting in front of the Sun. This was also part of a global effort run by the University of Chile to collect data for schools and student groups to determine the distance to our Sun. Results were published in "The Hetu'u Global Network: Measuring the Distance to the Sun Using the June 5th/6th Transit of Venus" (Faherty et al. 2012).

On November 13, 2011 and November 10, 2012 we hosted the third and fourth annual Exploring Your Universe. This free public event included talks, demonstrations, exhibits, and hands-on activities from the Departments of Physics and Astronomy, Earth and Space Sciences, Atmospheric and Oceanic Sciences, Chemistry, the CNSI High School NanoScience Program, and the Center for Environmental Implications of Nanotechnology, as well as new student groups AXE, SMACS, ESSN, and SPIE (added in 2011) along with BEAM, IEEE, and the local science group STAR Ecostation (added in 2012). The event has grown dramatically, and this year we had between 2500 and 3000 visitors at the event, nearly three times as the inaugural year. Visitors came from all of the Los Angeles area, including many students, staff and faculty of local schools and UCLA.

Free weekly planetarium shows are also provided Wednesday nights by the astronomy graduate students, and outreach activities can be coordinated along with the planetarium for larger groups of students.

Visit the planetarium website for more information:

http://www.astro.ucla.edu/planetarium/



FOR INFORMATION ON THIS EVENT AND OTHER OUTREACH OPPORTUNITIES VISIT THE WEBSITE:

http://www.astro.ucla/edu/~outreach/

CREATING AND UPGRADING TEACHING LABORATORIES

Over the past year, Academic Affairs has initiated a complete review and overhaul of the Department's teaching laboratories, beginning with the upper division labs. Alumni often recall fondly the countless hours they spent in these labs, and the first hands-on contact with physics experiments they enjoyed there. Indeed, the teaching lab set-up at UCLA is distinct from that at most other universities, and quite unique in that respect. Each lab is tightly knit into the research group of the each subject. In addition to the classics, namely 180 Astro, 180A Nuclear, 180C Condensed Matter, 180D Acoustics, 180E Plasma, 180F High Energy Particles and Cosmic Rays, we now also have a new 180G Biophysics lab course created recently by Dolores Bozovic. Furthermore, in 2012 Eric Hudson will start developing a new 180Q Atomic and Molecular Physics (AMO) lab, where students will be able to look at single ultra-cold atoms and molecular ions.

Academic Affairs also started reviewing the teaching laboratories associated with the 6-series, which is the Department's one-year-long physics course sequence for life-science majors. Many of the experiments appear to be in urgent need of an overhaul, as some no longer operate reliably, while others are simply outdated. The Department is committed to providing a thorough upgrade for the 6-series labs, and will start implementing those in 2013.

Eric D'Hoker
Vice-Chair for Academic Affairs

WOMEN IN SCIENCE

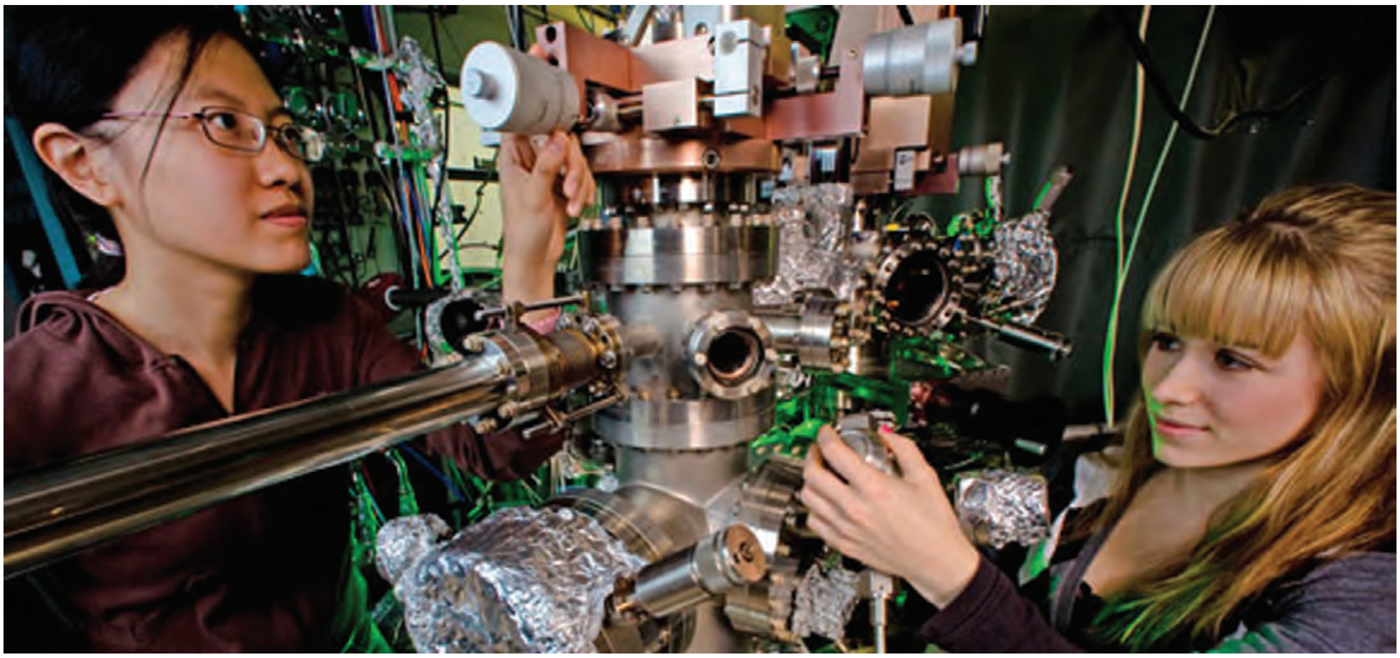
Physics & Astronomy has a major commitment to faculty and student diversity. Achieving diversity means creating a supportive campus environment for everyone, inclusive of women and other historically underrepresented groups, as outlined by federal affirmative action guidelines.

Women represent 50% of our national population and nearly 50% of all doctorates awarded annually. The intersection of women's issues with those related to race and ethnicity, as well as other characteristics such as sexual orientation, disability, and religion, is a key component of diversity.

Academic leadership on campus is focused on increasing and supporting diversity among students, faculty and staff through the work of the Council on Diversity & Inclusion, which is currently working on refining UCLA's strategic plan for diversity to assure accountability and methods of assessing progress.

The Office for Faculty Diversity & Development is supporting a culture of inclusion through faculty and chair development programs, programs to enhance the graduate pipeline, increasing access to work/life resources and more robust procedures, training and follow-up related to faculty searches.

There are several resource references below to explore information about opportunities for women in Physics & Astronomy.



PhD students work on the X-ray portion of a light source at SLAC National Accelerator Laboratory.
Photo Courtesy: SLAC National Accelerator Laboratory.

SOME RESOURCES:

Fermi Lab "Women in Physics:" .... http://www.fnal.gov/pub/diversity/women_in_physics/index.shtml
Association for Women in Science: .... http://www.awis.org
American Physical Society : .... http://www.aps.org/programs/women/index.cfm
Contributions of 20th Century Women to Physics: ...... http://cwp.library.ucla.edu

Bachelor of Science in Physics

Matthew Joseph Adams
James Matthew Allen
Taylor Anthony Barrella
Trenton John Beals
Nestor Samuel Carrenza
Thomas Philip Darlington
Christopher Ross Davidson
Ian Spencer Drayer
Ritika Dusad
Midhat Farooq
Bryce Flores Flor
Sabrina Ellen Fong
Nicholas Andres Frega
Pruthvirajsinh Kishorsinh Gohil
Christopher Craig Haddock
Chen Huang
Kelly M. Humphrey
Douglas Stuart James
Sarah Khan
Bum Sang Khim
Rekha Victoria King
Paul Daniel Kirkpatrick
Calvin Lau
Shijia Liu
Jared Joseph Lodico
Daniel Marcus Lombardo
Jeffrey William Lutz
Scott Michael Mills
Sheryll Margaret Nery
Anh Nguyen
Youna Park
Eric Michael Allan Robinson
Jacob Alexander Schwartz
Brian Shevitski
Brian J. Springer
Attila Szilargi
Francisco Javier Toro
Alvin Yat-Kun Tung
Tyler Carroll Underwood
Joel Elwin Williams

Bachelor of Arts in Physics

Kevin Tristan Bryant
Seyed Ali Mousavi
Yuan Wan
Lucas Allen Wukmer
Xin Zhang

Biophysics

Rebecca Gean Brown
Thomas Richard Brown
Jessica Janelle Chew
Peter Zhongxi Du
James Michael Kelvin
Amit Kumar Koduri
Marcos Francisco Nunez
Duy Stepehn Luu Quoc Phan
Sundipta Dharanipragada Rao

Astrophysics

Jessica Lee Asbell
Josepha Marie Baker
Julius Mark Berezin
Mike Eun Hyuk Choe
David Shin Park
Eylene Rachel Pirez
August Edward Pohl
Michael Wesley Sheridan
Rafael Eleazar Trujillo

AWARDS

Abelmann-Rudnick awards

UNDERGRADUATE STUDENTS
Daniel M. Hill
Alan D. Tran

GRADUATE STUDENTS
Kristin Kulas
Gregory Mace

Winstein Award

Nicholas Frontiere

Doctor of Philosophy
Astronomy

Christopher Crockett
Advisor: James Larkin

Ian Crossfield
Advisor: Brad Hansen

Kevin Hainline
Advisor: Alice Shapley

Katherine Kornei
Advisor: Alice Shapley

Sylvana Yelda
Advisor: Andrea Ghez

Doctor of Philosophy

Physics

Diego Assencio
Advisor: Giovanni Zocchi & Joseph Teran (Math)

David Auerbach
Advisor: Troy Carter

Jonathan Bergknoff
Advisor: Joseph Rudnick

Nassim Bozorgnia
Advisor: Graciela Gelmini

Ramon Cendejas
Advisor: Huan Huang

Xi Cheng
Advisor: Terry Tomboulis

Christopher Cooper
Advisor: Walter Gekelman

Tristan Dennen
Advisor: Zvi Bern

Jonghyoun Eun
Advisor: Sudip Chakravarty

Andrew Forrester
Advisor: Gary Williams

Nathaniel Hamlin
Advisor: William Newman

Jon Hillesheim
Advisor: Troy Carter

Silas Hoffman
Advisor: Yaroslav Tserkovnyak

Matthew House
Advisor: Hong-Wen Jiang

Gabriel Marcus
Advisor: James Rosenzweig

Matthew Mecklenburg
Advisor: B. Chris Regan

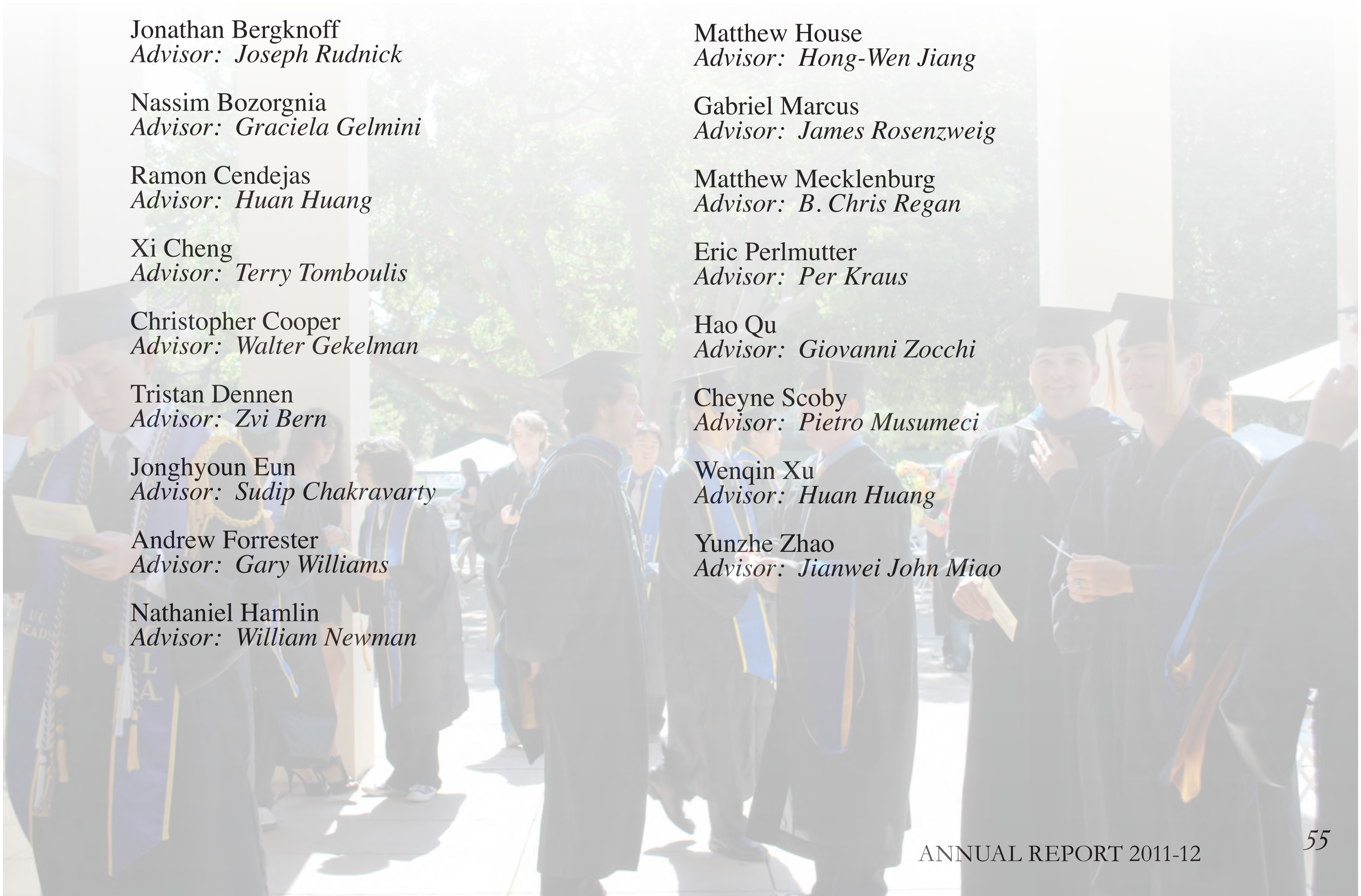
Eric Perlmutter
Advisor: Per Kraus

Hao Qu
Advisor: Giovanni Zocchi

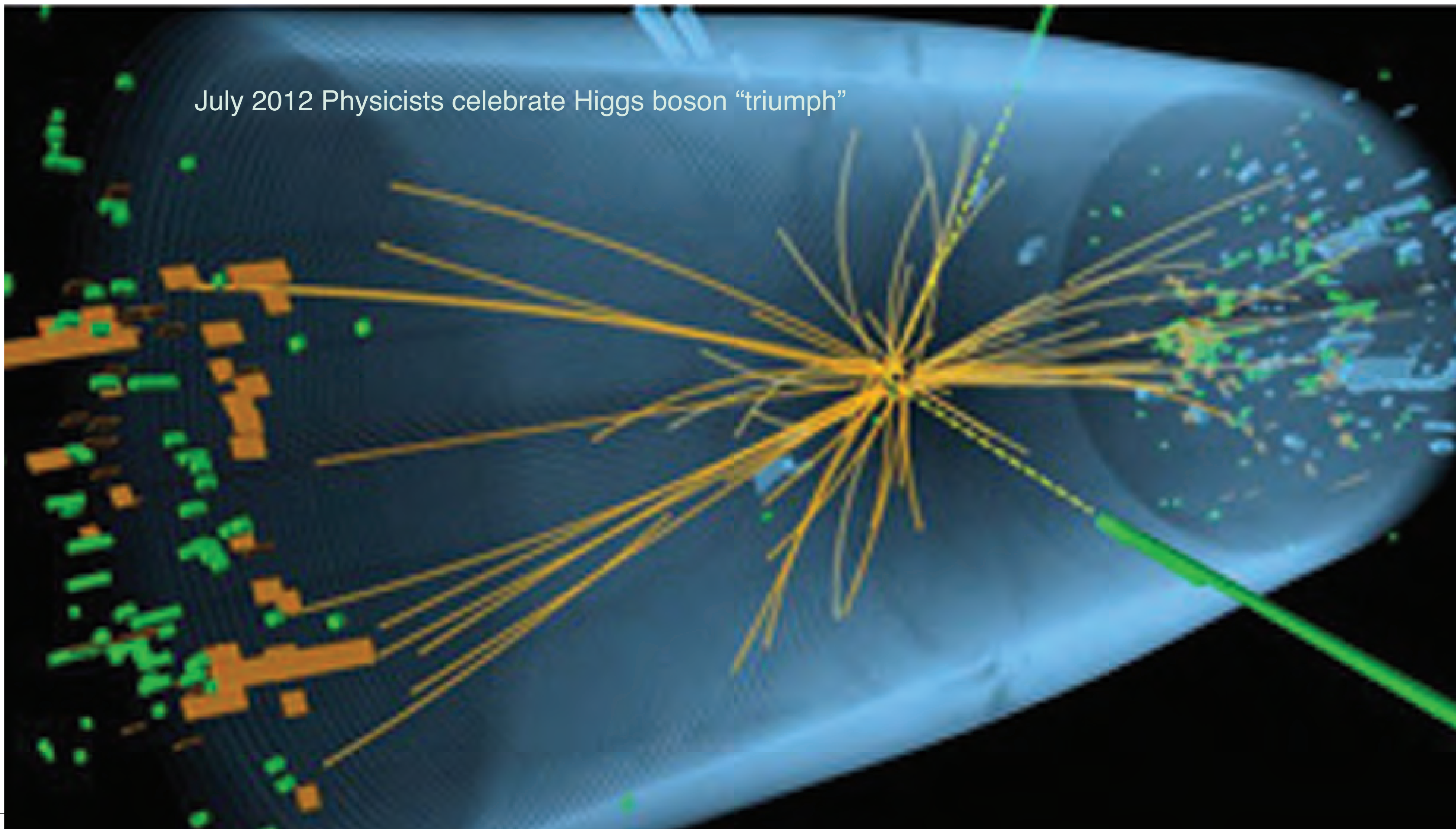
Cheyne Scoby
Advisor: Pietro Musumeci

Wenqin Xu
Advisor: Huan Huang

Yunzhe Zhao
Advisor: Jianwei John Miao



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



July 2012 Physicists celebrate Higgs boson “triumph”