INSIDE

Excitement at the Large Hadron Collider—A Behind the Scenes Report
First Measurements of AntiHydrogen
Nitrogen Vacancy Centers in Diamond
Topological Insulators—The New Superstars of Condensed Matter Physics
Alumni News and more!
Cover:
Clockwise from top left: evidence of Higgs events at the Large Hadron Collider (page 4); nitrogen vacancy centers in a diamond lattice (page 10); theorist Joel Moore discusses topological insulators (page 12); anti-hydrogen trap (page 8).
Features

4  Excitement Reigns at the Large Hadron Collider
   A behind-the-scenes report from Berkeley physicists on observations of the Higgs boson and the continuing search for new physics
   Experimental particle physicist Beate Heinemann shares details about her role in the ATLAS project at CERN.

8  First Measurements of AntiHydrogen
   Berkeley physicists catch, trap, and probe anti-atoms
   Experimental physicist Joel Fajans and theoretical physicist Jonathan Wurtele help lead CERN’s ALPHA project into new frontiers of research with antimatter.

10 Nitrogen Vacancy Centers in Diamond
   Flaws in diamond crystals spark a new revolution in physics and technology
   Physicist Dmitry Budker’s research group explores new roles for diamond in atomic physics research and in development of high-precision nanoscale sensors.

12 Topological Insulators
   The New Superstars of Condensed Matter Physics
   Theoretical physicist Joel Moore marries math and physics to discover an entirely new class of materials.

Departments

2  Notes from the Chair
15  Department News
28  In Memory
31  Physics in the Media
35  Undergraduate Affairs
38  Graduate Affairs
44  Alumni Affairs
NOTES FROM THE CHAIR

October 25, 2012

DEAR ALUMNI AND FRIENDS,

It is hard to believe, but this is my sixth year as Chair of this amazing department. This newsletter will describe remarkable events from the past year, including another Nobel Prize, the likely discovery of the Higgs Boson, and other awards and scientific breakthroughs.

In this letter, I want to tell you about the just-completed once-a-decade Academic Program Review (APR). Physics faculty, students (both undergraduate and graduate) and staff devoted much energy and time over two years to this strategic planning exercise, which culminated in a 423 page self-study document (1) and a review by a very distinguished external committee. This exercise allowed us to consider our strengths and our weaknesses and to create a strategic plan for the next 10 years. I am delighted to share with you some of the findings.

The Department is arguably stronger than it has been in decades. The National Research Council (NRC) tied Berkeley with Harvard as the top Physics programs in the country. Three Nobel Prizes have been awarded to faculty and alums in 7 years, we have hired great young faculty who have been recognized with top young faculty prizes, and our student group Compass won a 2012 American Physical Society Award for Improving Undergraduate Physics Education. We have made tremendous strides in the areas of faculty hiring, infrastructure improvements, leveraging on- and off-campus partnerships, and fund raising. Quoting from the external review committee: “In the eight to nine years since the previous external review, the Physics Department has renewed itself with strong support from the University. Today, it ranks as one of the best, possibly even the top Physics Department in the world, with strength and vitality across a broad range of physics subfields.”

The Department is poised at a unique time in its history. Several subfields of physics are entering particularly exciting eras of discovery, at a time when the Department will be hiring many new faculty. The goal is that this department should be the best place in the world to work and study for the best students, post-docs, and faculty. It should be known as a place where colleagues welcome students and collaborators into their labs and their offices, with time to discuss common research interests and ideas. Collaborations, both within the department and between disciplines, will flourish as a result of new interaction spaces, research-driven centers and institutes, resulting in ground-breaking discoveries. Over the next decade, we envision growth in three research areas: Physics of the Universe, Quantum Scale Physics, and Biophysics, and some key improvements in our undergraduate and graduate programs.

Physics of the Universe encompasses cosmology, particle physics, nuclear physics, and astrophysics, where some of the most exciting physics is occurring at the boundaries between these sub-fields. This field, exemplified by the discoveries of not-yet understood dark matter, dark energy, and neutrino oscillations, the search for and possible discovery of the Higgs boson, gravitational waves, and for physics beyond the Standard Model, is concerned with measuring and understanding the evolution of the Universe, and the laws that govern fundamental particles and their interactions. One of our newest hires, for example, Gabriel Orebi Gann, does research on neutrino physics and dark matter searches. The science listed above represents the exciting research areas where we will be looking for new faculty.

Physics at the Quantum Scale describes phenomena that emerge from the interactions of electrons, nuclei, and photons, forming the basis of both condensed matter and AMO (atomic, molecular, and optical) physics, and the increasing areas of overlap between these fields. There are direct connections to applications including energy storage and harvesting, information technology, and sensors. One of Berkeley’s greatest strengths in this sub-field is the close connection between experimentalists and theorists, and across the different departments and institutes on campus and LBNL. Our most recent faculty hire, James Analytis, fills in a key missing component: design, synthesis, and understanding of quantum materials. Future hires are similarly anticipated to broaden and strengthen the Department, leading to breakthroughs in our understanding of quantum matter and creating new technologies.

UC Berkeley is also a powerhouse in Biosciences, and Biophysics is a key component. The Department’s traditional strength in molecular biophysics, with a single faculty member in neuroscience, will grow in the areas of cellular and systems biophysics, starting with our most recent hire, an evolutionary biophysicist, Oskar Hallatschek, who starts in 2013.

Our undergraduate and graduate programs also were closely examined in the APR self-study. Despite our top ranking in the NRC assessment, there are still several
graduate student issues we identified and will be addressing. Our undergraduate program is also one of the best; we annually award 75-90 Bachelor’s degrees, the highest in the nation. Approximately half of our undergraduates get involved in research and continue to graduate school in physics or related disciplines. A significant fraction of the others get jobs in industry, and the rest take other career paths. Our goal is to support all of these students.

We recently completed a significant study of the goals of the major, working with campus on the Undergraduate Student Learning Initiative, and are part way through a major revamp and infrastructure upgrade of our capstone class, Physics 111 Advanced Lab (page 36). We prioritized several areas for further study and improvement.

Along with most of the country, we also recognize the need to address issues of diversity in the faculty, graduate, and undergraduate populations in physics; our goal is to create a welcoming environment for all genders, ethnicities, and sexual orientations, and to improve the representation of under-represented minorities in Physics by encouraging applicants from diverse backgrounds to apply to Berkeley and by creating a welcoming environment which supports all of our students and faculty. Finally, reaching out to the public to share the excitement we feel about Physics and to help them understand the science behind major issues facing the country is a priority for the Department in general.

Turning to infrastructure, the Department’s facilities and research infrastructure have improved significantly since the 2003 APR and external review. The remodel and seismic upgrade of Old Le Conte greatly improved the environment for faculty from several fields, as did the $11M campus-funded Birge Infrastructure project. Most notably, the long-awaited Campbell Hall rebuild is happening!

This is a hugely positive step forward for the Department that will provide some excellent new lab space and shared astronomy/astrophysics spaces, and lessen the space pressures in the other Physics buildings. Notable success by the faculty in obtaining two significant infrastructure improvement grants (from NIST and NSF) and a number of major research instrumentation grants from NSF allowed us to leverage the available campus and state funding, thus leaving us optimistic about our experimental facilities. Remaining issues center on “New” Le Conte Hall, now our oldest building – built 60 years ago, with little to no infrastructure improvements since then.

I conclude this letter with a grand picture of where we would like to be in ten years. The next decade will be one of growth: strengthening some existing structures and creating new ones; cultivating an atmosphere of collaboration; building new labs and new interaction spaces to support the research and teaching that lead to ground-breaking discoveries in our understanding of the Universe and its components; training and mentoring of the next generation of students; and communication of physics to the public.

Our vision includes:

- the newly envisioned Berkeley Particle Physics Center (page 7), which forms the third leg of a “tripod” whose other legs are the Berkeley Center for Theoretical Physics and the Berkeley Center for Cosmological Physics. Along with faculty and colleagues in Astronomy, Space Sciences Lab and LBNL, these centers will create an overarching Institute for the Study of the Physics of the Universe that enables shared research goals and infrastructure.

- the creation of a cross-campus Institute for Science and Engineering at the Quantum Scale, with funds to support seed projects that lead the way to future science and technology.

- a re-energized Biosciences community with strong Biophysics participation to complete the integration of the physical, biological, and bioengineering parts of Biosciences, taking Berkeley’s current pre-eminence in Bioscience to an even higher level.

- a Center for Teaching Physical Sciences, to coordinate and expand existing activities within the Physical Sciences and provide a nationally visible focus for Berkeley’s efforts in this area.

The talent for all this – faculty and students – already exists in the department and on campus. What is needed are institutional and financial support. I look forward to watching these initiatives, centers, and institutes unfold, and I invite you to take part in the process.

I hope you enjoy reading about the exciting research and activities under way in the Department of Physics. With thanks for another year of amazing discoveries, tremendous teaching, and deeply appreciated contributions from our Friends of Physics,

—Frances Hellman

Frances Hellman has been a member of the physics faculty since 2004, and was named Chair in 2007. Her research is in experimental condensed matter and materials physics.
Excitement Reigns at the Large Hadron Collider

A behind-the-scenes report from Berkeley physicists on observations of the Higgs boson and the continuing search for new physics

The elusive Higgs boson – long touted by theorists as the reason matter has mass – has at last been glimpsed. News of the sighting came on the Fourth of July, when researchers at CERN gathered in front of the press at 9:00 am Geneva time to announce that “clear signs of a new particle” had been observed at the Large Hadron Collider (LHC).

It was midnight in California. A large group of scientists from the UC Berkeley Department of Physics and Lawrence Berkeley National Laboratory (LBNL) were gathered to watch a live telecast of the CERN press conference in the seminar room in the Berkeley Center for Theoretical Physics. All of them have central roles in the construction and operation of ATLAS, one of the two detector experiments that made the discovery, and are deeply involved in gathering, analyzing, and theorizing about the unprecedented volume of data ATLAS produces.

The news was just what everyone had been hoping for. Tantalizing spikes in data from both ATLAS and the other detector experiment, CMS, indicated a new particle with a mass of 125-126 GeV, well within the range predicted for a Higgs boson. The ATLAS findings, submitted for publication to Physics Letters B on July 31, describe “the discovery of a new particle consistent with the Higgs boson.” Papers from both ATLAS and CMS passed peer review in September.

Beate Heinemann, a physics professor at UC Berkeley and a research scientist at LBNL, has been a member of the ATLAS collaboration since 2007. In response to the July 4 announcement, she said, “This particle is unlike any other elementary particle we know. It’s truly a discovery. By making measurements of its decay rates we can find out if this is indeed the Higgs boson that generates the masses of both matter particles and of electroweak bosons as predicted by the theory.”

The Higgs boson was initially proposed by theorists in 1964 as the ‘missing piece’ of the Standard Model, the predominant theory of particle physics that has so far been proven out by accelerator experiments. The Higgs represents an energy field, known as the Higgs field, which permeates the entire cosmos. It’s often compared to a viscous fluid, like honey or molasses, which slows subatomic particles as they move through it. More massive particles, such as top quarks, move more slowly through the Higgs field. Lighter particles, including electrons, move through it quickly. Particles that can move through the field without being affected, such as photons, have no mass.

Excitement Reigns at the Large Hadron Collider

The news was just what everyone had been hoping for. Tantalizing spikes in data from both ATLAS and the other detector experiment, CMS, indicated a new particle with a mass of 125-126 GeV, well within the range predicted for a Higgs boson.

WHICH HIGGS IS IT?

The Standard Model remains the best theory for explaining the behavior of matter and energy at the subatomic scale, but it leaves many mysteries unsolved. It doesn’t explain dark matter, for instance, or why gravity is so much weaker than the other basic forces.
Over the past few decades, physicists have been busy formulating alternative theories that might answer these questions. Virtually all of these theories have their own Higgs particles, with masses and quantum numbers that differ from those of the Standard Model (SM) Higgs. As an example, at least five different Higgs bosons and two Higgs fields are called for in Supersymmetry – a theory that proposes every subatomic particle has a partner particle. Supersymmetry easily explains dark matter and resolves discrepancies between the strength of gravity and the other subatomic forces.

In the data from both ATLAS and CMS, “we see a particle that looks very much like the Higgs boson, but we cannot yet confirm that it is the Higgs boson,” Heinemann cautions, “and if it is, whether or not it’s the Higgs boson in its most simple form – the version that would be consistent with the Standard Model.”

Confirming which kind of Higgs we’ve glimpsed requires examining it much more closely. In particular, says Heinemann, we need to determine its quantum numbers, including its spin and parity, and measure the ratios of its decay rates.

“The name ‘spin’ comes from the fact that most quantum particles rotate,” Heinemann explains, “and it’s the speed at which they rotate that defines this property. The SM Higgs boson should have a spin of zero, which means it does not rotate. Other theories call for a spin of 2.” So far, the data have not ruled out either possibility.

“Other quantum properties we need to measure are even more technical,” Heinemann adds. “We need to determine the parity of the new particle, which, if it’s the SM Higgs, should be even. But there are theories that say it could be odd.”

The particle’s decay modes also need to be pinned down. “The Higgs boson is expected to decay in a number of different ways,” she continues. “Currently, we see the new particle mostly in two of its decay modes – photon decay and Z-boson decay.” But there are two very important decay modes that haven’t yet been observed: tau decay and b-quark decay.

Photons and Z particles are bosons – ‘force’ particles that mediate interactions among fermions. Tau and b particles are fermions – ‘matter’ particles, such as electrons and protons, that act on each other by exchanging bosons. “At this moment we know mostly how the new particle couples to bosons,” Heinemann notes. “Once we have observations of the tau and b-quark decay modes, we’ll find out much more directly how it couples to fermions.”

“This is important,” she adds, “because the Standard Model predicts very precisely how strongly the Higgs boson couples to the b-quark, versus the tau lepton, versus the top quark. The predictions are directly related to the mass of each particle. By directly measuring the new particle’s decay modes, we can find out exactly how it couples to mass.”

When will we know whether the new particle that emerged from the LHC this year belongs to the Standard Model? Heinemann tells us the investigation will likely continue for another decade. “Demonstrating that the Higgs boson coupling is related to the mass of the new particle will require at least 10 times more data than we will have by the end of this year,” she reports. “However, demonstrating that it has no spin may already be possible with this year’s data.”

The ATLAS collaboration hopes to announce initial data on tau and b-quark decay in November 2012. In the spring of 2013, they expect to have completed their analysis of all data acquired at the LHC during the current run, which ends in December.

**RUN-UP TO DISCOVERY**

Getting to this point has required enormous effort from thousands of scientists all over the world who are collaborating on the ATLAS project. Heinemann’s contributions included serving a two-year stint as Data Preparation Coordinator, from Sept 2009 to October 2011. In that role, she and her team pioneered all the
procedures used for organizing, validating, and prioritizing an unprecedented volume of data.

The ATLAS detector is half the size of the Notre Dame Cathedral in Paris and weighs in at 7000 tons. Its cylindrical shape is composed of three concentric layers of detector equipment that envelope one of the proton-proton collision points in the collider beam at the LHC. Debris from collisions radiates outward, encountering each layer of the detector in turn.

Elements within each detector layer record millions of encounters every second. “We have nearly 100 million individual detector elements that can be read out separately,” Heinemann explains. “The Pixel detector alone, the layer closest to the collision, has the capacity to record 20 million events per second. We actually record the 400 we find most interesting. What we record are hits within each detector layer – we don’t see the trajectory of the debris particles directly.” Software she and her colleagues have developed reconstructs the path of a particle as it moves through the layers.

In 2010, the volume of data gathered by ATLAS reached a total of 40 inverse picobarns (pb⁻¹) – a unit of area physicists use to measure the volume of data emerging from a collider experiment. In 2011, data volume increased more than 100-fold, to 5000 pb⁻¹. In 2012, when energies in the collider rose to their present maximum of 8 TeV, the volume increased even further, to about 25,000 pb⁻¹, surpassing all previous collider experiments.

Heinemann and her team had to work quickly, first calibrating the detector to a precision of ten micrometers, then developing procedures for rapidly reconstructing all the data in preparation for physics analyses.

“There is a lot of technical work that needs to be done to facilitate the analyses,” Heinemann explains. “We assess if the data are of good quality, because sometimes it happens that elements of the detector don’t work. All of this information has to be propagated quickly, to avoid any confusion.”

“It was very exciting,” she says, “because within just two years we went from no data at all to really a very interesting amount with which you could do a lot of physics. Sometimes we show data at a conference that were taken less than a week before. We’re very keen on getting the data out as quickly as possible.” As an example, the final data set included in the July 4 CERN announcement was taken just two weeks earlier.

**INITIAL MEASUREMENTS**

Though the 2010 data set was comparatively small, it gave research teams a chance to become familiar with the most complex machine ever built by human hands. That process involved measuring collision events that are already well understood, to learn what they look like at the higher energies of the LHC. “It’s important to measure all these processes at a new energy,” Heinemann notes. “With the small data set, the entire collaboration put a lot of effort into making basic measurements of known processes.”

As part of that endeavor, and in addition to her data preparation responsibilities, Heinemann worked with Berkeley graduate student Lauren Tompkins to measure how often two protons actually interact with each other at the LHC. “We call this a cross-section,” Heinemann explains. “It’s a very fundamental measurement. Before the LHC went online, predictions varied by 20 to 30 percent. We were the first to make an accurate measurement.”

As part of that endeavor, and in addition to her data preparation responsibilities, Heinemann worked with Berkeley graduate student Lauren Tompkins to measure how often two protons actually interact with each other at the LHC. “We call this a cross-section,” Heinemann explains. “It’s a very fundamental measurement. Before the LHC went online, predictions varied by 20 to 30 percent. We were the first to make an accurate measurement.”

With another Berkeley graduate student, Max Scherzer, Heinemann also measured the cross-section for a particle known as the upsilon, first discovered in 1977. “Using the 2010 data,” she says, “we demonstrated we were able to measure known processes and get reasonable answers that agree with theoretical calculations. Then in 2011, with the much bigger data set, searches became much more exciting.” That’s when the search for the Higgs, as well as other exotic particles, began in earnest.

The Higgs boson predicted by the Standard Model is electrically neutral. Among its decay products would be two muons – one with a positive charge and one with a negative charge. “It would never decay into two muons of the same charge,” Heinemann asserts. In collaboration with Berkeley graduate student Louise Skinnari and postdoctoral fellow Martina Hurwitz, she is actively...
looking for collisions that produce two muons of the same charge, which would point to a Higgs that belongs to a new theory.

“Also,” Heinemann adds, “there are so-called Higgs triplet models which are helpful to explain, for instance, the fact that there are neutrino oscillations, and other phenomena that present problems for the Standard Model. So, if we found these muons, we would also help solve some of the problems we still have in our mainstream theory.”

THE SEARCH FOR NEW PHYSICS CONTINUES

Will the Standard Model retain its authority as the best theory for explaining the fundamental laws of matter and energy? If the SM Higgs is the one that's been found, it probably means the Standard Model is indeed the last word. Or, will new physics emerge? Will theories involving Supersymmetry, extra dimensions, or other tantalizing ideas begin to take precedence? So far, data on the new particle have not completely ruled out any of the theories that have been posited as alternatives to the Standard Model.

Though analysis of the data gathered by ATLAS during the current LHC run should be available by next spring, final answers to these questions will most likely have to wait until after a scheduled shutdown, set to begin in January. The pause will permit upgrades that increase collision energies from the current 8 TeV to a maximum of 14 TeV. Operation is expected to resume early in 2015. Once the LHC comes back online, Heinemann predicts, “there is a great chance that the data will surprise us and another discovery will be made.”

In the meantime, she has been appointed for another two-year special assignment at CERN. In March 2013, Heinemann becomes Deputy Spokesperson for the ATLAS project. “It’s a big job,” she acknowledges, “but it will be fun.” Developments are sure to be posted on the Department of Physics website. Stay tuned.

NEW PARTICLE PHYSICS CENTER AT BERKELEY

The Department of Physics is in the very early stages of establishing a new research center, the Berkeley Particle Physics Center (BPPC). The mission of the BPPC is to bring together experimentalists and theorists to improve the understanding of the most fundamental particles and their interactions. Members of the new center will include distinguished experimental and theoretical physicists from campus and from Lawrence Berkeley National Laboratory who conduct research that aims to understand the origin of mass, the origin of dark matter, and the reason for the large matter/antimatter asymmetry in the universe.

“BPPC’s goal is to bring together experimentalists and theorists working on these problems via workshops and visitor programs,” says physics professor Beate Heinemann. “In particular, we hope to create a forum of discussion among different areas of inquiry, such as searches for supersymmetry at the Large Hadron Collider and searches for dark matter in underground laboratories.” In addition, a graduate student fellowship in the field of experimental particle physics will be awarded each year. An outreach program for teachers and high school students is also planned.

The new center, in concert with the existing Berkeley Center for Theoretical Physics (BCTP) and Berkeley Center for Cosmological Physics (BCCP), “will create a ‘tripod’ of centers that are scientifically distinct,” adds Frances Hellman, Chair of the Department of Physics, “but with overlapping interests at their boundaries. Together, they form a coherent approach to the overarching theme of the Study of the Universe.”
Antimatter is one of the big puzzles of modern physics. The universe contains very little of it. Yet all known theoretical models of the Big Bang tell us that almost equal amounts of matter and antimatter were created when the universe was born. We know that matter and antimatter don’t coexist—they annihilate in a burst of energy the instant they come into contact. If that’s so, why didn’t everything annihilate soon after the Big Bang? How did ordinary matter gain the upper hand?

“Physicists call this the baryogenesis problem,” says Berkeley physics professor Joel Fajans. “The conservation of baryon numbers is a symmetry principle in physics that says equal amounts of matter and antimatter must be created at the same time. We know of very few routes by which that symmetry could be broken to create more of one than the other. And those routes cannot explain what we see, which is essentially a complete lack of antimatter in the universe.”

According to every measure made so far, matter and antimatter are perfectly symmetrical opposites—identical except for having opposite electrical charges. That means a world made of antimatter would obey exactly the same fundamental laws of physics as the ordinary matter world we live in. Or would it? If we could measure the fundamental properties of antimatter as precisely as we can measure ordinary matter, would we find differences that could explain the triumph of matter over antimatter?

ALPHA, the Antihydrogen Laser Physics Apparatus collaboration at CERN, has set out to find the answer. ALPHA’s goal is to measure the internal properties of anti-hydrogen atoms and compare them with atoms of ordinary hydrogen, to find out if there are undetected asymmetries between the two. “Specifically, we want to look at the spectral properties of anti-atoms,” says Fajans, “and their gravitational characteristics as well.” Fajans, an experimental physicist, is a founding member of ALPHA and a member of the Accelerator and Fusion Research Division (AFRD) at Lawrence Berkeley National Laboratory (LBNL).

“The charge conjugation/parity/time reversal (CPT) theorem, a crucial part of the foundation of the Standard Model of elementary particles and their interactions, demands that hydrogen and antihydrogen have the same spectrum,” adds Berkeley physics professor Jonathan Wurtele. “Antihydrogen is of interest for use in a precision test of nature’s fundamental symmetries.” Wurtele, a theoretical plasma physicist and longtime member of ALPHA, is also a member of AFRD at LBNL.

Antimatter particles are created in high-energy particle collisions. Examples include the bombardment of earth’s atmosphere by cosmic rays as well as collisions in particle accelerators. Positrons can be produced readily enough to be used in medicine, as in positron emission tomography (PET) scanning.

Anti-atoms, on the other hand, have to be coaxed into existence. Anti-hydrogen (anti-H) atoms were first produced experimentally in 1995, but were not trapped. The ALPHA collaboration has taken on the challenge of not only creating and trapping anti-H atoms, but also holding onto them long enough to measure them. Contributions made by the Fajans and Wurtele research groups continue to be central to this effort.

**TRAPPING AND MEASURING ANTI-ATOMS**

In 2010, the ALPHA team made headlines by becoming the first to trap and hold anti-atoms. They managed to trap 38 anti-H atoms for 170 milliseconds each. Less than a year later, in June 2011, they increased the number of trapped anti-H atoms to 112 and extended the time to 1000 seconds. That’s more than long enough to allow the anti-atoms to settle into the ground state, which is necessary for accurate measurements.

In March 2012, ALPHA was in the news again. This time, the group reported not only increasing the number of trapped anti-atoms to more than 300, but also making the first-ever spectral measurements of anti-H. The team measured the microwave frequency required to reverse the spin of anti-H.

“This eventually gets to the measurement of what’s called the fine structure constant of antimatter,” Fajans explains. “The fine structure constant is an extraordinarily important basic concept for the way atoms behave, and has never been directly measured for antimatter. This wasn’t a precision measurement, but it’s on the way there.”

The Fajans and Wurtele groups played major roles in the design and modeling of ALPHA’s Minimum Magnetic Field Trap, the apparatus that achieved these breakthroughs. To keep antimatter from contacting ordinary matter, Fajans says, “you have to build a trap that doesn’t have any sides. And you do that with magnetic
AntiHydrogen

Berkeley physicists catch, trap, and probe anti-atoms

fields. The magnetic field configuration we've been using, which was designed here at Berkeley, uses an octupole superconducting magnet.”

Previous antimatter traps had used quadrupole magnets. The decision to move to an octupole design came out of experiments conducted by the Fajans group and simulations developed by the Wurtele group.

ALPHA’s anti-H atoms are formed by injecting antiprotons from CERN’s Antiproton Decelerator, along with positrons, into a vacuum. “The method of tickling the two species together to make atoms cold enough to trap and measure is something we call autoresonance,” Fajans explains. “Autoresonance was a primary focus of research in my lab for many years, and some of the fundamentals about it were discovered here at Berkeley.” In parallel to this experimental work, simulations have been developed by Wurtele’s group to explore methods of increasing antihydrogen production.

So far, the ALPHA team has been able to trap about one anti-atom for every 10,000 created. “Do you remember those handheld games where you try to manipulate a ball bearing into shallow dimples in a piece of metal?” Fajans asks. “That’s analogous to our challenge. What we have to do is create the anti-atoms in the dimple in the first place. One anti-atom in 10,000 is not a very high data rate. We’d like to increase that, and we have plans to do so. We made a decision earlier this year to tear apart our apparatus and build a new one.”

“CERN can supply us with ten million antiprotons every three minutes,” Wurtele adds, “while ALPHA currently synthesizes one trappable antihydrogen in about fifteen minutes. We intend to improve our antihydrogen production rate by a factor of ten or more over the next few years.”

NEW GOALS, NEW APPARATUS

Fajans points out that the goal of the original experiment was to make and trap anti-H atoms. “There were no provisions for actually studying them,” he explains. “It was great that we were able to do the microwave spin-flip measurements, because it was not something we had designed into the original experiment.” The new apparatus they are developing will separate the process of collecting antiprotons provided by CERN from the creation and study of antihydrogen. It will allow for laser access, feature improved diagnostics, and provide a more homogeneous magnetic field. These and other enhancements will permit higher precision spectral measurements using both microwaves and laser light.

Professors Fajans and Wurtele look forward to 5-10 years of exciting physics with the new ALPHA apparatus that will, if all goes as planned, open up the field of neutral antimatter science.

ALPHA’s antimatter experiments will take a break during the two-year shutdown of the Large Hadron Collider, set to begin in January. CERN is the only facility in the world with an anti-proton decelerator (AD) and it is critical to creating anti-protons with energies low enough for ALPHA’s purposes.

“Partially because of our recent successes,” Fajans says, “CERN has decided to go ahead with an upgrade of the AD. That will come online in 2017 or 2018, and will provide us with far more antiprotons to use for our measurements.”

AT TOP, A CUTAWAY SCHEMATIC OF THE ALPHA ANTIMATTER TRAP SHOWS THE SUPERCONDUCTING OCTUPOLE MAGNET, MIRROR MAGNETS, AND OTHER FEATURES. BELOW IS A MAP OF MAGNETIC FIELD STRENGTH INSIDE THE TRAP. ONE OF THE GOALS IS TO MEASURE THE HYPERFINE STRUCTURE OF ANTIHYDROGEN ATOMS AT THE TRAP’S CENTER, WHERE THE MAGNETIC FIELDS ARE AT MINIMUM STRENGTH.
The crystal structure of a diamond is beautifully symmetrical and fairly simple to picture: a three-dimensional lattice of carbon atoms arranged so that each atom is bonded to four others. So-called defects are created if some carbon atoms are replaced by atoms of other elements, or if the shape of the lattice itself is deformed. Defects confer many of diamond’s most desirable attributes, from the color and flash of gemstones to unique optical, thermal, and other characteristics that make diamonds valuable in research and technology.

Of the hundreds of known defects that can occur in a diamond lattice, one in particular, known as a nitrogen-vacancy (NV) center, has become a golden child of atomic physics. It is formed by the removal of two adjacent carbon atoms from the lattice. One of the missing carbons is replaced by a nitrogen atom. Nothing replaces the second missing carbon. “Now you have a substitutional nitrogen atom adjacent to a vacancy,” explains Berkeley physics professor Dmitry Budker. “These two form a bound state similar to a molecule or an atom, with a whole host of amazing properties.”

Those properties include unique spin states and optical characteristics that make NV centers extraordinarily useful in areas like quantum information processing, biological sensing, and ultra-sensitive magnetometry.

NV centers have well-defined electron spin and energy levels, making them highly sensitive to magnetic fields, electric fields, microwave radiation, and photons. “At the same time,” Budker adds, “this spin state is rather insensitive to the usual perturbations in a crystal, such as lattice vibrations. Also, most optical systems in condensed matter tend to bleach, which means if you work with them for a long time they go into states that become invisible. NV centers are stable enough to avoid bleaching.”

“Normally,” he continues, “spin states in NV centers are in a combination of ground state levels. But they can be optically initialized by using a beam of laser light to pump them into an absolute ground state. They can then be optically probed, to determine what quantum state the center is in.”

NV centers occur naturally, and can be created in synthetic diamond via radiation and annealing processes. Although they’ve been the object of scientific study for decades, “about five years ago, people suddenly woke to their amazing properties, and that started a revolution,” Budker says.

Budker leads an experimental atomic physics group at Berkeley that works with researchers all over the globe on a variety of topics, including tests of the fundamental theorems of quantum mechanics, probing for violations of basic symmetry relations in atomic nuclei, and problems in applied physics. Budker and his colleagues are among the world’s leaders in investigating the unique properties of NV centers in diamond.

“Our group is exploring the fundamental properties of NV centers, and their sensing applications,” he notes. Potential sensing applications are legion, ranging from magnetometers to thermometers to gyroscopes, all on the nanoscale.

DIAMOND MAGNETOMETERS

For Budker, who has already made significant contributions to the field of atomic magnetometry, the magnetic sensitivity of NV centers is of particular interest. Among his group’s accomplishments in this area is development of high-precision optical-atomic magnetometers that are portable and operate at room temperature – they don’t require cryogenically cooled superconductors, as alternative designs do. The atomic magnetometers developed by Budker and his colleagues have led to major advances in magnetic resonance imaging (MRI) and nuclear magnetic resonance (NMR).

“NV centers are analogs of atomic magnetometers in many ways,” Budker says. “They have a favorable combination of high sensitivity and high spatial resolution. So they may be an even better choice, although the science of NV centers hasn’t matured to the same degree. But it’s moving very rapidly.”

“In the extreme, you can use one NV center to detect one nuclear spin and know where it is with atomic resolution,” he continues. “A lot of people are working with single NV centers. For example, a group in Australia recently reported a magnetic measurement of cell division by taking nanodiamonds with NV centers and injecting them into living cells.” Diamond is biologically inert, making single NV centers especially promising as biosensors.

Budker’s group has moved beyond the study of single NV centers, taking the lead in research that focuses on multiple NV centers. “We work with relatively large ensembles,” he says. His typical diamond sample measures about 1.0 mm square and 0.5 mm deep and contains about a trillion NV centers.

“Even though many people are studying and using NV centers,” Budker notes, “a lot of their basic properties
are not yet understood.” His group uses an optical technique known as pump-probe spectroscopy to learn more about electron energy levels, vibrational structure, and spin relaxation in ensembles of NV centers. The technique uses a pair of lasers, one to excite the centers into metastable states, and the other to probe those states.

**THERMOMETERS, GYROSCOPES, SUPERCONDUCTORS**

The Budker group’s explorations have already led to new applications. For example, their research revealed that the splitting of ground spin states in diamond is dependent on temperature. “To us, this was an unpleasant systematic effect for magnetometry,” he remarks. “But we published a paper a couple of years ago reporting this effect, and now people are using it as a thermometer. There are not many ways to measure temperature inside a living cell, and this is now one of the techniques of temperature measurement in biology.”

The group recently published a proposal describing how the rotational sensitivity of NV centers could be harnessed for use in microscale gyroscopes. And another paper discusses possible advances for the study of high-temperature superconductors. Currently, the best sensors for this purpose are SQUIDS (superconducting quantum interference devices), which work only at cryogenic temperatures. “You can’t use SQUIDs to study high-temperature superconductors unless you have some separation between the two,” he explains. “With diamond, there is not that problem. Sensors based on NV centers have good spatial resolution and operate in a broad temperature range.” Budker is collaborating with scientists at UCLA on using NV centers this way.

**WIDESPREAD COLLABORATIONS**

One of the remarkable things about Budker’s group – and a big contributor to its many successes – is its network of collaborators. The research going on in Budker’s Birge Hall labs has connections all over the building, on campus, across the country, and around the globe.

Virtually every research paper on NV centers that Budker has produced includes co-authors from elsewhere, including Silicon Valley, UCLA, Germany, Poland, France, and Australia. “I’m happy to say our lab has become a sort of center where people working with NV centers come to spend some time,” he says. He currently has postdocs from Denmark and Latvia, and visiting professors recently arrived from Israel and Poland.

“While we are developing really new ways to collaborate on experiments,” he adds. As an example, his group’s work with spin relaxation times in NV centers involves collaborators at Harvard who remotely monitor experiments underway in Birge Hall. They are able to analyze data in real time with software they developed for the purpose.

Budker has several collaborators on campus, including Alexander Pines and Graham Fleming from the Department of Chemistry. Ultrafast laser techniques developed by Fleming’s group for the study of photosynthesis can be applied to the study of NV centers, and some of the joint work on NV centers is taking place in Fleming’s lab.

The sense of collaboration and mutual aid extends among labs within Birge Hall. Damon English, a former graduate student and postdoc in Budker’s group, created fiber optic connections among many Birge Hall labs, making it possible for research groups led by different physics faculty to share light from the same laser. “The probe laser we use in our experiments actually belongs to physics professor Feng Wang,” Budker remarks.

**SUPPORTIVE ATMOSPHERE**

“What really strikes me about the community of people working on NV centers is the supportive atmosphere,” Budker reports. “People are obviously competing with each other for who’s going to get first results, but also support each other very strongly.”

“We meet at least twice a year,” he continues, “and these meetings are always very exciting. The intellectual temperature is really high. Every talk is amazing and you learn something new. There is lots of rapid progress.”
Topological insulators have properties never before observed in condensed matter. They behave as insulators on the inside and conductors on the outside. They represent a new electronic phase of matter, distinct from insulators, conductors, and semiconductors. First imagined only six years ago, they have quickly become the big celebrities of materials science, grabbing the attention of physicists and engineers around the globe.

Electrons in the interior of a topological insulator are bound in place, as in any other insulating material. But electrons on the exterior surfaces speed along with high conductivity, even at room temperature. Their conductivity is surprisingly robust to encounters with defects, impurities, or spurious electrical signals that can slow or stop conductivity in other materials. This robust stability stems from the very quantum mechanical attributes that give rise to the surface conductivity in the first place. What's more, these materials are fairly well-known alloys that are already in use as semiconductors.

Topological insulators are prime candidates for all kinds of electronic applications, from improved thermoelectric materials and novel superconductors to extremely high-capacity interconnects—the intricate pathways that shuttle power and data among the components of computer chips. They could help make it possible to use the phenomenon of electron spin not only for data storage but also for logic operations, leading to more energy-efficient and faster microprocessors. They could be the key to development of practical quantum computers. Equally important, topological insulators provide a rich field of inquiry for theorists probing the quantum mechanical nature of condensed matter.

**THEORY CAME FIRST**

Most new phenomena in materials science are initially observed by experimentalists, with theorists offering their explanations later on, sometimes much later. But this discovery came the other way around. Topological insulators were born in the inventive and persevering minds of theoretical physicists at the University of California. In 2006, UC Berkeley physics professor Joel Moore, in collaboration with physicist Leon Balents at UC Santa Barbara, published the first paper predicting the existence of three-dimensional (3D) topological insulators. They coined the term “topological insulators” to indicate that the differences between these materials and ordinary insulators result from the topological properties of their electrons. Research groups at the University of Pennsylvania and the University of Illinois published similar ideas shortly thereafter.

In 2007, their predictions came true. A group of experimenters based at Lawrence Berkeley National Laboratory and Princeton University announced discovery of the first 3D topological insulator. Led by Princeton’s M. Zahid Hasan, the group used photoemission spectroscopy to detect topological surface conductivity in a bismuth-antimony alloy. The discovery created quite a stir, sparking an almost immediate explosion of theoretical and experimental research.

**A MARRIAGE OF MATH AND PHYSICS**

According to Moore, topological insulators represent one of the first practical applications of topology, a branch of mathematics concerned with spatial properties that are not changed by stretching. A classic illustration uses a doughnut and a coffee cup. The doughnut shape can be smoothly deformed, without tearing or gluing, into the shape of a cup, with the doughnut hole becoming the open space in the cup handle. In mathematics, such features are described as ‘topologically invariant.’
In their 2006 paper, Moore and Balents predicted that although the conducting surfaces of topological insulators would be atomically thin, topological invariance would render them impervious to disorder, electronic noise, and similar effects that impair or destroy conductivity at surfaces of other materials. It is topological invariance that gives this new class of materials their intrinsic stability and underscores their promise for practical applications.

It’s important to note that topological invariance has nothing to do with the physical shape of a topological insulator. Moore explains that topological invariance in these materials describes the wave functions of their electrons. In the interior, he says, “the wave functions can be knotted up, sort of like a string can be knotted up.” At the surface, the wave functions can no longer stay knotted. “When a topological insulator is positioned next to a vacuum or a normal insulator,” Moore continues, “there’s a kind of catastrophe at the surface, because the topology has to change. The only way the system can reconcile that catastrophe is by going metallic – there has to be a metal at the boundary. You can’t get rid of it. All the experiments are detecting this metallic boundary in these materials.”

“THE SURPRISING THING IS THAT TOPOLOGY HAS ANYTHING AT ALL TO DO WITH ELECTRONS IN SOLIDS,” Moore adds. “We had a few esoteric examples back in the 1980s, but all of a sudden we realized it’s much more common than originally thought. And there are fairly standard materials, like bismuth telluride, that require topology if we’re to understand them. What was essentially a subfield or niche until about five years ago has become one of the hottest topics in condensed matter.”

RELATIVISTIC ELECTRONS

In atoms with high atomic numbers, electrons travel at relativistic speeds – speeds so fast that Newtonian mechanics cannot accurately describe them and the laws of quantum mechanics come to bear. Relativistic electrons possess strong spin-orbit coupling forces, which are the forces ultimately responsible for surface conductivity in topological insulators.

The topological insulators that have been identified so far are alloys of bismuth and other heavy elements. They are fairly standard materials whose characteristics have been studied before. So why has it taken so long to observe their topological properties? “These properties are difficult to detect,” Moore answers. “A bulk crystal will always have this metallic surface that’s one nanometer thick, but if you do a casual experimental probe, the insulating characteristics of the interior will over-
whelm signatures of mobile electrons at the surface. You need a surface-sensitive probe like photoemission spectroscopy, which sends in a single photon and bounces out an electron.” Moore is currently discussing several optical probes of these surface states with Berkeley experimental colleagues Alessandra Lanzara and Joseph Orenstein.

**THERMOELECTRICS AND MULTIFERROICS**

Moore’s theoretical studies of topological insulators embrace a variety of topics, including energy efficiency in thermoelectric materials and exploration of the magnetoelectric effect in solids.

One of the very promising spin-offs of research on topological insulators is the possibility of developing improved thermoelectric devices. “Applying a voltage to a thermoelectric material generates a temperature gradient that produces some cooling power,” Moore explains. Thermoelectrics are used in refrigeration equipment and are especially important for remote applications, such as satellites, because they have no moving parts and are relatively low in cost. “But they aren’t very energy efficient,” Moore continues, “and there’s a real need to find more efficient thermoelectric materials. Bismuth telluride is currently the best room-temperature thermoelectric, and now we know it’s also a topological insulator. I’m interested in knowing if we can use that feature to make it a better thermoelectric.”

“In doing research on topological insulators,” Moore continues, “we’ve learned that the magnetoelectric effect is very important to understand in all insulators. In many materials, including multiferroics, if you apply an electric field, you generate a magnetic moment; if you apply a magnetic field, you generate an electrical moment. Understanding how electrons contribute to this effect turns out to involve a lot of subtle topology and geometry.”

Moore recently completed a theory of the electronic contribution to the magnetoelectric effect in solids in collaboration with Berkeley physics students and postdocs and with David Vanderbilt at Rutgers University. The topological insulator can be regarded as a special case of this more general theory, with a particular value of the magnetoelectric effect, and future experiments may be able to test the theory’s predictions in other materials.

Moore is also collaborating with Berkeley physics professor Steven Louie on understanding the detailed properties of the topological insulator surface in specific materials and identifying potential applications that could arise from that understanding. Moore says, “We’ve done a lot of surface-state transport calculations that address questions like, Now that we have this metallic surface state, how can we tell that it’s different from an ordinary metal?” The surface state has an unusual coupling between spin and charge transport, quantified in their joint work, that may enable new kinds of fundamental devices.

In a survey article published in the July 2011 issue of IEEE Spectrum Inside Technology column, Moore wrote, “Put together all the advantages — fast electrons, sensitivity to applied fields, reversibility of doping, robustness in the face of noise — and you can see why topological insulators have excited the engineering community.” The possibilities are tremendous, and exploration has barely begun. ■

**BERKELEY-BASED RESEARCH ON TOPOLOGICAL INSULATORS**

Topological insulators represent a major new focus for research in condensed matter physics. A number of faculty members in the Berkeley Department of Physics, theorists and experimentalists alike, are involved in a wide spectrum of research in this arena.

**Professor Alessandra Lanzara**, an experimentalist, uses advanced forms of photoemission spectroscopy to probe the electronic properties of materials, including topological insulators. One set of experiments uses photoemission to characterize the transient electronic state of a material after a strong “pump” optical pulse.

**Professor Joe Orenstein** is an experimentalist who uses optical techniques to characterize high-temperature superconductors, semiconductors, and other materials. He has employed a “transient grating spectroscopy” technique to characterize spin and charge transport in two-dimensional electron systems, including surface states of topological insulators, without the necessity of making electrical contacts.

**Assistant Professor James Analytis** is an experimentalist who synthesizes single crystals of a wide variety of materials and measures their thermodynamic properties. His work as a postdoc and staff scientist at Stanford included the synthesis of materials for some of the first experiments on topological insulators.

**Professor Steven Louie** is a theorist who uses first-principles theories and computation to understand novel materials and nanostructures, including topological insulators. His research aims at explaining and predicting the properties and behaviors of specific materials, and exploring their potential applications.

**Professor Ashvin Vishwanath** is a theorist. In addition to contributions to the theory of topological insulators, he has proposed the existence of semimetallic materials with unusual surface states (Weyl semimetals) and bulk conductivity.
Luis Alvarez 100th Anniversary Symposium

A symposium celebrating Luis Alvarez (1911-1988), heralded as “one of the greatest experimental physicists of the 20th century,” took place on Nov 19, 2011 in Stanley Hall on the UC Berkeley campus. Presentations by a number of Alvarez’s former colleagues, students, and scientific heirs at UC Berkeley and Lawrence Berkeley National Laboratory (LBNL) recounted some of his many innovations and discoveries. These ranged from his Nobel Prize-winning work with hydrogen bubble chambers to his more unorthodox pursuits: investigating the assassination of John F. Kennedy, using cosmic rays to search for hidden chambers in Egyptian pyramids, and discovering how dinosaurs became extinct.

After a welcome by Chancellor Robert Birgeneau, Berkeley emeritus physics professor Richard Muller kicked off the day’s sessions with an overview of Alvarez’s career. Muller, Alvarez’s last graduate student, said Alvarez was a master at identifying really important questions that could actually be approached experimentally. He described the great care Alvarez took to make sure his results were correct, by trying his hardest to prove himself wrong. Alvarez’s development of the hydrogen bubble chamber, along with the associated analysis systems that resulted in a flurry of new particle discoveries, was the topic of several speakers. Berkeley emeritus physics professor Art Rosenfeld talked about his days with the research group, helping to develop procedures for scanning and identifying the particles. Rosenfeld recalled, “What Luis considered visionary, I considered overwhelming.”

Nobel Prize

The Alvarez group became the largest high energy physics group in the world. Its work led to the quark model in particle physics, earning Alvarez the 1968 Nobel Prize in Physics. Lina Galtieri, a physicist at LBNL who joined the group in 1961, remembered Alvarez as the commander-in-chief of “a dedicated staff of physicists, exceptional graduate students, an army of very talented engineers and programmers, and a greater army of scanners working 24/7. He encouraged everyone to try new ideas and go beyond what they thought to be their limitations.”

That was a hallmark of Alvarez’s approach, and he created a culture that fostered that spirit in others. George Smoot and Saul Perlmutter, both Nobel laureates and UC Berkeley physics professors, were beneficiaries of that environment. Alvarez, said Smoot, demonstrated “careful and strong science standards,” while encouraging taking risks. Perlmutter characterized it as a “can-do cowboy spirit.” Alvarez, he said, was “the master at creating things that would allow you to make a measurement or make a discovery.”

In his autobiography (Alvarez: Adventures of a Physicist), Alvarez wrote, “The single most important characteristic of my success in physics has been invention. Whenever anything has interested me, I’ve instinctively tried to invent a new or better way of doing it.” Speakers noted that he held 40 US patents, with patent applications dating from 1943 to 1988. He made important contributions during World War II, including the VIXEN radar system, which hampered the ability of German U2 submarines to detect oncoming Allied attack planes, and a ground-controlled approach technique for landing airplanes in heavy fog.

Alvarez’s inventive spirit sometimes took him down unpredictable paths. After a visit to Egypt in the early 1960s he put together a team of Egyptian and American scientists, including Berkley physics alumnus Jerry Anderson (PhD ’63), to build an experiment that detected cosmic rays passing through Chephren’s pyramid, eventually determining that the pyramid was solid, with no spaces or voids.

Mass Extinction Theory

Alvarez’s last major undertaking was described by his son, UC Berkeley geology professor Walter Alvarez. It started with a rock Walter gave to Luis. It was from an outcropping in Gubbio, Italy, and had a layer of clay that marked the boundary between the Cretaceous and Tertiary geologic periods, noted for a major extinction. Luis put his physicist’s mind – and the resources of LBNL – to work to determine the cause. Analysis revealed that the clay layer had an abundance of iridium that could only have come from an extraterrestrial source. The two Alvarezes and their collaborators concluded that the catastrophe that killed the dinosaurs, and most other forms of life, was caused by an asteroid or comet that hit the earth 65 million years ago. This hypothesis is considered to be proven.

Information about the Luis Alvarez 100th Anniversary Symposium, including video recordings of most of the talks, can be found at http://luis-alvarez-symposium.lbl.gov. The event was held on the UC Berkeley Campus, organized by LBNL, and funded in part by the U.S. Department of Energy, Office of High Energy Physics.

—Written with contributions from Jeanne Miller, Physics Division, LBNL
BERKELEY ALUMNUS WINS PHYSICS NOBEL

UC Berkeley alumnus David Wineland was one of two recipients of the 2012 Nobel Prize in physics announced Tuesday. Wineland received a BA from Berkeley in 1965. He earned his MA and PhD in physics from Harvard, and since 1978 has been a physicist with the National Institute of Standards and Technology (NIST).

Wineland, along with French physicist Serge Haroche, was awarded the prize “for ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems,” according to the prize website. In addition to his position at NIST, Wineland is a lecturer at the University of Colorado at Boulder.

Wineland developed methods to control isolated, electrically charged atoms using light particles called photons. Haroche used the opposite approach, measuring photons using atoms.

By allowing physicists to isolate and study trapped ions or photons that simultaneously occupy two different energy levels, Wineland and Haroche pioneered the idea that experiments can be conducted with single atoms, other researchers said.

“This is something that is really very exceptional,” said Hartmut Haeffner, an assistant professor of physics at UC Berkeley. “People thought you’d never be able to experiment with a single atom.”

According to physicists, this research can be used to improve the accuracy of atomic clocks to lose only about one second every 3 billion years or create powerful computers with quantum bits – called qubits – that could store vast amounts of information.

Additionally, Dmitry Budker, a campus professor of physics, said the research methods can be used to verify predictions of the general theory of relativity and whether fundamental constants of nature may actually be changing over time.

—from an Oct 26, 2012 article by Megan Messerly in the Daily Californian

BIRGENEAU STEPS DOWN AS CHANCELLOR AT YEAR’S END

On March 13, Berkeley Chancellor Robert Birgeneau announced that he would step down as Chancellor at the end of 2012, when he will return to the Department of Physics and the Department of Materials Science and Engineering as a regular faculty member. Birgeneau took the post of Chancellor in September, 2004.

In his outgoing statement, Birgeneau said, “Serving as the Ninth Chancellor of one of the world’s preeminent teaching and research universities has been an immense privilege and honor. I am deeply grateful to have been entrusted with the profound responsibility of leading this great institution and its outstanding faculty, staff, and students through one of the most challenging periods in its 144-year history.”

Responding to Birgeneau’s announcement, UC President Mark Yudof said, “In his more than seven years as Chancellor at the University of California, Berkeley, Robert Birgeneau has proven to be a passionate, dedicated, and effective steward of the world’s greatest public university. He has been an ardent champion of academic excellence, as well as an unwavering advocate for the underdog.”

“A world-renowned physicist,” Yudof continued, “the Chancellor grasped early on the growing importance of multi-disciplinary research in addressing the complex problems of the 21st century. This foresight led him to foster a variety of new research initiatives at Berkeley, from the Blum Center for Developing Economies to the Li Ka Shing Center for Biomedical and Health Sciences.”

Yudof also pointed out that Birgeneau “oversaw the largest fundraising campaign in UC Berkeley’s history; by placing heightened focus on philanthropic support for faculty positions and graduate fellowships, he united donors around the university’s mission of maintaining and even enhancing its peerless academic quality.”

Birgeneau pledged to remain in office until his successor is appointed by the UC Regents, and to work with the new appointee to effect a smooth transition.
CHARLES H. TOWNES FELLOWSHIP IN PHYSICS

Reinhard Genzel, UC Berkeley professor of physics, Director of the Max Planck Institute for Extraterrestrial Physics in Germany, and winner of the prestigious Shaw Prize in 2008, generously donated $100,000 to the Department of Physics to establish a graduate fellowship in honor of his collaborator and friend, Charles H. Townes.

Genzel encouraged the physics faculty and Townes’ former students to contribute as well, to help fully fund the endowed fellowship at $500,000. A campus-wide program called the Chancellor’s Challenge offered a full match to all faculty donations, thus helping the fellowship grow quite quickly. Many of Townes’ students, collaborators, and colleagues gave generously to this campaign in his honor.

Physics professor Buford Price helped raise funds by writing to many friends and colleagues of Townes. He also asked the members of the Isle of Aves, the camp in the Bohemian Club to which he and Townes belong, to contribute.

On July 28, 2012, at the summer Encampment of the Club at Bohemian Grove, the members of Isle of Aves celebrated their role in helping to reach $500,000 on the day of Townes’ 97th birthday. The Isle was founded 107 years ago by former Berkeley Professor Henry Morse Stephens. Its members have included former Governor Earl Warren, former Cal President Robert Gordon Sproul, former Berkeley chancellors Mike Heyman and Roger Heyns, and Robert Haas, who participated with Price in ensuring that 100% of the Isle of Aves members contributed.

At his talk during the Encampment, Stan Prusiner, Nobel Prize winner in medicine, showed that his pointer was just one of the spinoffs of Townes’ invention of the laser. He then led the audience in singing Happy Birthday to Townes.

—Contributed by physics professor P. Buford Price

BERKELEY CENTER FOR THEORETICAL PHYSICS AT TAHOE SUMMIT

In September, Berkeley physics alumnus Doug Tuttle ('71) and Lynn Brantley hosted members of the Berkeley Center for Theoretical Physics (BCTP) at their home in Glenbrook, Nevada on the beautiful shores of Lake Tahoe. Both are longtime supporters of the BCTP, and this is the second time they have hosted the BCTP Tahoe Summit. The event gives BCTP members and colleagues an opportunity to come together to share the latest research in theoretical physics, free from the distractions of the office.

Summit participants were also free to enjoy the great outdoors and had a chance to form friendships that are sure to benefit their important work together. The Tahoe Summit is a rare opportunity for graduate students to listen to and participate in discussions in such a relaxed atmosphere.

The 2012 Tahoe Summit also included participants from outside the BCTP, including Stanford physics professors Shamit Kachru and Eva Silverstein, UC Davis physics professor Markus Luty, and Berkeley’s own physics professor Beate Heinemann, who represented the experimental side of particle physics.

Berkeley theorist Lawrence Hall joined Heinemann in a presentation about the newly discovered Higgs Boson for local Cal alumni and interested Glenbrook neighbors.

Summit attendees, their hosts, and neighbors were delighted to have this tremendous level of scholarship in their own backyard. The third annual Tahoe Summit will soon be on the calendar for 2013.

—Contributed by Maria Hjelm, Development Officer for the Department of Physics
NEWS FROM BERKELEY CENTER FOR COSMOLOGICAL PHYSICS

The Berkeley Center for Cosmological Physics (BCCP) will receive $6.7 million over six years, in support from the Heising-Simons Foundation, and has two new directors at the helm. Physics professor Saul Perlmutter, 2011 Physics Nobel Laureate, was appointed the new BCCP executive director. Uros Seljak, professor of physics and astronomy, was appointed the new BCCP director. The appointments, made by Vice Chancellor for Research Graham Fleming, became effective March 1, 2012, when 2006 Physics Nobel Laureate George Smoot completed his term as director.

“My five-year term passed by more quickly than I ever imagined,” Smoot said in a statement. “The first five years of the Berkeley Center for Cosmological Physics have been very exciting and fulfilling. We look to the next five years as one of great opportunities and successes in this cutting edge work. ...That BCCP has Nobel Laureates as its first two directors is an indicator of the leading role being played here. In practice, very much outstanding work is going on through BCCP by extraordinary researchers.”

The $6.7 million from the Heising-Simons Foundation will provide funding for a variety of important activities at BCCP, including a visiting scholars program and an endowment for postdoctoral fellowships.

Visiting Scholars

The visiting scholars program will bring in influential and innovative scientists from other institutions. A constant influx of short-term visitors promises to increase BCCP’s intellectual breadth and its impact on the scientific community, as well as attract promising young scientists and enhance future recruitments.

Director Uros Seljak describes the vision he shares with Saul Perlmutter: “The BCCP will become an umbrella for anything cosmology-related at Berkeley, and it will expand Berkeley’s visibility and relevance worldwide. This includes attracting some of the best postdoctoral scholars to come and do their research at Berkeley, creating a place to develop computational algorithms that can be used by anyone doing cosmology research, organizing meetings and workshops, and establishing a BCCP visitors program, including hosting long-term visits and sabbaticals from scholars in other fields.”

Postdoctoral Fellowships

The permanently endowed postdoctoral fellowships will give young scientists the freedom to pursue a broad spectrum of research, chosen once they arrive at UC Berkeley. Collaboration between faculty and postdoctoral scholars offers an important means for initiating and maintaining interdisciplinary research, and young postdoctoral fellows play a vital role in advancing the forefront of significant scholarly investigation.

Fellowships generally last three to five years, and BCCP’s goal is to have three to five postdocs at any one time. Funding from the Heising-Simons Foundation includes $1 million to endow the postdoctoral fellows program, plus another $1 million as a dollar-for-dollar challenge grant to attract matching funds.

Additional areas within BCCP that will benefit from the Heising-Simons Foundation include cosmology computing capability, colloquia and retreats, and a faculty-in-residence program to foster collaboration with Berkeley faculty from other departments within the university.

The Heising-Simons Foundation is a family foundation established by two Berkeley alumni: Mark Heising, who received a BA in physics in 1980 and an MS in Engineering in 1983; and Liz Simons, recipient of a BA in Journalism in 1982. The Heising-Simons Foundation supports causes relating to early childhood education, advanced energy research, and physics.

FRIENDS OF TODAI SPONSORS EXCHANGE STUDENTS

An exciting exchange of people and ideas is taking place between UC Berkeley's Center for Theoretical Physics (BCTP) and the University of Tokyo's Kavli Institute for the Physics and Math of the Universe (Kavli IPMU). Berkeley physics professor and BCTP member Hitoshi Murayama travels between the two institutions and serves...
as Director of the Kavli IPMU. Friends of Todai, a US organization that supports the work of the University of Tokyo, sponsors exchange students from both institutions.

William Buckley

One of the first Berkeley physics students to participate in the exchange program was William Buckley, who received his PhD in 2008. He arrived at Kavli IPMU in January 2008 to continue his work in theoretical physics. While there, he worked on his thesis, met with other scientists, and attended international conferences. He reports that there are lots of interaction areas in the IPMU, making it an easy place to meet with people, discuss ideas, and get feedback.

American students coming to Japan are given a crash course in Japanese. The IPMU staff offers assistance in everyday matters like public transportation, banking, and medical care. Buckley says everyone there was incredibly helpful and friendly.

Kohsaku Tobiaka

Kohsaku Tobiaka came to Berkeley for the Spring 2012 semester, while he was a third-year graduate student at the University of Tokyo. He works with data from the Large Hadron Collider (LHC) at CERN, searching for evidence of extra dimensions, which is related to the search for dark matter. While at Berkeley, he and Hitoshi Murayama developed a new search method using upstream radiation.

Tobiaka also collaborated with Murayama and Berkeley physics professor Yasunori Nomura on supersymmetry, one of the most important topics under investigation at the LHC. They created a model for the search for low-energy supersymmetric particles. Tobiaka reports that his time at the BCTP was very fruitful, and he achieved more than he expected. While in Berkeley, he lived at International House, and got to know many Berkeley students involved with the BCTP.

The exchange program is continuing. Three more students from BCTP stayed at Kavli IPMU this summer: Brian Henning, Marat Freytsis, and David Pinner, who started a collaboration with Tsutomu Yanagida, a senior professor there. Another Berkeley student, Claire Zukowski, arrived in October.

“I believe it is very important for graduate students to be exposed to different cultures and languages, as well as new fields of research,” says Murayama, “to open up their eyes and prepare them for whatever research opportunities will be presented.”

Friends of Todai, Inc. is a non-profit organization interested in promoting the University of Tokyo within the US. This fruitful exchange program has been made possible by the organization’s donations to the BCTP over the past several years.

CONSTRUCTION OF NEW CAMPBELL HALL IS UNDERWAY

Old Campbell Hall is no longer. It was quickly – and very carefully – demolished in May. A ‘far-reach excavator’ took down each of its six stories, one at a time, to avoid disturbing neighboring structures, including Old Le Conte Hall. Groundbreaking for its replacement, New Campbell Hall, took place on May 14. Construction is well underway, with completion expected at the end of 2014.

New Campbell Hall will house offices, classrooms, and laboratories for the Departments of Astronomy and Physics, including a roof-top observatory and a radio observatory. An elevated walkway will connect the six-story building with Old LeConte Hall. The basement will house a state-of-the-art high stability, low-noise research facility called the Center for Precision and Quantum Measurement.

The new facility is designed to enhance collaborations between astronomy and physics. “There are roughly a dozen faculty in the physics department working on astrophysics,” says astrophysics professor Eliot Quataert, “some of whom will have their offices in New Campbell Hall, along with a comparable number of Astronomy faculty.” That fact, in addition to the walkway between buildings, will increase interactions among faculty from both departments.

“Ultimately, new ideas and research programs will result,” Quataert asserts. “It is often the interaction between people working on related problems from some-
what different perspectives that lead to new ideas and progress. New Campbell will create the right conditions for this to happen and we are all tremendously excited about the opportunities it will enable.”

Quataert adds that the building will house “a combination of wonderful teaching and research facilities, from laboratories where colleagues will build state-of-the-art telescopes to interaction areas where theorists will scribble new ideas on white boards, to classrooms for close interaction between the faculty and Berkeley undergraduates.”

According to physics professor Mike Crommie, the basement laboratory will provide much needed research space for investigations that must be protected from vibrations, acoustical noise, and electromagnetic interference. It’s being funded in part by an $11 million grant from the National Institute of Science and Technology (NIST) to establish the Center for Integrated Precision and Quantum Measurement (CIPQM).

“Research in the center will include atomic-level microscopy, characterization of nanometer-scale electrical and mechanical devices, and the investigation of ultra-cold atoms suspended in optical traps,” Crommie reports.

“The new lab space is designed to encourage collaborative, interdisciplinary research spanning condensed matter physics, atomic physics, and biophysics.”

Registered to receive a silver LEED rating from the US Green Building Council, the new structure is being built in accordance with UC Berkeley green building practices.

**COMPASS PROJECT WINS APS AWARD**

The American Physical Society (APS) has given UC Berkeley’s Compass Project the APS Award for Improving Undergraduate Physics Education. Since its founding in 2006, Compass has focused on helping students interested in physics, astronomy, and earth and planetary sciences succeed during their time at Berkeley. The award announcement reads as follows:

> Compass is dedicated to building a collaborative, diverse and creative community of undergraduate students that will enrich their experience in the physical sciences. Graduate student volunteers coordinate the program and foster an inclusive environment so that incoming undergraduates from groups traditionally underrepresented in the physical sciences may acquire a solid sense of direction.

The centerpiece of the Compass Project is the Compass Summer Program, which takes place during the two weeks before the start of the fall semester. The residential, all-expenses-paid program brings together approximately 15 incoming freshmen and six graduate student instructors for intensive research on a physical question – recent examples include ‘How do wind turbines work?’ and ‘What is the nature of time?’ Students work in small groups to design experiments that help answer the question posed. Rather than listening to lectures, students are urged to work collaboratively and learn through discovery.

After the summer program, Compass students participate in a semester-long course in problem solving and model building, in which they continue to take advantage of the community they have built in order to help each other become better scientists. Additionally, undergraduates are paired with a graduate student mentor who helps guide them through the rest of their undergraduate experience. Other programs Compass sponsors include a lecture series, office hours for homework help, and community dinners.

Jacob Lynn, a physics graduate student who has been part of Compass since 2010, said, “This award reflects the national attention that Compass is receiving in the physics education community. We hope that Compass can be a model for physics departments who understand that science can be a space where anyone has the opportunity to thrive, regardless of background.”

**TWO SIMONS POSTDOCS JOIN BERKELEY PHYSICS**

Two very talented young scientists recently joined the UC Berkeley Department of Physics as Simons Postdoctoral Fellows with three-year terms. Daniel Kreif arrived at Berkeley in 2010; Siddharth Parameswaran came to campus in 2011.

The Simons Foundation is a private foundation based in New York City, incorporated in 1994 with the mission to advance the frontiers of research in mathematics and the basic sciences. In fall 2009, the foundation initiated an interim Simons Postdoctoral Fellows Program to support a total of 68 postdoctoral positions at 46 universities over several years. The goal of the Simons Fellows Program is to provide the highest quality postdoctoral training to a group of the most promising new PhDs.
Daniel Krefl

Krefl, who came to Berkeley from LMU, Munich, is already making important contributions in the field of string theory. During his PhD studies, he collaborated with his advisor Dieter Luest on a highly cited paper on moduli stabilization in string theory. The authors shed light on the subject of string compactifications by explaining how classically forbidden terms in the potential can arise quantum mechanically and help stabilize the vacuum.

Krefl also won a prestigious Marie-Curie fellowship, which allowed him to work at CERN. While there, he collaborated on a study of Calabi-Yau orientifolds that uses a new technique relating complicated string theory models to simple models in statistical mechanics. The central focus of his PhD, a collaboration involving orientifolds of topological strings, culminated in a complete solution of the theory in a certain large class of models, with important mathematical consequences currently under study by several groups.

Krefl also wrote a noted paper explaining how some string models of supersymmetry breaking, previously thought to be rather exotic, can be dual to a well understood mechanism of supersymmetry breaking in a gauge theory.

Since arriving at Berkeley, Krefl has initiated several new collaborations and proven to be a valuable addition to the Berkeley Center for Theoretical Physics and the research group of Mina Aganagic, Berkeley professor of physics and mathematics. While at Berkeley Krefl has published three papers on a refinement in topological string theory that is currently a topic of very active research in mathematics and physics. This area of study is related to black-holes, mirror symmetry, and gauge theories on the physics side, and representation theory and algebraic and symplectic geometry on the mathematics side. Krefl has also participated in development of a connection between the refined topological string, integrable systems, and gauge theories in four dimensions.

Parameswaran won the Friends of Davis International Center Excellence in Teaching Award.

Parameswaran’s research focuses on the Quantum Hall effect, topological phases of matter, and quantum magnetism. Since arriving at Berkeley, he has continued to work on the physics of the Quantum Hall effect in collaboration with Berkeley physics professor Joel Moore and his group. Parameswaran has also initiated new research directions on studying the transport of charge and heat through a newly proposed state of matter, the Weyl semimetal, in collaboration with physics professor Ashvin Vishwanath and his group.

In addition, Parameswaran works with several other research groups at Berkeley. He bridges the gap between theory and experiments by working on Mott phases at fractional filling, which may be realized in the cold atom experiments of physics professor Dan Stamper-Kurn. He has actively collaborated with the groups of professor Joe Orenstein and R. Ramesh on optical signatures of magnetic excitations in the helimagnets.

Parameswaran’s strongly collaborative style of research has had a significant impact in helping to forge collaborations between theory and experiment, and is also promoting interactions within the condensed matter theory group. He has been co-running the condensed matter theory seminars – known as ‘Quantum Materials’ seminars – which have also contributed significantly to the scientific atmosphere.

Simons Fellowships are restricted to candidates who receive their PhD in the academic year before they would become Simons Fellows. Three-year positions in Mathematics and Theoretical Physics started in the academic years 2010 and 2011, and two-year postdoctoral positions in Theoretical Computer Science started in 2010, 2011, and 2012. Berkeley emeritus physics professor Mary K. Gaillard served on the committee that selected which universities would receive Simons Fellowships. Committee service came with an automatic award of two fellowships.

T’Hooft Gives Oppenheimer Lecture

The 2012 Oppenheimer Lecture in theoretical Physics was presented on April 9 by Gerard t’Hooft, Distinguished Professor at Utrecht University, Netherlands, and winner of the 1999 Nobel Prize in Physics for his elucidation of the quantum structure of the electroweak interactions. t’Hooft was introduced by emeritus physics professor Marvin Cohen, who has overseen the Oppenheimer Lecture since its inception in 1998.
In his talk, “The Higgs Particle: Pivot of Symmetry and Mass,” t’Hooft chose not to label the Higgs particle as “responsible for the mass of all subatomic particles.” Instead, he preferred to say that it’s “closely related to the mass of all particles,” and needs to be part of any theory that includes massive particles.

He explained that the Higgs particle solves problems involving not only the mass, but also the spin, or rotation, of subatomic particles. “The role of rotation is very important to the behavior of particles” he said. “It affects their orbits, how they move, the way they encounter other objects.” In fact, he added, spin has such an important influence on how particles exert force on each other that this leads to problems with mass in the Standard Model. “The Higgs field changes the helicity of a particle that moves through it,” he explained.

t’Hooft took his listeners on a brief tour of the history of the Higgs particle, including Emma Noether’s work in the early 20th century, in which she showed that symmetry breaking in physics is related to laws of conservation. And he used the famous “Mexican Hat” potential function analogy to explain spontaneous symmetry breaking and why the Standard Model needs a massive, spin-zero particle – the Higgs – to explain the masses of all other particles.

A webcast of the entire talk, as well as many other lectures presented by the Berkeley Department of Physics, can be viewed by clicking on the “Webcasts” button on the department’s home page, www.physics.berkeley.edu.

Berkeley’s Robert J. Oppenheimer Lectureship, awarded annually, celebrates Oppenheimer’s contributions to science by bringing some of the brightest minds in physics to the Berkeley campus. It was established in 1998 with support from Berkeley alumnus Steve Krieger, Arlene Krieger, the Jane and Robert Wilson Endowment in Physics, and other Friends of Physics.

CABRERA GIVES ANNUAL SEGRÈ LECTURE

Stanford physicist Blas Cabrera gave the 2011 Segrè Lecture on October 24 last year. Cabrera is Stanley G. Wojcicki Professor of Physics at Stanford, Chair of the Stanford Department of Physics, and co-spokesperson for the Cryogenic Dark Matter Search (CDMS) experiment. CDMS is looking for dark matter particles in and around the Milky Way Galaxy, under the hypothesis that dark matter is composed of weakly interactive massive particles, or WIMPs. WIMPs, which arise from supersymmetric theories of particle physics, have not yet been observed.

In his talk, “What makes up the dark matter of our universe,” Cabrera reviewed how cosmology and particle physics, including major contributions from Berkeley physicists, have brought us to our current understanding of the origin of the universe. He noted that dark matter, which comprises 23 percent of all matter, is the source of all structure formation in the universe. And he listed particles that theorists have thus far proposed as candidates for dark matter.

He explained how the rotational velocity of galaxies can be accounted for by the dark matter that penetrates and surrounds them. “If you assume that the mass contained within a sphere increases proportional to the radius, you see the velocity as a constant,” he said. “That means by the time you’ve gotten out beyond the point where you see no more stars, you’ve got ten times more dark matter than luminous matter.”

“Direct detection experiments such as CDMS search directly for dark matter particles passing through the laboratory,” he pointed out, “indirect detection experiments such as GLAST/Fermi look for gamma rays from dark matter particle-antiparticle annihilations, and accelerators such as the LHC at CERN may soon provide direct evidence for the structure of particle physics in the dark matter sector.”

Cabrera went on to describe the initial CDMS experiment, located one-half mile underground in the Soudan Mine in northern Minnesota, as well as the subsequent version, which will increase sensitivity by using larger detectors. A successor to CDMS, SuperCDMS, will be located even farther underground at SNOLAB mine in Sudbury, Canada.

In his conclusion, he said, “Within the next five to ten years, WIMPs will be discovered and confirmed by multiple experiments, or this favored explanation for dark matter will be ruled out.”

The Emilio Segrè Lectureship enables the Department of Physics to bring some of the world’s most important and influential scientific figures to the Berkeley campus. It was established by an endowment from the Raymond and Beverly Sackler Foundation to honor Segrè, who shared with Owen Chamberlain the 1959 Nobel Prize in physics for the discovery of the antiproton.
MAXWELL AND HIS EQUATIONS T-SHIRT CONTEST

The winners of the seventh annual “Maxwell and his equations” t-shirt contest, open to undergraduates in Physics 110A and graduate students in Physics 209, were honored at the first colloquium of Spring 2012 by Emeritus Professor J. D. Jackson. T-shirts were awarded for outstanding mastery of electricity and magnetism in 110A to Nicholas A. Kellaris and Yeh, Hsu-Hang. In 209 there was a tie, with two winners, David D. Gee and Fredrico Zalamea.

The t-shirts have the four Maxwell equations printed on the front and a portrait of James Clerk Maxwell on the back. The Maxwell equations describe how electromagnetic fields of all frequencies relate to their sources and propagate through space and through matter.

CAL DAY 2012

This year’s Cal Day, UC Berkeley’s annual open house, took place Saturday, April 21. The day featured a variety of physics events, from lectures on cutting-edge physics to guided tours of research labs to demonstrations and lab experiments.

Visitors enjoyed “Hands-On Physics”, interactive exhibits and demonstrations for all ages, hosted by physics graduate and undergraduate students in the second-floor labs of LeConte Hall. Guided tours of the Quantum Nanoelectrics Lab and the Physics 111 Advanced Lab were offered throughout the day.

Visitors were treated to several lectures. Professors Howard Shugart and Bob Jacobsen offered two sessions of the perennially popular lecture-demonstration “Fun with Physics: Why Should Students Have all the Fun?” Professors Lawrence Hall and Beate Heinemann presented “The Higgs Boson: What is it and why is it important? How do we look for it and have we found it?” And Chancellor Robert Birgeneau interviewed Berkeley’s newest Nobel laureate, Saul Perlmutter about “The Expanding Universe.”

Potential physics majors were invited to meet with the undergraduate advisor, who answered questions about the physics program, academic requirements and opportunities, and life as an undergraduate. Tables for Physical Science Majors were set up in the Information Marketplace on Sproul Plaza, along with a Society of Physics Students table that featured startling physics demonstrations.

Cal Day 2013 is set for Saturday April 20, 2013.

BUSTAMANTE WINS 2012 VILCEK PRIZE

On February 15, The Vilcek Foundation named Berkeley physics professor Carlos J. Bustamante winner of the 2012 Vilcek Prize for Biomedical Science. The Vilcek Foundation honors and supports foreign-born scientists...
and artists who have made outstanding contributions to society in the United States.

Bustamante uses magnetic beads, atomic-force microscopes, and laser “tweezers” to explore the inner workings of the cell and the physical forces behind DNA replication. The award announcement said Bustamante was being “cited for his pioneering discoveries in the field of molecular biology and biophysics; most notably, he has invented tools that make it possible, for the first time, to study life-sustaining cellular processes at the level of single molecules. His methods allow for the manipulation of individual molecules that play central functions inside a cell, giving scientists deeper insight into some of the vital processes occurring inside cells. Beyond laying the groundwork for future potential treatments for life-threatening human diseases, Dr. Bustamante’s work has made it possible to use ever-finer tools to observe molecular interactions inside cells.”

In addition to his post with the Department of Physics at UC Berkeley, Bustamante is a professor in the Departments of Molecular and Cell Biology and of Chemistry. He is a Howard Hughes Medical Institute Investigator and Director of the Advanced Microscopies Department at Lawrence Berkeley National Laboratory. He has established a relationship between UC Berkeley and his alma mater, the University Cayetano Heredia, in Lima Peru. He also leads a Peruvian laboratory in research on tuberculosis, a disease that causes a significant number of deaths in Peru. Born in Peru, Bustamante came to the US in 1975, when he became a Fulbright Scholar and entered UC Berkeley as a graduate student in biophysics.

The award, presented at a ceremony in New York City on April 2, 2012, includes a $100,000 cash prize.

CHARLES TOWNES WINS GOLDEN GOOSE AWARD

Nobel laureate and UC Berkeley emeritus physics professor Charles H. Townes is one of the first scientists to win a Golden Goose Award. He was recognized for the unexpected impact of his studies of molecular and atomic spectroscopy, which led to development of the laser.

The award was announced September 9, 2012, by US Congressional Representative Jim Cooper (D-TN), who conceived the award, and Dr. Alan Leshner, CEO of the American Association for the Advancement of Science (AAAS), one of the award’s sponsors. In their announcement, they noted that Townes “is hailed as a primary architect of laser technology. Early in his career, though, he was reportedly warned not to waste resources on an obscure technique for amplifying radiation waves into an intense, continuous stream. In 1964, he shared the Nobel Prize in Physics with Nikolay Basov and Alexander Prokhorov.”

The Golden Goose Award “highlights the unpredictable nature of basic scientific research and the fact that some of the most important scientific discoveries come from federally funded research that may once have been viewed as unusual, odd or obscure.”

In an April 2012 press release Representative Cooper said, “We’ve all seen reports that ridicule odd-sounding research projects as examples of government waste. The Golden Goose Award does the opposite. It recognizes that a valuable federally funded research project may sound funny, but its purpose is no laughing matter. I hope more of my colleagues will join us in supporting, not killing, the goose that lays the golden egg.”

Other members of Congress supporting the Golden Goose Award include Representatives Jason Altmire (D-PA.), Rush Holt (D-NJ) and Paul Tonko (D-NY).

FACULTY AWARDS AND HONORS, 2011-2012

Robert Birgeneau was awarded the 2012 Clifford G. Shull Prize of the Neutron Scattering Society of America (NSSA) “for his seminal scientific contributions, tireless leadership, and devoted mentoring in the field of neutron scattering.”

Dmitry Budker received a Miller Professorship for 2012-13.

Carlos Bustamante won the prestigious 2012 Vilcek Prize for Biomedical Science, “in recognition of his groundbreaking research into the inner workings of the cell and movement of individual molecules within cells.” He was also named the Raymond and Beverly Sackler Professor in Biophysics.
**John Clarke** was elected as a Foreign Associate of the National Academy of Sciences. He also delivered the Morris Loeb Lectures at Harvard University.

**Marvin Cohen** received Carnegie Mellon's 2011 Dickson Prize in Science at an award ceremony and lecture held on March 8, 2012. The nomination was given “to honor one of the most influential condensed matter physicists in the world. His work, which focuses on developing theories to predict and explain the properties of materials, has had a significant impact in the fields of nanotechnology and materials science.”

**Joel Fajans** is the recipient of the 2011 John Dawson Award for Excellence in Plasma Physics “for the introduction and use of innovative plasma techniques which produced the first demonstration of the trapping of antihydrogen.”

**Reinhard Genzel**, along with Andrea Ghez of UCLA, received the prestigious Crafoord Prize in Astronomy from the Swedish Royal Academy “for their observations of the stars orbiting the galactic centre, indicating the presence of a supermassive black hole.” In addition, Genzel received the Tycho Brahe Prize of the European Astronomical Society “in recognition of his outstanding contributions to European near-infrared astronomy, through the development of sophisticated instrumentation, and for ground-breaking work in galactic and extragalactic astronomy leading to the best evidence to date for the existence of black holes.” He was also elected as a Foreign Member of the Royal Society (London).

**Naomi Ginsberg** received The David and Lucile Packard Fellowship in Science and Engineering. She is also the recipient of a Defense Advanced Research Project Agency (DARPA) Young Faculty Award.

**Wick Haxton** is a Phi Beta Kappa Visiting Scholar 2012-13. He also received an Alexander von Humboldt Award.

**Robert Jacobsen** completed a term as the Chair of the Berkeley Academic Senate.

**Daniel Kasen** is the recipient of a 2012 Department of Energy Early Career Award for Modeling Astrophysical Explosions and the Nucleosynthesis of the Heavy Elements.

**Edgar Knobloch** received a Docteur Honoris Causa from the Université Paul Sabatier in Toulouse, France. He was also named Chaire d’Excellence Pierre-de-Fermat-Région, Midi-Pyrénées, France. He will hold this Chair at the Institut de Mécanique des Fluides de Toulouse.

**Steve Louie** was named a Simons Fellow in Theoretical Physics for 2012-13.

**Robert Lin** was appointed an Honorary Fellow of the Royal Astronomical Society, London.

**Holger Mueller** received a Defense Advanced Research Project Agency (DARPA) Young Faculty Award. He also received a National Science Foundation (NSF) career award.

**Yasunori Nomura** was named a Simons Fellow in Theoretical Physics for 2012-13.

**Eliot Quataert** received a Simons Investigator award for 2012-13. He is the Selpeter Lecturer, Cornell University, 2012.

**Bernard Sadoulet**, along with Blas Cabrera from Stanford University, were awarded the 2013 W.K.H. Panofsky Prize in Experimental Particle Physics “for their pioneering work and leading roles in the development and use of phonon detection techniques enabling direct searches for weakly interacting massive particle.” In addition, he was elected to the National Academy of Sciences and to the American Academy of Arts and Sciences.

**George Smoot** received the 2012 Premio scientifico Capo d’Orlando Prize.

**Charles Townes** is one of the recipients of the inaugural Golden Goose Award as the inventor of laser technology. The first annual ceremony took place on Capitol Hill, Washington, D.C. He also received an Honorary Doctor of Letters, Texas A&M University and a plaque of appreciation for “unique contribution to humanity, including the invention of the Maser and Laser” from the Nepal Association for Global Cooperation 2012. In addition, he received the Nancy DeLoye Fitzroy and Ronald V. Fitzroy Medal from the American Society of Mechanical Engineers (ASME) 2012.

**Ashvin Vishwanath** holds a Distinguished Research Chair at the Perimeter Institute for Theoretical Physics, Ontario, Canada, and was also named a Simons Fellow in Theoretical Physics for 2012-13.

**Jonathan Wurtele** received the 2011 John Dawson Award for Excellence in Plasma Physics “for the introduction and use of innovative plasma techniques which produced the first demonstration of the trapping of antihydrogen.”

**Martin White** was elected a fellow of the American Academy of Arts and Sciences (AAAS).
Christopher McKee, a distinguished member of the Berkeley faculty since 1974, retired in June of this year. McKee is a theoretical astrophysicist who studies the physical processes that take place in the interstellar medium, particularly the mechanisms of star formation. He served as Founding Director of Berkeley’s Theoretical Astrophysics Center in 1985, directed the Space Sciences Laboratory from 1985-1998, and chaired the Department of Physics from 2000-2004.

McKee was supported by a Hertz Fellowship and received his PhD from Berkeley in 1970, working under the supervision of American astrophysicist George Field. Before joining the Berkeley faculty in 1974, McKee worked at Lawrence Livermore National Laboratory for a brief time, spent a year as a postdoctoral fellow at Caltech, and then served as Assistant Professor of Astronomy at Harvard University for three years. He is a member of the National Academy of Sciences and the American Academy of Arts and Sciences, and has been both a Miller Professor and a Guggenheim Fellow. He co-chaired the year 2000 decadal survey in astronomy and astrophysics.

“Chris has been an exemplary citizen of the department and the campus for many years,” says Mark Richards, Dean of Physical Sciences in the College of Letters and Science. “He provided important leadership for the Space Sciences Laboratory (SSL), including planning of the new building. His support as SSL Director was instrumental in helping Berkeley establish a presence in atmospheric and climate science. He provided a steady hand and strong strategic leadership as physics department chair during a very difficult period for the department. And he also provided important leadership for the campus as chair of the important Academic Senate Budget Committee. Chris managed to do all this while continuing to be one of the leading lights in theoretical astrophysics.”

An important element of McKee’s University service portfolio is his successful founding of Berkeley’s Theoretical Astrophysics Center. “The TAC is another Organized Research Unit analogous to the Space Sciences Lab,” says Jon Arons, TAC emeritus director. “That Center, and Chris’s leadership of the astrophysics theory effort, has been essential to Berkeley’s advance over the last 40 years to its current status as a world capital of astrophysics theory, as well as astrophysics in general.”

Berkeley astronomy professor Eliot Quataert adds, “Over the past four decades McKee has made some of the most significant contributions in astronomy on a wide spectrum of topics. Many of his papers have defined the direction of research in subsequent decades. McKee has had a particularly large impact on studies of the dynamics of gas in galaxies (out of which stars form); how stars themselves form; and the atomic emission produced by gas near massive black holes, which is used to measure the masses of astrophysical black holes.”

Berkeley astronomy professor Carl Heiles, a colleague of McKee’s for several decades, identifies McKee as “the foremost theorist in the field of the interstellar medium on scales above protostellar disks, and a frontier player on the smaller scales as well. The whole body of work lays the foundation for just about everything that’s relevant to the interstellar medium.”

Heiles also commends his colleague’s dedication to teaching graduate students, citing his experience when he and McKee team-taught a course on the interstellar medium. “It was a challenge to keep up with him,” Heiles notes.

Early in his career, McKee developed a model for the interstellar medium, in collaboration with astrophysicist Jerry Ostriker of Princeton, that has been widely used to both understand observations in our galaxy and to model the dynamics of the interstellar medium of galaxies. The work McKee did on relativistic explosions, in collaboration with astrophysicist Roger Blandford of Stanford University, is now used to interpret gamma-ray bursts, the most luminous events in the universe. With David Hollenbach, astrophysicist at NASA Ames, McKee studied the structure of shock waves in molecular gas and the spectrum of the radiation they emit.

For the last 20 years, much of McKee’s research has focused on the question of how stars form out of the tenuous interstellar medium. Like turbulence, which is one of the great unsolved problems in classical physics, star formation is challenging because it involves an enormous range of scale, in both space (from light years to less than a light second) and time (from millions of years to minutes). Even the largest supercomputers today cannot handle this enormous range of scales.

With his colleague Richard Klein, a scientist at Lawrence Livermore National Laboratory and an adjunct professor in the Astronomy Department, McKee and their students and postdocs put together a powerful
computer code that includes magnetohydrodynamics, gravity, and radiative transfer. With this code, they have simulated the formation of individual stars and small clusters of stars, as well as the massive clouds of molecular gas out of which the stars form. Questions they are addressing now include: What determines the distribution of stellar masses? How do magnetic fields affect star formation? How did the very first stars form?

In looking back at his career, McKee notes that he is particularly appreciative of the wonderful students with whom he was privileged to work. A number of these students are now faculty members at other universities, and he recently had the opportunity of collaborating with one of his ‘grand-students’.

As for the future, McKee sees himself as being on a permanent sabbatical, free to pursue the research that interests him while at the same time, as he puts it, “being able to take time off to travel the world – especially those places with great food and wine.”

**NEW FACULTY**

**James Analytis** joined the faculty of the Department of Physics as assistant professor this summer, with a joint appointment in the Material Science Division at Lawrence Berkeley National Lab. He received a Bachelor degree from the University of Canterbury, New Zealand and a PhD from the University of Oxford as a Rhodes’ scholar. He spent 2 years as a Lloyd’s Tercentenary Fellow at the University of Bristol, UK and for the two years prior to his arrival at Berkeley, he was an Associate Staff Scientist at SLAC, National Accelerator Lab.

Analytis’ research focuses on the investigation of exotic materials that manifest quantum phenomena with both fundamental and technological implications, particularly superconductors, exotic magnets, and topological insulators. He says, “The physics of quantum matter transcends the properties of a given material. Each compound can shed new light on a very general scientific question. Materials should be used as a tool to get to important problems and it is through this process that we learn how we might design materials with their quantum mechanical properties in mind.”

Analytis has a lab at LBNL capable of a number of synthesis techniques directed primarily toward fabrication of single-crystal materials. He has a second lab located on campus which will measure thermodynamic properties of these materials, including heat capacity, magnetization, and elastic constants. The Analytis lab will focus on developing high-field magneto-transport techniques in-house and in collaboration with national facilities across the US, particularly the National High Magnetic Field Lab in Florida and Los Alamos National Labs in New Mexico.

**Gabriel Orebi Gann** joined the U. C. Berkeley physics department as an Assistant Professor in January of this year, with a joint appointment in the Nuclear Science Division at Lawrence Berkeley National Laboratory.

Orebi Gann attended the University of Cambridge in the UK from 2000 to 2004, where she received her BA and MSci in Natural Sciences. She went on to the University of Oxford, and was awarded her DPhil in Particle and Nuclear Physics in 2008. Her post-doctoral research was performed at the University of Pennsylvania, in Professor Klein’s research group.

Orebi Gann is an experimental particle physicist with an interest in weakly interacting particles. Her research focuses on neutrinos and dark matter, which is about as weakly interacting as you can get!

“Neutrinos are unique in the Standard Model of particle physics, with masses many orders of magnitude below any other known fundamental particle,” says Orebi Gann. “The reason for this is not yet understood, but could shed light on critical questions such as the absence of antimatter in our matter-dominated Universe. Their tiny masses and incredibly weak interaction strengths make neutrinos our ‘hidden messenger’, allowing us to probe otherwise unreachable regions: from the depths of the Earth beneath our feet to the very core of the Sun, and even into far-distant supernovae.”

Orebi Gann works on the SNO+ experiment, which uses an underground neutrino detector located in Ontario, Canada. SNO+ will study the fundamental nature of the neutrino itself, with the potential to determine whether the neutrino is in fact its own antiparticle. It will also use neutrinos to better understand the composition of the Sun, heat production in the Earth, and the mechanisms of star collapse.
Professor Kinsey A. Anderson, a pioneer and international leader in the research field that is now called space physics, passed away Monday June 11, 2012. He was surrounded by his wife Lilica, daughters Sindri and Danae, and his grandchildren.

Kinsey was a Professor of Physics at the University of California, Berkeley from 1960 and he was the second director of the Space Sciences Laboratory, one of its most prestigious research units. His research achievements resulted in his election as a Member of the National Academy of Sciences as well as his receiving a Guggenheim Fellowship, the Space Science Award from the American Institute of Astronautics and Aeronautics, a NASA Medal for Exceptional Scientific Achievement, the Alexander von Humboldt Award, Fellowships in the American Geophysical Union, the American Physical Society and the American Association for the Advancement of Science, as well as Docteur Honoris Causa de l’Universite de Toulouse. Upon retirement in 1990, Kinsey received the Berkeley Citation for distinguished achievement and notable service to the University.

Kinsey was an author of approximately 200 papers in the refereed literature. He trained 24 graduate students on such diverse topics as instrument design; auroral, solar, and cosmic x-ray emissions; energetic particles from the Sun, the Earth’s bow shock, magnetosphere, and tail; the plasma physics of the Halley’s comet; and remnant magnetic fields of the moon and Mars.

Kinsey was born into an art and music loving family on September 18, 1926, in Preston, Minnesota. He inherited a love of culture that was passed on to his children and grandchildren, who are commercially successful in such fields. His interest in science was triggered and nurtured by a high school biology teacher who took him on many field trips. This led to his majoring in physics at Carleton College where, among his other achievements, he met and tutored a Greek girl, Lilica, whom he married. A large array of friends benefited from the Greek food and dancing that Lilica brought to this marriage.

Together Kinsey and Lilica moved to the University of Minnesota in 1949. Kinsey was awarded his PhD in 1955, during the same week that his first daughter was born. Kinsey was a member of the team that did the original research and development of balloons later used in many ways for high-altitude research and he was awarded a patent for a novel method of measuring stresses in balloon material for different shapes of balloons. Under the supervision of John Winckler, and using the balloon technology he had helped to develop, Kinsey measured cosmic rays as functions of latitude and altitude for his Ph.D. thesis, which included balloon launches from a U.S. aircraft carrier in the South Pacific.

During a high-altitude balloon flight from northern Canada while he was a post-doc at Minnesota, Kinsey and Winckler observed an enhancement in the x-ray counting rate that might have been due to bremsstrahlung x-rays from electrons associated with auroras precipitating into the upper atmosphere. This was the beginning of a long career on x-ray measurements in space.

Kinsey accepted a post-doctoral and then a faculty position at the University of Iowa in 1958. While at Iowa, he was the first person to study long duration temporal variations of auroral zone x-ray fluxes and to confirm that intense fluxes of very energetic protons were emitted by the sun during solar flares. This energetic proton work had such profound importance to the field that it was mentioned extensively in books by Bruno Rossi and Walter Sullivan, among others.

During an extended visit in 1959 to the laboratory of Hannes Alfven in Stockholm, Kinsey was offered a faculty position at Berkeley by Carl Helmholz. Kinsey accepted this offer over several others and moved to Berkeley from Stockholm in 1960. In Berkeley, he switched to the new technology of satellite instrumentation and he and his students successfully flew instruments on more than two dozen spacecraft since the beginning of the space age. These include IMP 1-6, Explorers 33 and 35, OGO 5, and the Apollo 15 and 16 Subsatellites during his first decade on campus, which may be a record number for any individual or research group. A characteristic of this work was Kinsey’s unselfish leadership, which enabled his students to manage all aspects of their own research programs. This approach produced scientists who are world leaders in research fields initiated by Kinsey and colleagues who appreciated Kinsey’s assistance in establishing their own research programs.

Another lasting contribution of Kinsey Anderson came from his service as the second director of the Space Sciences Laboratory. During his decade-long tenure as director, the laboratory achieved its independence and greatest growth to become a world leader in space research. A major contributor to this growth was the Senior Fellow program initiated by Kinsey. This program allowed research scientists to become principal investigators.
and to thereby allow faculty members to be free of the administrative and technical burdens associated with the special needs of space flight programs.

Kinsey is remembered not only as a preeminent scientist, but as a humble, curious, and witty man whose interests in art, music, nature, and culture enriched the lives of all who knew him. A fund in his memory has been established at the California Audubon Society. For more information on donating to the Kinsey Anderson Memorial Fund, contact Audubon California, 4225 Hollis Street, Emeryville, CA 94608, 520-601-1866, or visit ca.Audubon.org.

A memorial celebration of Kinsey Anderson’s life and legacy was held on September 9th, 2012 in the Atrium at the Unitarian Universalist Church of Berkeley.

—Contributed by Forrest Mozer; George Parks; Bob Lin; and Lilica, Danae, and Sindri Anderson

KENNETH CROWE (1926-2012)

Professor Kenneth M. Crowe, a distinguished nuclear physicist who worked at Lawrence Berkeley National Laboratory from 1956 and served on the UC Berkeley Department of Physics faculty from 1958 to 1991, died February 1, 2012. He was 85.

A precocious student, Crowe skipped his senior year of high school to attend Brown University, graduating in 1948. He received his PhD from UC Berkeley in 1952, with Luis Alvarez and Wolfgang Panofsky on his doctoral committee. He joined Stanford University's Hansen Laboratories of Physics, where he stayed until 1956, then returned to UC Berkeley to work at the Lawrence Radiation Laboratory — now the Lawrence Berkeley National Laboratory (LBNL).

Crowe co-authored with E. Richard Cohen and Jesse DuMond the influential textbook, *Fundamental Constants of Physics*, published in 1957. He joined the Berkeley physics faculty in 1958. His career focused on medium-energy experiments, in particular on the muon, the electron’s massive cousin. He is credited as a pioneer who defined these areas of study.

Crowe’s research was summarized in a March 13, 2012 obituary written by Paul Preuss of the LBNL News Center:

Crowe’s forte was small-scale experiments of fundamental importance. Early on, much of his research could be performed at Berkeley Lab’s 184-Inch Cyclotron, while later he and his students and colleagues pursued projects at “meson factories” like the Los Alamos Meson Physics Facility in New Mexico, LAMPF (now LANSCE); TRIUMF in Vancouver, B.C.; and the Swiss Institute for Nuclear Physics, now the Paul Scherrer Institute (PSI).

Beams of muons, the heavy and short-lived cousins of electrons, have excellent qualities for exploring the properties of molecules and materials, and muons also have the peculiar ability to catalyze nuclear fusion at low temperatures: replacing electrons in hydrogen molecules, their extra mass encourages the nuclei to fuse readily.

“Crowe was a leader in investigating these phenomena and their underlying principles. Many of his students and postdocs from the United States and other countries sought him out in Berkeley or were lucky enough to make his acquaintance here, and are now leaders in such fields as muon spin rotation and muon-catalyzed fusion. Beyond muons, medium energy physics embraces many other areas, and in the 1980s Crowe, together with European collaborators, conceived an experiment for the Low Energy Antiproton Ring (LEAR) at CERN called the Crystal Barrel, used to test the fundamental theory of nuclear physics, quantum chromodynamics (QCD). His work involved searching for exotic QCD states in relatively unexplored lower-energy regions.

“The Crystal Barrel experiment lasted several years, and during that time Crowe and his wife, Penny, lived across the border from CERN headquarters in the French countryside, a home fondly remembered by his colleagues, not least for Penny’s bouquets of wildflowers and her excellent cooking. In California the cooking was just as memorable, where home was a hexagonal house on stilts, on the waterfront in Point Richmond; Crowe built it himself from a kit and kept his boat tied to the rail.

Crowe’s honors included being named a Fellow of the American Physical Society and a Fellow of the Japan Society for the Promotion of Science. He received the Humboldt Senior Scientist Award in 1987, and was a Scientific Associate in the CERN Fellowship Program from 1990-1991.

Crowe was an enthusiastic cellist. He took up the instrument after retirement and became accomplished enough to participate in a number of recitals. He was also a dedicated yachtsman and sailor who drew his students and postdocs into races on his 5.5 meter sloop.

Crowe is survived by his wife and six children. A memorial service was held in Kensington, CA on March 17. Donations in Crowe’s memory can be made to an annual fund at Brown University. For information, contact crowememorial@gmail.com.
In Memoriam: Stuart Freedman, Renowned Nuclear Physicist

STUART FREEDMAN (1944-2012)

Stuart Jay Freedman, a member of the UC Berkeley physics faculty since 1991, died suddenly on November 9 while attending a scientific conference in Santa Fe, NM. He was 68.

Freedman was a nuclear physicist and a world-renowned investigator of fundamental physical laws. He held a joint appointment with Lawrence Berkeley National Laboratory (LBNL).

“Stuart was a truly remarkable scientist, with extraordinarily diverse interests, and still very much at the height of his powers,” says James Symons, Director of LBNL’s Nuclear Science Division. “It is somehow fitting that he spent his last few days with close friends, actively engaged in discussing new ways to make a fundamental measurement requiring deep insight and ingenuity. We have lost a great physicist, but I can’t imagine that he would have wanted to leave us in any other way.”

Freedman’s friend and long-time associate, Berkeley Lab physicist Robert Cahn, recalls that “Stuart started as a particle theorist but became an extraordinarily versatile and creative experimentalist, with a reputation for getting the right answer, often when others didn’t.”

Freedman became widely known for work with neutrinos, notably the 2003 confirmation that different neutrinos have different tiny masses and oscillate from one “flavor” to another. His essential contributions to that result were a consequence of his leadership of US participation in the KamLAND experiment in Japan, especially in detector technology and signal processing.

“The KamLAND oscillation result was one of Stuart’s own proudest accomplishments,” says Jason Detwiler, an Assistant Professor at the University of Washington who met Freedman during the construction of KamLAND and subsequently worked with him at LBNL for many years. While the SNO experiment in Canada had established that neutrinos change flavor while traveling from the sun to Earth, “KamLAND was designed to capture antineutrinos produced by nuclear reactors, and it was Stuart’s kind of experiment – a laboratory-style experiment in which both the source and the detector were controlled. The upshot was that KamLAND produced the first clean signature of actual oscillation.”

Detwiler characterizes Freedman’s experimental style as “like a Grand Master in chess, always thinking many steps ahead. He always had the clearest view of the science and the experiment’s essential rationale.”

Spencer Klein, Deputy Division Director of the Nuclear Science Division, says, “Stuart was a driving force in our division, in the physics department on campus, and in the international neutrino community.”

Besides neutrino oscillation, Freedman’s contributions to neutrino science include KamLAND’s detection of “geo-neutrinos” originating from radioactive decays inside the Earth, and, as US spokesperson and US construction project manager of the CUORE experiment at the Gran Sasso underground laboratory in Italy, devising a promising approach to the search for the as-yet-undetected process of neutrinoless double-beta decay, which if found would indicate that neutrinos are their own antiparticles.

Within the last decade Freedman contributed widely to the nuclear science community, including co-chairing the recent National Academy of Science’s decadal survey of nuclear physics, Nuclear Physics: Exploring the Heart of Matter; co-chairing the National Research Council report, Scientific Opportunities with a Rare-Isotope Facility in the United States; and co-chairing the American Physical Society’s magisterial neutrino study, The Neutrino Matrix.

At the time of his death, Freedman was also the leader of the Weak Interaction Group based in LBNL’s Nuclear Science Division. His work established the parameters of the weak interaction in the coupling of weak currents to the neutron. Because these measurements are essential to understanding nuclear fusion, says Robert Cahn, “They make it possible for us to determine the temperature at the center of the sun.”

Freedman was born in Los Angeles on January 13, 1944 and received his education at UC Berkeley, graduating with a BS in Engineering Physics in 1965, an MS in Physics in 1967, and a PhD in Physics in 1972. His teaching career took him from Princeton to Stanford, and then to a stint at Argonne, where he meanwhile became a professor in the University of Chicago’s Fermi Institute.

In 1991 he came to LBNL and UC Berkeley, where he assumed joint appointments as Faculty Senior Scientist in the Nuclear Science Division and Professor in the Department of Physics, while maintaining his affiliation with Argonne and the University of Chicago. Since 1999 he held the Luis W. Alvarez Memorial Chair in Experimental Physics at UC Berkeley. His numerous awards and honors include election to the National Academy of Science in 2001 and the 2007 Tom W. Bonner Prize for Nuclear Physics from the American Physical Society.

Freedman was a resident of Berkeley and is survived by his wife, Joyce, his son Paul, and two grandchildren.
PHYSICS IN THE MEDIA

PHYSICS IN THE NEWS
EXCERPTS FROM NEWS COVERAGE OF BERKELEY PHYSICISTS

QUANTUM EFFECTS OBSERVED IN OPTOMECHANICAL SYSTEM
from Photonics.com August 21, 2012
The first direct observations of distinctly quantum optical effects—amplification and squeezing—have been recorded in an optomechanical system. The step forward points the way to low-power quantum optical devices and enhanced detection of gravitational waves, among other applications.

...“We’ve shown for the first time that the quantum fluctuations in a light field are responsible for driving the motions of objects much larger than an electron and could in principle drive the motion of really large objects,” said physicist Daniel Brooks, a member of Dan Stamper-Kurn’s research group. Using light to move large objects has long been a staple of science fiction: think the tractor beam used in both “Star Trek” and “Star Wars.” While these tractor beams remain science fiction, beams of light today are being used to mechanically manipulate atoms or tiny glass beads, with rapid progress being made to control increasingly larger objects.

PHOTOVOLTAICS FROM ANY SEMICONDUCTOR
from GreenDesignElements.com July 27, 2012
A technology that would enable low-cost, high efficiency solar cells to be made from virtually any semiconductor material has been developed by researchers with the U.S. Department of Energy (DOE)’s Lawrence Berkeley National Laboratory (Berkeley Lab) and the University of California (UC) Berkeley. This technology opens the door to the use of plentiful, relatively inexpensive semiconductors, such as the promising metal oxides, sulfides and phosphides, that have been considered unsuitable for solar cells because it is so difficult to tailor their properties by chemical means.

“It’s time we put bad materials to good use,” says physicist Alex Zettl, who led this research along with colleague Feng Wang. “Our technology allows us to sidestep the difficulty in chemically tailoring many earth abundant, non-toxic semiconductors and instead tailor these materials simply by applying an electric field.”

Zettl, who holds joint appointments with Berkeley Lab’s Materials Sciences Division and UC Berkeley’s Physics Department where he directs the Center of Integrated Nanomechanical Systems (COINS), is the corresponding author of a paper describing this work in the journal Nano Letters. The paper is titled “Screening-Engineered Field-Effect Solar Cells.”

THEORY EXPLAINS THE QUANTUM WEIRDNESS OF EXOTIC MATERIALS
from Wired.com June 18, 2012 by Adam Mann
The universe has no shortage of bizarre materials. Superfluids are liquids that can flow straight up walls, Bose-Einstein condensates are gasses that will vibrate eternally, and neutron stars are essentially city-sized subatomic particles.

Physicists have now developed a mathematical theory that describes how collective quantum mechanical weirdness leads to the strange properties of these materials. While previous work has focused on each individual system, the new theory unites the behavior for many materials, including magnets, superfluids, and neutron star matter.
“It’s like shooting many, many birds with one stone,” said particle physicist Hitoshi Murayama of UC Berkeley, co-author of a paper on the work that appeared in Physical Review Letters June 15. Murayama and his graduate student, Haruki Watanabe, showed that the behavior of these materials hinges on a phenomenon known as spontaneous symmetry breaking. Symmetry breaking happens when a group of particles that once had no preferred alignment or direction suddenly does, creating a collective behavior.

CLOCKING AN ACCELERATING UNIVERSE: FIRST RESULTS FROM BOSS

from the Berkeley Lab News Center March 30, 2012

Some six billion light years ago, almost halfway from now back to the big bang, the universe was undergoing an elemental change. Held back until then by the mutual gravitational attraction of all the matter it contained, the universe had been expanding ever more slowly. Then, as matter spread out and its density decreased, dark energy took over and expansion began to accelerate.

Today BOSS, the Baryon Oscillation Spectroscopic Survey, the largest component of the third Sloan Digital Sky Survey (SDSS-III), announced the most accurate measurement yet of the distance scale of the universe during the era when dark energy turned on.

...“BOSS’s first major cosmological results establish the accurate three-dimensional positions of 327,349 massive galaxies across 3,275 square degrees of the sky, reaching as far back as redshift 0.7 – the largest sample of the universe ever surveyed at this high density,” says Martin White of Berkeley Lab’s Physics Division, a professor of physics and astronomy at the University of California at Berkeley and chair of the BOSS science survey teams. “BOSS’s average redshift is 0.57, equivalent to some six billion light-years away. BOSS gives that distance to within 1.7 percent – 2,094 megaparsecs plus or minus 34 megaparsecs – the most precise distance constraint ever obtained from a galaxy survey.”

A NEW TOOL TO ATTACK THE MYSTERIES OF HIGH-TEMPERATURE SUPERCONDUCTIVITY

from Nanotimes June 2012

A team of scientists at Berkeley Lab and the University of California at Berkeley (US), led by Alessandra Lanzara in collaboration with [Berkeley physics professors] Joseph Orenstein and Dung-Hai Lee of the Lab’s Materials Science Division (MSD), has used a new and uniquely powerful tool to attack some of the biggest obstacles to understanding the electronic states of high-temperature superconductors – and how they may eventually be put to practical use.

The team reports their research using ultrafast laser ARPES (ultrafast Angle-Resolved PhotoEmission Spectroscopy) in the journal Science. “The mechanism binding Cooper pairs together in high-Tc superconductors is one of the great mysteries in materials science,” says Christopher Smallwood, a member of Lanzara’s group and first author of the Science paper. “What we’ve done with ultrafast laser ARPES is to start with a high-Tc superconductor called Bi2212 and cool it to well below the critical temperature where it becomes superconducting.”

ANNOUNCING THE FIRST RESULTS FROM DAYA BAY: DISCOVERY OF A NEW KIND OF NEUTRINO TRANSFORMATION

from Interactions NewsWire March 8, 2012

From Dec. 24, 2011, until Feb. 17, 2012, scientists in the Daya Bay collaboration observed tens of thousands of interactions of electron antineutrinos, caused by six massive detectors buried in the mountains adjacent to the powerful nuclear reactors of the China Guangdong Nuclear Power Group. ...The copious data revealed for the first time the strong signal of the effect that the scientists were searching for, a so called “mixing angle” named theta one-three (written 013), which the researchers measured with unmatched precision.
“Although we’re still two detectors shy of the complete experimental design, we’ve had extraordinary success in detecting the number of electron antineutinos that disappear as they travel from the reactors to the detectors two kilometers away,” says Kam-Biu Luk of the U.S. Department of Energy’s Lawrence Berkeley National Laboratory (Berkeley Lab) and the University of California at Berkeley. Luk is co-spokesperson of the Daya Bay Experiment and heads U.S. participation.

“What we didn’t expect was the sizable disappearance, equal to about six percent. Although disappearance has been observed in another reactor experiment over large distances, this is a new kind of disappearance for the reactor electron antineutrino.”

“Even with only the six detectors already operating, we have more target mass than any similar experiment, plus as much or more reactor power,” says William Edwards of Berkeley Lab and UC Berkeley, the U.S. project and operations manager for the Daya Bay Experiment. Since Daya Bay will continue to have an interaction rate higher than any other experiment, Edwards explains, “it is the leading theta one-three experiment in the world.”

The first Daya Bay results show that theta one-three, once feared to be near zero, instead is “comparatively huge,” Kam-Biu Luk remarks, adding that “Nature was good to us.” In coming months and years the initial results will be honed by collecting far more data and reducing statistical and systematic errors.

“Exemplary teamwork among the partners has led to this outstanding performance,” says [UC Berkeley physics professor] James Siegrist, DOE Associate Director of Science for High Energy Physics. “These notable first results are just the beginning for the world’s foremost reactor neutrino experiment.”

FIRST SPECTROSCOPIC MEASUREMENT OF AN ANTI-ATOM

from Science Daily March 7, 2012

The ALPHA collaboration at CERN in Geneva has scored another coup on the antimatter front by performing the first-ever spectroscopic measurements of the internal state of the antihydrogen atom. ...the ALPHA researchers created and captured hundreds of antihydrogen atoms in a magnetic bottle, then probed their internal states by bathing them in microwave radiation that flipped the spins of the positrons, causing the immediate ejection of the atoms from the magnetic trap and their annihilation on the trap wall.

“To measure the hyperfine structure of antihydrogen we tune the frequency of the microwaves,” says Jonathan Wurtele, a member of the Accelerator and Fusion Research Division (AFRD) at the U.S. Department of Energy’s Lawrence Berkeley National Laboratory (Berkeley Lab), a professor of physics at the University of California at Berkeley, and a long-time member of the ALPHA collaboration.

...Joel Fajans, a founding member of ALPHA who is also a member of AFRD and a physics professor at UC Berkeley, explains that if one were trying to capture ordinary hydrogen atoms in a similar trap, “the vacuum in these traps is always contaminated with hydrogen, so how could you distinguish the background hydrogen from the deliberately trapped hydrogen?” But, says Fajans, “you can’t trap antihydrogen accidentally; it just doesn’t occur naturally.”

BOOKS AND ARTICLES AUTHORED OR EDITED BY BERKELEY PHYSICISTS

ENERGY FOR FUTURE PRESIDENTS: THE SCIENCE BEHIND THE HEADLINES


Berkeley physics professor Richard A. Muller has penned a new book that follows in the tradition of his earlier release, Physics for Future Presidents. The new book is written for general readers and contains fundamental information Muller believes is needed by anyone trying to make well-considered decisions about energy supply and demand.

A May 2012 review in Publisher’s Weekly calls Energy for Future Presidents “a no-nonsense scientific primer on energy policy” that “explores the contentious issues that will increasingly preoccupy politicians and citizens. ...Muller brings fresh, often contrarian perspectives to topics that have been saturated in misinformation and hype, arguing, for example, that new techniques to extract the stupendous reserves of petroleum in shale and tar sands will eliminate all talk of peak oil;
that wind power and photovoltaics will boom while corn ethanol, geothermal, and tidal power will fizzle; that household energy conservation is a great investment, while public transit is usually a bad one; and that China’s soaring carbon dioxide emissions will render America’s almost irrelevant—and that the best way to abate China’s emissions is by switching from coal to natural gas. Especially revealing is his positive assessment of nuclear energy, which effectively debunks the alarmism surrounding the March 2011 Fukushima accident. The author’s explanations of the science underlying energy production are lucid but never simplistic—and often fascinating in their own right. Policy makers and casual readers alike can benefit from Muller’s eye-opening briefing, which sheds lots of light with little wasted heat.”

Muller has written several other books. Among them are a textbook, Physics and Technology for Future Presidents, and two general interest titles, Physics for Future Presidents, and The Instant Physicist.

**COMMENTARY: JIM SIEGRIST FORGING AHEAD TOWARD THE FRONTIERS**

*from an article by Jim Siegrist in Symmetry Vol. 9 Issue 1, Feb 2012*

It’s a challenging time for particle physics in the United States. The outlook for federal spending for physics research — indeed for all of science — is uncertain. For the first time in decades, there is no particle collider for high-energy physics operating or under construction on US soil. In the midst of fierce international competition in neutrino physics, the future of the Long-Baseline Neutrino Experiment remains unclear. And in the midst of this time of uncertainty I stepped into the role of director for the Department of Energy’s Office of High Energy Physics. You might wonder: why?

I took the job because I believe that a strong US particle physics research program is vitally important for the nation, and for the world. This program must be diverse in order to best position our community to make the next major discoveries and to follow where they lead. It must keep the US a leader in the field, to keep the balance between the major world regions and ensure a steady flow of new talent and ideas to US physics institutions. It must restore a healthy balance between funding for R&D, construction, and operations, so we can be ready to build and exploit the facilities necessary to take advantage of new discoveries.

The US was the birthplace of particle accelerators and today boasts the largest single community of particle and accelerator physicists in the world. Congress, recognizing the importance of particle physics and accelerator science to our country, directed DOE in its 2012 budget to deliver within nine months two strategic plans: one for particle physics with intense beams and a second for advanced accelerator R&D.

My colleagues and I in the Office of High Energy Physics have a busy year ahead, working with the US physics community to devise long-term strategies for those two areas while ensuring a balanced portfolio of research at the energy, intensity, and cosmic frontiers of particle physics.

**TOPOLOGICAL INSULATORS**

*from a feature article by Joel E. Moore in IEEE Spectrum, July 2011*

This is the story of a remarkable theory, hatched in the middle of the past decade, that experimentalists have been pursuing ever since. It is particularly sweet because it is linked to a branch of mathematics—topology—that had until now been mostly beyond any hope of practical application. And the discovery is about as straightforward as it gets: It is possible to produce materials that are insulators on the inside but conductors on the outside.

This is heady stuff, for engineers and physicists alike. The mobility, or speed, of the surface electrons in these materials is increasing dramatically every year. Just as important is their intrinsic stability, a quality that suggests they’d be robust enough to work in practical devices, such as extremely high-capacity interconnects and, one day, maybe even practical quantum computers. Physicists, meanwhile, are deeply intrigued by the possibility of using such materials to simulate new particles and other items of theoretical interest.
SOCIETY FOR PHYSICS STUDENTS

Berkeley’s Society for Physics Students (SPS), founded and operated by undergraduate students, was established to foster a sense of community in the Departments of Physics and Astronomy. SPS sponsors monthly barbecues, helps out with annual Cal Day activities, organizes tutoring sessions for lower division students, sponsors an annual Undergraduate Poster Session, and presents a series of noontime seminars that give students an opportunity to learn about the careers of physics alumni.

Undergraduate Poster Session

This year’s Undergraduate Poster Session took place in April and featured 28 research projects displayed in 375 Le Conte Hall. Research topics and the students who presented them included:

- Max Baugh – The Development of a Laue Lens Prototype for High-Energy Astrophysics
- Rebecca Carney – Electrical Prototyping of FE-14 Modules on Pixel Layer Staves for ATLAS Upgrade
- Thamine Dalichaouch – Numerical Simulations of Two-Dimensional Superconducting Quantum Interference Device (SQUID) Arrays
- Joe De Rose – On the Negative Correlations Between Maximum Intrinsic Luminosity and Silicon II Ration of Type Ia Supernovae
- Alexey Drobizhev – Measurement of Thermal Conductivity of Al2O3 Ceramic for Use in Bolometric Detection of Double Beta Decay Events
- Andrew Dunsworth – Polar Bear Telescope
- Nitin Kitchley Egbert – Approximating the Magnetorotational Instability with Spring-Coupled Masses in otherwise Keplerian Orbit
- Minyu Feng – Search Dark Photons in Electron/Positron Annihilation into Muons
- Jonathan Gibbons – AMR in an Antiferromagnetic material and CoO-FE Magnetic Interlayer Coupling
- Chi-Sing Ho – Tunable Plasmonic Diffraction Grating
- Edwin Huang – Pump Probe Spectroscopy of Gated Monolayer and Bilayer Graphene
- Rylan Hunt – Beta-Phase Mn3Al Grown in Thin Film Form
- Geoffrey Iwata – Electro-Optical Kerr Effect in Solid PMMA
- Rebecca Jolitz – Monte Carlo Model of High Energy Ion Precipitation in the Martian Atmosphere
- Dong Won Kim – Methods of Improving Event Selections in Black Hole Search in Same-Sign Dimuon Final States
- Andrew Lampinen – R&D for Cherenkov Based Detectors for Rare Processes
- Michael Lyons – Measuring Index of Refraction of Liquid Scintillator for the Daya Bay Neutrino Experiment
- Isha Nayak – Geometry of Spinar Condensates with Large Spins
- Matthew Nichols – Ultra-low Frequency MRI: Multiple Echo Imaging Sequences
- Matthew Noakes – Measurement of Inelastic Proton-Proton Cross Section at Square Root 2.76 TeV
- Kelsey Oliver-Mallory – Directional Dark Matter Prototype (Time Projection Chamber)
- Gina Quan – Building Together: An Undergraduate Freshman Class Defines Physics Model
- Darin Rosen – Development of Broad-Band Anti-Reflection Coating for Millimeter Wave Experiment
- Jessica Scholey – Thick Tri-Layers in High Aspect Ratio Nanostructures
- Maria Simanovskaia – Negatively Charged Nitrogen Vacancy Centers in Diamond for Magnetometry Applications
- Hyungmok Son – Electric Control of Plasmon Resonance with Graphene
- Andrew Vanderberg – An Algorithm to Increase the Spectral Resolution of the TEDI/Triplespec Instrument
- William Walker – Development of Helium3 Sorption Fridge for Millimeter Wave Experiment
SPS Noontime Career Seminars

At each noontime career seminar, undergraduate students are treated to pizza and a presentation about how a physics education can lead to a wide variety of successful careers. Offerings from the 2011-2012 academic year featured presentations from four Berkeley physics alumni.

Katherine Schwarz (PhD ’08) is a Seismic Imager at CGGVeritas in Houston, Texas. In her presentation, Physics and Seismic Imaging, she detailed the computation-intensive nature of seismic data processing, which requires a great deal of noise removal and constant development of new algorithms.

Mike Grobis (PhD ’05) is Technologist at Hitachi GST in San Jose, California. In his presentation, Hard Disk Drives: Rumors of their Death Have Been Greatly Exaggerated, he described the “remarkable science and technology inside the hard drive and the many opportunities that exist for physicists and engineers in the industry.”

Aniruddha Das (PhD ’85) teaches at the Department of Neuroscience at Columbia University’s College of Physicians and Surgeons. In his presentation, From Astrophysics to Brain Imaging, he described his research on the neurobiology of visual processing and the neural interpretation of common brain imaging techniques. He also talked about what life in med school was like for students and researchers.

Doug Tuttle (BA ’79) is a computer graphics specialist whose presentation was titled Physics in the Unreal World. He is now retired from a wide-ranging career that included working at Lawrence Berkeley National Laboratory and Lucasfilm’s Industrial Light and Magic. In 1998 he co-founded Onflow, a powerful graphics plugin that, he said, “supported animated content over the internet and ultimately had 40 million downloads.”

UPDATE ON THE PHYSICS 111 ADVANCED LAB CAMPAIGN

This summer, Phase 1 of the Campaign for the Advanced Lab was completed, including the renovation of the Instrumentation side – or Basic Semiconductors (BSC), as many know it. With over $1 million raised, including $300,000 in matching funds from Chancellor Birgeneau, we were able to rearrange the adjoining classrooms so that all 19 BSC stations could fit comfortably in one room, along with space for instruction and interaction. A new HVAC system makes the classrooms downright comfortable on hot days, and the noise (or lack thereof) means that GSIs can more easily be heard by students.

About $500,000 is still needed to complete Phase 2 of the Advanced Lab renovations, which involves reorganizing and upgrading the Experimentation side. We hope to make this happen in Summer 2013 or 2014. We invite you to drop by the classroom, both to see our progress and to remember your own challenging but rewarding experience in this important class. See the Development insert at the center of this issue of Physics@Berkeley for more information about giving to this campaign!

—Contributed by Maria Hjelm, Development Office

SEGRÈ SUMMER INTERNS 2012

Berkeley’s Emilio Segrè Internships provide three undergraduates the opportunity to work for eight weeks during the summer to hone their research and technical skills by improving the Physics 111 Advanced Lab course. This summer, the internships were awarded to May 2012 graduates Griffin Hosseinzadeh and Harry Nunns, Jr., and to continuing student Nitin Egbert. They participated in the transformation of the Physics 111 lab, both by...
PROGRAMS OF STUDENT ACTIVITY

SEGRÈ INTERNs Griffin HosseinZadeh and Nitin Egbert work on the quantum interference and entanglement experiment in the Advanced Lab.

completing new experiments and pitching in to reorganize the experiment layout as part of the phase 1 renovation of the lab rooms. The Segrè internship program is made possible through the generosity of alumnus Doug Giancoli (PhD ’66).

Quantum Interference

Griffin and Nitin took on the task of bringing the new Quantum Interference and Entanglement experiment started last summer to completion. The heart of the experiment is the generation of a particular entangled quantum state of the polarization of two individual photons, a Bell state.

To create the entangled photons, single 405 nm photons are converted by birefringent crystals to pairs of 810 nm photons emitted to either side of the original beam. The polarity of a photon pair is measured by passing each photon through separate polarization optics and detecting them with avalanche photodiodes. By analyzing large numbers of photon pairs, students can compare the results to predictions of alternative theories to quantum mechanics. The students’ goal will be to obtain results incompatible with theories that predict measurement results locally, i.e. what might be called a sensible theory based on our everyday intuition. These violations of Bell-inequalities are strong evidence that a proper theory of nature necessarily needs to be at least as strange as quantum mechanics.

The resulting experiment challenges students to assemble and align all of the optics downstream of the conversion crystal, requiring both a good understanding of the optics and careful technique. Griffin and Nitin enabled this by shielding the beam path of the high-powered 405 nm laser so students can work with the low-powered 810 nm beams without any chance of hazardous exposure. Professor Hartmut Häffner is helping the first student groups to perform the new experiment this Fall as he teaches the Physics III Experimentation section. Funding for this experiment was provided by Häffner’s NSF Career Award and a donation by alumnus Hans Mark (BA ’51).

Single Molecule Force Measurement

Harry Nunns added a new section to the Optical Tweezers Experiment that for the first time allows students to measure the stall force of a single dynein motor molecule. He wrote new software to control and take data on the optical tweezers and learned a technique from graduate student Vladislav Belyy in the laboratory of Professor Ahmet Yildiz.

In this experiment, a small Silica bead coated with the dynein motor molecules is trapped with the laser and moved next to a microtubule until the motor can attach and begin stepping along the microtubule. It pulls the bead along until the force of the laser stops it. Harry measured a stall force of just 3 piconewtons. This project was supported by the Professor Jan Liphardt and the Physical Sciences Oncology Center.

Renovating the Physics 111 Lab

As the three Segrè interns proceeded with their two major projects, the walls were literally coming down around them. Because several rooms were combined to create the new instrumentation lab, all of the experiments formerly housed there had to be moved, reassembled, and tested. Each intern took on several of these projects and helped move equipment and furniture as contractors ran pipes, pulled wires, and created clouds of dust. Nitin Egbert commented “I learned a lot more about each experiment than I did in the course, thanks to the large blocks of time to focus on one thing without the interruptions of problem sets and lab write-ups.”

Griffin HosseinZadeh is now doing research at Frascati National Laboratories (LNF) in Frascati, Italy, using lunar laser ranging (LLR) as a high-precision test of general relativity. Harry Nunns is doing a research internship on bacterial aging under stress at the University of Copenhagen and applying to graduate programs in biophysics and mathematical biology. Nitin Egbert is finishing his last year at Cal before pursuing his goal of becoming a surgeon and performing medical research.

—Contributed by Tom Colton, physics laboratory staff support, and physics professor Hartmut Häffner
UC Berkeley Departments of Physics, Astronomy, and Physical Sciences celebrated the 2011 Commencement at Zellerbach Auditorium on May 14, 2011. Alex Filippenko, UC Berkeley Professor of Astronomy and Rhoda Goldman Distinguished Professor in the Physical Sciences, delivered the commencement address. Pierre Christian was Student Speaker for Astronomy. Matthew Alan Nichols was Student Speaker for Physics.

COMMENCEMENT CEREMONIES

Officiating at the commencement were Mark Richards, Dean of Physical Sciences in the College of Letters and Science, Frances Hellman, Chair of the Department of Physics, Imke de Pater, Chair of the Department of Astronomy, Robert Jacobsen, Vice-Chair of the Department of Physics, Yury Kolomensky, Head Faculty Undergraduate Advisor in the Department of Physics, and Eliot Quataert, Faculty Undergraduate Advisor in the Department of Astronomy.

For the 2011-2012 academic year, 100 bachelor degrees were awarded in Physics, 25 in Astrophysics, and 15 in Engineering Physics. Two students in Astrophysics and 35 students in Physics received Master degrees. The degree of doctor of philosophy was awarded to 12 students in Astronomy and 42 students in Physics.

COMMENCEMENT ADDRESS

Commencement Speaker Alex Filippenko is one of the world’s most highly cited astronomers. His research on supernovae, active galaxies, black holes, gamma ray bursts, and cosmology is documented in almost 700 research papers. His research group developed the 0.76 meter Katzman Automatic Imaging Telescope at Lick Observatory, which is conducting one of the most successful searches for nearby supernovae. Filippenko was a member of both teams that used nearby supernovae to measure the accelerating expansion of the universe, a discovery for which the team leaders were awarded the 2011 Nobel Prize in Physics. Filippenko was elected to the National Academy of Science in 2009 and shared the Gruber Cosmology Prize in 2007.

Much of the public is afraid of science, he said, and you can help stop this cycle. Share what you know, enlighten people, and spark the creative and inquisitive juices within them.

Filippenko’s honors also include top teaching awards. He has been voted “Best Professor” on campus a record-breaking nine times, received the Carl Sagan Prize for Science Popularization in 2004, was named the Carnegie/CASE National Professor of the Year in 2006, and won the Astronomical Society of the Pacific’s
Emmons Award for undergraduate teaching in 2010. He has co-authored an award-winning college textbook, produced five astronomy video courses with ‘The Great Courses’ series, and appeared in many television documentaries, including 40 episodes of ‘The Universe’ series on The History Channel.

In his remarks, Filippenko congratulated the new graduates and offered a few highlights from his own career in science, beginning with grade school. “Maybe you’ll be inspired by what happened to me,” he said. He recounted his experiences with Nobel Laureate Richard Feynman at Caltech, who, Filippenko said, convinced him to never fear asking questions and to encourage questions from his own students.

Filippenko described how a chance encounter with a supernova changed his career, ultimately leading to his participation in the two research groups that used Type Ia supernovae to measure the expansion rate of the universe. And he extolled the satisfactions of teaching, encouraging the graduates to offer public talks about science even if they don’t become teachers. “Much of the public is afraid of science,” he said, “and you can help stop this cycle. Share what you know, enlighten people, and spark the creative and inquisitive juices within them.”

“People,” he added, “often ask, ‘What’s the purpose of the Universe?’ Well, I don’t know, I’m just an astrophysicist. Maybe the purpose is to produce organisms that simply enjoy being part of the Universe for a fleeting moment – organisms that have thoughts, experiences, and emotions. Or, maybe part of the purpose is to produce sentient beings who can figure out and appreciate its physical beauty – the extraordinary way in which relatively simple physical laws give rise to essentially infinite variety.”

“Einstein,” he continued, “once said, ‘The most incomprehensible thing about the Universe is that it’s comprehensible.’ And y’know, he was right. Friends and family members, the intense desire to understand the Universe is what has driven today’s graduates to work and study so hard all these years.”

ASTRONOMY PRIZES AND AWARDS

**Department Citation**
Keaton James Burn

**Dorothea Klumke Roberts Prize**
Pierre Christian

**Mary Elizabeth Uhl Prize**
Nicholas James McConnell
Andrew Patrick Vincent Siemion

Outstanding Graduate Student Instructor Award
Garrett Kent Keating
Francesca Maria Fornasini

PHYSICS PRIZES AND AWARDS

**Department Citation**
Matthew Alan Nichols

**Student Service Award**
Nicole Liu Carlson
Geoffrey Z. Iwata
Gina Marie Quan

**Lars Commins Memorial Award in Experimental Physics**
Thomas Michael O’Donnell

**Jackson C. Koo Award in Condensed Matter Physics**
Kwanpyo Kim

OUTSTANDING GRADUATE STUDENT INSTRUCTOR AWARDS

Recipients of the Outstanding Graduate Student Instructor (OGSI) Awards are recognized for their dedication and skill in teaching physics undergraduates. Each recipient receives a certificate of commendation from the Graduate Division, a cash award of $250, membership in the American Association of Physics Teachers (AAPT), and a subscription to the AAPT journal from the Friends of Physics Fund. Professor Robert Karplus established the tradition of the AAPT memberships that the Department of Physics continues in his honor.

Robert Jay Campbell
Raymond Tung Ming Co
Sharif William Kenneth Corinaldi
Ian Matthew Hayes
Eugene Kur
Armon Mahajerin
Keenan Pepper
Long H. Tran
Haruki Watanabe
Sean Jason Weinberg
Dillon Wong
AIR FORCE PILOT RESUMES GRADUATE STUDIES

Sandra Mierecki entered the graduate program at UC Berkeley in 2007, after completing a career as a pilot in the US Air Force. She spent her first few years here working to qualify for PhD candidacy. During that time she contributed many hours of service to the University and the community, which earned her the 2010 Student Service Award from the Department of Physics. In September 2012 she passed her qualifying exams and has now shifted focus to PhD research on neutrino astrophysics.

Sandy was awarded a BS degree in Astronomy/Physics in 1986, summa cum laude, from University of Illinois at Urbana-Champaign. At the same time, she completed the Air Force ROTC military training course. “While I was in college,” she says, “I decided to pursue the astronaut dream. The best way to build a resume for NASA was to join the military, and in particular to become a pilot.” She graduated from pilot training in 1988, and went on to receive her MAS from Embry-Riddle Aeronautical University (ERAU) in 1995 and MA from Air Force University in 1999. She eventually became a test pilot and was one of 120 finalists chosen from 3000 applicants for an interview with the 1997-98 astronaut selection board.

During her career, she flew the C5 Galaxy on worldwide cargo missions. Flying a C5, she says, “is very challenging because the plane is so huge, bigger than a 747. You have to think way ahead of the plane because it reacts slowly to inputs. You wait for the input to take effect and make another correction if you guessed wrong. It is very different from flying a small aircraft, which typically reacts instantly.” She retired from the Air Force in April 2007 with the rank of Lieutenant Colonel.

Following retirement, Sandy decided to return to another lifelong dream, of becoming a physicist. She’s now working with the IceCube Neutrino Detector group, under the supervision of Berkeley research physicist Spencer Klein. “My thesis project,” she says, “involves a measurement of the muon neutrino to nucleon cross section at high energies, around 30 TeV, by looking at the differential neutrino absorption by the earth. I am examining how the varying densities and path lengths, as you look deeper into the earth, affect the number of neutrinos that we see in the detector. With that information, I expect to calculate a cross section for the muon neutrino.”

As a former Air Force pilot, Sandy also volunteered with several groups in the community to help prepare for the ‘big one’. “I find all these activities to be very rewarding.”

GRADUATE STUDENT POSTER SESSION

Forty graduate students shared their research at the Department of Physics Annual Graduate Student Poster Session held November 18, 2011 in the Helmholtz room, 375 LeConte Hall. The session was organized by graduate students Ammar Husain, Hilary Jacks, and Christopher Smallwood.

Poster exhibits covered a variety of topics in physics and astrophysics. The Best in Show honor went to Lindsay Glesener of Professor Robert Lin’s research group for her poster, ‘The Focusing Optics X-Ray Solar Imager.’ Her prize was a bag of coffee beans and giant Toblerone chocolate bar. Punit Gandhi, Jonas Kjall, and Ryan Olf served as judges.

Honorable Mentions went to Claire Thomas and Jennie Guzman of Professor Dan Stamper-Kurn’s group for ‘Ultracold Atoms in an Optical Kagome Lattice,’ and to David Kaz of Professor Naomi Ginsberg’s group for ‘Tracking and tracing energy and molecules in light harvesting materials on the nanoscale.’

Graduate students have an opportunity every fall semester to share their research at the annual poster session. In addition, student-only research seminars held throughout the academic year give them a chance to talk about their work and to practice for oral exams. These seminars are open only to physics graduate students.

LARS COMMINS AWARD IN EXPERIMENTAL PHYSICS

The 2011 Lars Commins Memorial Award in Experimental Physics was awarded to graduate student Thomas Michael O’Donnell. The Lars E. Commins award is given annually to the most deserving graduate research student in experimental physics.
O’Donnell received his PhD degree in Fall 2011 in particle physics, as a research student with Prof. Stuart Freedman. He is currently a postdoc at Lawrence Berkeley National Laboratory.

In his letter nominating O’Connell for the award, Freedman wrote, “In the course of his work on KamLAND, Tommy distinguished himself as an outstanding experimental physicist. He is a hands-on scientist. He took great efforts to know and understand nearly every aspect of the KamLAND facility. He led an effort to build and operate a muon-tracking system in order to study the muon induced backgrounds in KamLAND. It is often problematic for young people to distinguish themselves as members of large experimental groups. Tommy is an exception, and he won the respect of the entire collaboration. Tommy is productive working alone or as part of a team. He combines impressive technical talent with clear focus on the physics goals of the effort.”

Lars Commins, the son of Berkeley emeritus physics professor Eugene Commins and his wife Ulla, was an accomplished engineer with a deep interest in experimental physics. The Lars Commins Award was created in 2004 as a lasting tribute to Lars and to help perpetuate the strong tradition of experimental physics that has always existed at UC Berkeley.

JACKSON C. KOO AWARD

Graduate student Kwanpyo Kim received the 2011-2012 Jackson C. Koo Award in Condensed Matter Physics. The award is given annually to a high-achieving physics graduate student in condensed matter who has advanced to PhD candidacy. Kim entered UC Berkeley as a graduate student in Fall of 2006 and will file his dissertation in Fall 2012, as a member of Professor Alex Zettl’s research group. Kim has accepted a postdoctoral position at Stanford University.

In his nomination letter, Zettl wrote, “Kwan has been a fantastic researcher, and has become expert in carbon nanomaterials synthesis, NEMS, and in-situ TEM transport/nanomanipulation studies. ...He thinks deeply about the physics and figures out a way to get even ‘impossible’ experiments done. He performs the better experiment either independently or organizes an effective team to do it. He tracks down suitable theorists and gains necessary insight from them or enlists them as collaborators. He writes the paper. Amazingly, Kwan does all this in a totally, unassuming, friendly manner.”

“...Kwan’s discovery and analysis of multi-folded graphene (termed grafold) involved a spirited collaboration with Marvin Cohen’s theory group, and Kwan proved to be the key liaison between the groups. The physics is elegant and many related experiments are now underway stimulated by Kwan’s findings. He exudes the highest level of scholarship and workmanship and is a pleasure to be around.”

The Jackson C. Koo Award was created in 2009 by Mrs. Rose Koo in honor of her husband Jackson Koo, a bright and hardworking student who received BS and MS degrees in Electrical Engineering and a PhD in physics from UC Berkeley under the guidance of Professor Erwin Hahn. He was a member of Phi Beta Kappa and of the Honor Students society of UC Berkeley. After graduating, he worked at AT&T Bell Laboratories then joined Livermore National Laboratory. During his career he published numerous papers and was listed as an inventor on eight patents.

HELMHOLZ AWARD AT INTERNATIONAL HOUSE

The Carl and Betty Helmholz Gateway Fellowship and the Kathleen Rosevear Gateway Fellowship, both housed at International House, have been granted to Byungmin Kang for 2012-2013. As a Gateway Fellow, he will receive full room and board at International House. The award also pays tuition, fees, and a $5000 stipend through a special matching program established with UC Berkeley’s Graduate Division.

Byungmin Kang entered Berkeley as a graduate student in Fall 2012. He is an international student from Seoul, Korea, where he received his undergraduate degree at Seoul National University. One of UC Berkeley’s top-admitted students interested in condensed mater theory, he was chosen for this award based on his academic merit as an undergraduate.

Over thirty donors stepped forward jointly to establish this $250,000 endowment in the name of Carl and Betty Helmholz that provides an International House room and board award each year for an entering UC Berkeley first-year doctoral student, preferably in physics. Carl Helmholz was a nuclear physicist and former Chair of the UC Berkeley Department of Physics. His wife, Betty, has provided distinguished service to both IHouse and the Department of Physics. Inspired by the Helmholz fellowship, Allan and Kathleen Rosevear also created a Gateway fellowship for physics students at
IHouse. They too share a dedication to the mission of International House to foster cross-cultural respect, understanding, lifelong friendships and leadership skills to promote a more tolerant and peaceful world.

STUDENT SERVICE AWARDS

Four students from the Compass Group, an organization that helps orient new students to college life, were honored with Student Service Awards for 2011-2012.

Nicole Carlson received her PhD in computational neuroscience with Professor Michael DeWeese in Spring 2012. In addition to being a member of the Compass team, she helped with fundraising events for Compass.

Gina Quan received her AB degree in physics in Spring 2012. She was the Academic Activities Chair and Residence Assistant for Compass. This fall, she is starting work on her PhD in physics education at University of Maryland, College Park.

Geoffrey Iwata received his AB degree in physics in Spring 2012. He was the summer program coordinator and co-instructor of the Spring 2012 Compass course. He went to Columbia University this fall to begin work for a PhD in physics.

Anna Zaniewski will receive her PhD in Fall 2012. Under research adviser Alex Zettl, she studies photovoltaics. Anna has been involved with Compass since 2009 as a program coordinator, teacher, and mentor. She has accepted a postdoc position in physics education at Arizona State in Phoenix, AZ.

During the Spring 2012 commencement ceremony, these four students were honored with the following statement from Department Chair Frances Hellman:

“The Compass project is an extraordinary program for students interested in physics, astronomy, and earth and planetary sciences. It’s designed to assist students to successfully transition to college life and it creates and provides a strong sense of community and academic support for students to succeed. They are involved in outreach efforts and dedicated to science education. The Compass Project is the 2012 recipient of the APS award for improving undergraduate physics education. We are grateful for the enthusiasm and spirit you’ve brought to your involvement in the Department, and we recognize your many contributions to the physics community with the Student Service Award.”

PHYSICS PHD DEGREES

FALL 2011

Benjamin J. Alemán
Advisor: Alex Zettl
Carbon Nanotube and Graphene Nanoelectromechanical Systems

Zoe A. Boekelheide
Advisor: Frances Hellman
Effects of Nanoscale Structure on the Magnetism and Transport Properties of Chromium and Chromium-Aluminum Alloys

Steven F. Chapman
Advisor: Joel Fajans
The Effect of Multiple-Enhanced Diffusion on the Joule Heating of a Cold Non-Neutral Plasma

Michael J. Childress
Advisors: Greg Aldering and Saul Perlmutter
Host Galaxies of Type Ia Supernovae from the Nearby Supernova Factory

Jack R. Deslippe
Advisor: Steven G. Louie
Optical and Electronic Properties of Nano-Materials from First Principles Computation

Hung-Chung Fang
Advisor: Marjorie Shapiro
A Measurement of the Relative Branching Ratio BR (B->D0 K-) / BR(B->D0 pi-) in Three Do Decay Modes

Christopher M. Herdman
Advisors: K. Birgitta Whaley and Ashvin Vishwanath
Loop Condensation in Quantum Dimer Models

Craig L. Hetherington
Advisor: Carlos Bustamante
Dynamics of Viral Packaging: Single-Molecule Observations in Multiple Dimensions

Laura K. Kogler
Advisor: Stuart Freedman
A measurement of the 2 neutrino double beta decay rate of 130 Te in the CUORICINO experiment

Yiping Ma
Advisor: Edgar Knobloch
Localized Structures in Forced Oscillatory Systems

Thomas M. O’Donnell
Advisor: Stuart Freedman
Precision Measurement of Neutrino Oscillation Parameters with KamLAND

Daniel R. Queen
Advisor: Frances Hellman
The Specific Heat of Pure and Hydrogenated Amorphous Silicon
Maxwell I. Scherzer  
Advisor: Beate Heinemann  
Measurement of the Upsilon (1S) Production Cross Section in Proton-Proton Collisions at Center of Mass Energy 7 TeV

Erik D. Shirokoff  
Advisor: William Holzapfel  
The South Pole Telescope Bolometer Array and the Measurement of Secondary Cosmic Microwave Background Anisotropy at Small Angular Scales

Vasudha B. Shivamoggi  
Advisor: Joel Moore  
Majorana Fermions and Dirac Edge States in Topological Phases

Daniel H. Slichter  
Advisor: Irfan Siddiqi  
Quantum Jumps and Measurement Backaction in a Superconducting Qubit

Patrick S. Varilly  
Advisors: David Chandler and Jan Liphardt  
Fluctuations in Water and their Relation to the Hydrophobic Effect

Seth C. Zenz  
Advisors: Ian Hinchliffe and James Siegrist  
Properties of Jets Measured with Charged Particles with the ATLAS Detector at the Large Hadron Collider

SPRING 2011

Nicole L. Carlson  Advisor: Michael DeWeese  
Sparse Coding of Speech Data Predicts Properties of the Early Auditory System

David J. Cho  Advisors: Yuen Ron Shen and Feng Wang  
Optical Characterization of Plasmonic Metamaterials

Eric P. Corsini  
Advisors: Dmitry Budker and Wojciech Gawlik  
The Saga of Light-matter Interaction and Magneto-optical Effects; Applications to Atomic Magnetometry, Laser Cooled Atoms, Atomic Clocks, Geo-magnetism and Plant Biomagnetism

Jackson E. DeBuhr  
Advisors: Chung-Pei Ma and Eliot Quataert  
Numerical Models of Galaxy Evolution: Black Hole Feedback and Disk Heating

Nicholas D. Dunn  
Advisors: Christian Bauer and Lawrence Hall  
Effective Field Theory Techniques for Resummation in Jet Physics

Marat Freytis  
Advisors: Zoltan Ligeti and Lawrence Hall  
Non-standard Models of Dark Matter and their Experimental Signatures

Candace E. Gilet  
Advisors: John Bell and Christopher McKee  
Low Mach Number Simulation of Core Convection in Massive Stars

Pavan R. Hosur  
Advisor: Ashvin Vishwanath  
Consequences of Non-trivial Band Topology in Condensed Matter Systems

Satoru Inoue  
Advisor: Wick Haxton  
Use of Effective Theories in Nuclear Physics

Zigmund Kermish  
Advisor: Adrian Lee  
The POLARBEAR Experiment: Design and Characterization

Ruza Markov  
Advisor: Ori Ganor  
Dualities and Topological Field Theories from Twisted Geometries

Charles M. Melby-Thompson  
Advisor: Petr Hořava  
Anisotropy in Gravity and Holography

Roger S.K. Mong  
Advisor: Joel Moore  
Classification and Characterization of Topological Insulators and Superconductors

David A. Siegel  
Advisor: Alessandra Lanzara  
The Electronic Structure of Single-Layer Graphene

Kyle M. Sundqvist  
Advisor: Bernard Sadolet  
Carrier Transport and Related Effects in Detectors of the Cryogenic Dark Matter Search

Joseph S. Virzi  
Advisor: Marjorie Shapiro  
A Measurement of the Underlying Event Distributions in Proton-Proton Collisions at sqrt(s)=7 TeV in Events containing Charged Particle Jets using the ATLAS Detector at the Large Hadron Collider

Yi Zhang  
Advisor: Ashvin Vishwanath  
Theory of Topological Phenomena in Condensed Matter Systems
Donald Feldman, PhD ’59 (Advisor: Walter Knight), after waiting more than 50 years, finally enjoyed marching in a commencement ceremony. Back in 1959, just before commencement, tragedy struck his family and he had to return home. Maria Hjelm, Development Office for the Department of Physics, said “It’s been something he’s always wanted to do, and this was the year to finally make it happen. He and his wife flew out from the East Coast just to do this.”

After graduating with his PhD, Feldman joined the staff of the Westinghouse Research Laboratory, where he was a Fellow Scientist until 1984. He then became a Staff Member of The Los Alamos National Laboratory, remaining in that position until 1993. Feldman is currently a technical consultant for the Institute for Research in Electronics and Applied Physics at the University of Maryland. His research interests have included experimental solid state physics, including field emission microscopy, nuclear magnetic resonance, electron paramagnetic resonance, Raman spectroscopy, laser development, free electron lasers, and photo cathode development. He is a member of the American Physical Society and the Directed Energy Professional Society.

Nima Arkani-Hamed, PhD ’97 (Advisor: Lawrence Hall) was awarded $3 million as one of the first recipients of the new Fundamental Physics Prize. The new prize was established in 2012 by Russian billionaire Yuri Milner, a former physics student who made his fortune investing in internet companies. The first round of awards went to nine physicists from around the world. The prizes were not shared – each recipient was given $3 million.

An article that appeared in the New York Times on July 31, 2012 noted that Mr. Milner established the prize because he “wanted to recognize advances in delving into the deepest mysteries of physics and the universe. ‘This intellectual quest to understand the universe really defines us as human beings,’ he said.”

Arkani-Hamed is currently a professor in the School of Natural Sciences, the Institute for Advanced Study at Princeton University. The Institute’s web site describes him as a leader in particle physics phenomenology who is “concerned with the relation between theory and experiment. His research has shown how the extreme weakness of gravity, relative to other forces of nature, might be explained by the existence of extra dimensions of space, and how the structure of comparatively low-energy physics is constrained within the context of string theory. He has taken a lead in proposing new physical theories that can be tested at the Large Hadron Collider at CERN in Switzerland.”
Arkani-Hamed served on the physics faculty at Berkeley from 1999-2002. He has previously received numerous awards and distinctions, including a Gribob Medal in 2003 and the Raymond and Beverly Sackler Prize in Physics 2008. He is a member of the American Academy of Arts and Sciences and the European Physical Society.

Dana Weinstein, BA ’2004 (former member of Roger Falcone’s research group) received a 2012 Early Career Award from the National Science Foundation (NSF). The NSF makes these awards to junior faculty “who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research within the context of the mission of their organizations.”

Weinstein is assistant professor in the Department of Electrical Engineering and Computer Science and a principle investigator with the Microsystems Technology Laboratory at Massachusetts Institute of Technology (MIT). According to a press release from MIT, the five-year NSF award will be used to “explore multi-GHz MEMS resonators using electromechanical transduction with integrated circuit (IC) transistors and incorporate a cohesive education and outreach plan for students from K-12 through undergraduate level to increase awareness and understanding of MEMS and Electrical Engineering.” Weinstein heads a laboratory that focuses on the development of hybrid MEMS-IC devices for low-power wireless communication, microprocessor clocking, and sensor applications.

William Bertsche, PhD 2007 (advisor: Joel Fajans) received a 2011 John Dawson Award for Excellence in Plasma Physics Research. The award citation reads, “For the introduction and use of innovative plasma techniques which produced the first demonstration of the trapping of anti-hydrogen.” The award is given annually by the American Physical Society to recognize “a particular recent outstanding achievement in plasma physics research.”

Bertsche is a postdoctoral research assistant at Swansea University in Wales and is stationed full-time with the ALPHA collaboration at CERN. He has made significant contributions to the design, construction, and operation of the ALPHA apparatus, focusing on topics of plasma manipulation and anti-hydrogen production. He developed a novel auto-resonance-based injection technique that was instrumental in producing trappable anti-hydrogen atoms.

Kater Murch, PhD ’2008 (advisor: Dan Stamper-Kurn), was chosen by Siemens AG to participate in the 62nd Meeting of Nobel Laureates in Lindau, Germany July 1-6. The meetings, held every summer since 1950, facilitate encounters between promising young scientists and Nobel prizewinners.

This year’s meeting was dedicated to physics. Close to 600 young scientists were selected from thousands of nominees to attend. Twenty-seven Nobel laureates participated, including Berkeley physics professor George Smoot and Berkeley physics alumnus David Gross. Murch reports that the meetings gave him an opportunity to network with other young researchers and discuss ideas that will guide his future research.

After receiving a BA in physics from Reed College, Murch came to UC Berkeley as a graduate student in physics professor Dan Stamper-Kurn’s group. Murch studied Bose-Einstein condensation (BEC) and general problems in quantum measurement, making some of the first studies of position measurement quantum backaction.

After receiving his PhD in 2008, he continued work with the Stamper-Kurn group for another year, studying a possible super-solid phase of matter that occurs in spinor-Bose-Einstein condensates, and constructing a state-of-the-art BEC apparatus. Since August of 2009, Murch has worked with Berkeley physics professor Irfan Siddiqi, studying superconducting quantum bits and microwave quantum optics.
Class Notes 2012

Class Notes are a great way to keep in touch with old friends. Please update us about your activities, both professional and personal. Write to us when you have interesting news or just when you want to update us on what you’ve been doing for the past few years. We will include your message to fellow alums in the next Physics at Berkeley Newsletter. Email updates may be sent to alumni@physics.berkeley.edu or by US mail to: Maria Hjelm or Carol Dudley, Department of Physics, UC Berkeley, 366 LeConte #7300, Berkeley, CA 94720-7300.

’59
Donald N. Langenberg (PhD ’59, Research Advisor: Arthur Kip) is Chancellor Emeritus of the University of Maryland, College Park, and the University of Illinois, Chicago. The University of Pennsylvania celebrated its 50th Anniversary of the Laboratory for Research on the Structure of Matter (LRSM) on May 4, 2012 with a symposium in which Donald Langenberg, an expert in superconductivity, contributed as a former director of the lab.

’69
Wah Chiu. (AB ’69), is the Alvin Romansky Professor of Biochemistry, National Center for Macromolecular Imaging, Baylor College of Medicine, Houston. He was elected a 2012 member of the National Academy of Sciences.

’75
Michael Farrier (AB ’75, MS Engineering Science ’77) is currently design specialist for Teledyne Dalsa. Previously, he was a senior engineer-R&D Manager, Rad-icon Inc., 4 years, owner Farrier Micro Engineering LLC, 7 years Dalsa Corp., director of technology development, 8 years Hughes SBRC, senior physicist, 4 years Fairchild Imaging, Design Manager, 5 years Xerox Corp. CCD Designer, 2 years. Additional Information: 13 US Patents awarded, 2 Herman Mills Fairchild Awards, numerous technical publications, presentations in field of solid state image sensor development. “The education I toiled to achieve as a Calif. Physics student gifted me a mighty toolbox, filled with all the wrenches and widgets needed to solve most riddles, scientific and otherwise, and confidence to make the effort. It always seemed that the Department of Physics at Berkeley attracted and groomed people with vision far beyond narrative of the classroom, people who could shape and reshape the future.”

“I remain an active participant in technology development related to solid state detectors of various kinds. I recently worked with scientists at the Synchrotron Lab at LBL in developing CMOS X-ray detector panels for protein crystallography applications. The delight at making discovery and creating inventions never diminishes for some of us, and the training received at the Berkeley physics department has made that possible for those willing to embrace the challenge.”

’76
Nai Phuan Ong (PhD ’76, Research Advisor: Alan Portis) was elected a 2012 member of the National Academy of Sciences. He is the director of the Princeton Center for Complex Materials, and Eugene Higgins Professor of Physics in the Department of Physics at Princeton University. He is also a member of the Board of Review Editors at Science Magazine. In 2011 he was elected a Fellow of the American Association for the Advancement of Science.

’84
Harold (Hal) Zarem (AB ’84) received his PhD in Applied Physics from Caltech. He was president and CEO of Silicon Light Machines from 2003 to 2010, and is currently president and CEO of Seeo, a rechargeable lithium battery company based in Hayward, CA.

’89
Henry Kapteyn (PhD ’89, Research Advisor: Roger Falcone) is a professor of physics at the University of Colorado, Boulder, and a fellow of the Joint Institute for Laboratory Astrophysics (JILA) since 1999. He is the recent recipient of the APS Schawlow Prize “For pioneering work in the area of ultra-fast laser science, including development of ultra-fast optical and coherent soft x-ray sources.”

Margaret Murnane (PhD ’89, Research Advisor: Roger Falcone), a professor of physics at the University of Colorado, Boulder, has been selected by President Obama to chair the President’s
Committee on the National Medal of Science. She is also the recent recipient of the APS Schawlow Prize “For pioneering work in the area of ultra-fast laser science, including development of ultra-fast optical and coherent soft x-ray sources.”

David Deaven (MA ’90, PhD ’93) is director for design controls at GE Healthcare Technologies in the greater Milwaukee area.

Fiona Harrison (PhD ’93, Research Advisor: Steven Kahn) is a professor of physics and astronomy at the California Institute of Technology. She is the lead principal investigator of the recent launch of NASA’s NuSTAR mission. Fiona was also elected a 2012 Fellow of the American Physical Society.

Vijay Iyer (MA ’94) is a jazz pianist-composer-bandleader. The Vijay Iyer Trio recently released its fourth album, titled “Accelerando.” He was also named director of The Banff Centre’s International Workshop, Canada.

John Birmingham (PhD ’96, Research Advisor: Paul Richards) is the Chair of the Department of Physics at Santa Clara University and Associate Professor of physics. His home page describes his current research as using “physiological and computational approaches to study how sensory neurons encode information in trains of voltage impulses, and how the codes themselves can be modified to improve sensor performance.”

Xiaowei Zhuang (PhD ’96, Research Advisor: Yuen-Ron Shen) was elected a 2012 member of the National Academy of Sciences. Currently she is a Howard Hughes Medical Institute Investigator, Professor of Chemistry and Chemical Biology, Professor of Physics. In 2003 she was also a recipient of a MacArthur Fellowship and also named “one of the world’s top young innovators” by MIT Technology Review TR100.

Sunil Golwala (PhD 2000, Research Advisor: Bernard Sadoulet) after graduation was a Millikan Postdoctoral Scholar at Caltech. He became an assistant professor at Caltech in 2003 and is currently a Professor of Physics in the Division of Physics, Mathematics, and Astronomy at Caltech. His research work there focuses on the nature of dark matter and dark energy.

Aaron Lindenberg (PhD 2001, Research Advisor: Roger Falcone) is Assistant Professor in Materials Science and Engineering, Photon Science at the Stanford Linear Accelerator Center (SLAC).

Christopher Weber (AB ’99, PhD 2005, Research Advisor: Joe Orenstein) joined the faculty at Santa Clara University in 2008 as Assistant Professor. His home page states that he is “building an ‘ultra-fast optics’ laboratory, which will use a laser that generates pulses of light less than 0.0001 nanoseconds long.” He is studying “electronic interactions that take place on very short time-scales in magnetic and semiconducting materials, with an emphasis on properties of the electron spin.”

William Bertsche (PhD 2007, Research Advisor: Joel Fajans) received the 2011 John Dawson Award for Excellence in Plasma Physics. The citation reads, “For the introduction and use of innovative plasma techniques which produced the first demonstration of the trapping of antihydrogen.” He is currently a postdoc at Swansea University and located full-time with the ALPHA collaboration at CERN.

Alan Kubey (AB 2007) is currently attending Jefferson Medical College, Thomas Jefferson University, Philadelphia, PA.

Henry Garcia (MA 2008) is a Pixar animator. His work can be seen in the film features “Up” and “Toy Story 3.” Henry recently met with a group of physics grad students to discuss careers in industry and life after grad school.

Çağlar Girit, (PhD 2010, Research Advisor: Alex Zettl) writes, “I’m continuing my postdoc in Paris at the CEA, the French equivalent of LBL. I’m funded for two more years on a Marie Curie International Postdoctoral Fellowship, and then will look for a permanent position. I’m enjoying working on superconducting quantum circuits. I have a third child now, his name is Jin,
with different meanings in many languages, including “person” and “benevolence” in Japanese. We are in the process of buying a house just south of Paris, in a quaint artsy neighborhood that reminds us of Berkeley. With three kids, two jobs in research, and one house, we have too much to handle!”

IN MEMORY

Hamon W. Hubbard, (PhD ’52, Research Advisor: Wilson Powell) passed away on March 14, 2012, after a brief illness. He received his BS in Physics in 1947 from the University of Illinois, Urbana, and his PhD in Physics in 1952 from UC Berkeley. He served in the US Army from 1944-1946 and was a member of the Sigma Xi (elected in 1951), a society “Devoted to the Promotion of Research in Science”. He was a founding member of RDA (Research and Development Associates) working in nuclear technology and the application of physics to problems of national security until his retirement in 1988. His work included studies of seismic detection of underground explosions and studies of proliferation of nuclear explosions. He also worked on nuclear fusion explosion systems to produce commercial electricity. Prior to his work at RDA he was Senior Physicist at Rand Corporation (1958-1971) and the Lawrence Livermore National Laboratory (1952-1956).


Jennifer Corkill Deaven of Delafield departed suddenly and unexpectedly on Tuesday, November 22, 2011, aged 44. Beloved wife of David Deaven and proud mother of Aidan and Mia. She was born on December 3, 1966 in Tripoli, Libya, to Charles and Judith Corkill of Austin, Texas, who survive her. She received her doctorate in Physics from the University of California, Berkeley in 1993 where she met her husband. Jennifer was an engineer with GE Healthcare who returned to the workforce in 2010 after an 11-year period of raising her children and donating her time to charitable causes.

Jennifer spent her time surrounded by friends and family and was an accomplished musician who played the piano, flute, and piccolo and taught her children to play piano. A few activities she loved were skiing, hiking, knitting, and yoga but her true passion was learning, helping, loving, and laughing with those around her, especially her children. She was a member of All Saints Lutheran Church, an active parent in the Kettle Moraine schools, and an organizer for several local natural food cooperatives. Jennifer is survived by her husband David; her children Mia and Aidan; her parents Charles and Judith Corkill; her sister and her husband, Cynthia Corkill and Stephen Stappenbeck; her sister Melody Nitzberg; and her sister and her husband, Rebecca and Andrew Rose.

PAUL AND CHOR GEE SCHOLARSHIP

Caroline Gee (BA ’95) received her BA in Physics in 1975. Her siblings, David, Bertha, and Mei, all earned their Chemistry degrees at Berkeley around the same time. Caroline, David, and Bertha recently created the Paul and Chor Gee Undergraduate Endowed Scholarship in Physics and Chemistry in honor of their parents, Paul and Chor Gee.

Paul and Chor were immigrants from rural China who came to the United States seeking a better life. Paul worked long hours in his small Chinese restaurant, and Chor was a homemaker. They knew that education was the key to their children’s success, and they made every sacrifice to ensure that their kids could go to Berkeley. The scholarship will be given each year to a worthy student who graduated from high school in California, and will go to a physics student every third year.
CALENDAR OF EVENTS

START OF FALL SEMESTER 2012
Thursday, August 16

FIRST DEPARTMENT TEA
Monday, August 27, 4:00 PM
1 LeConte Hall Annex

THE 115TH BIG GAME
Saturday, October 20
Memorial Stadium
Berkeley Campus

THE BAY AREA SCIENCE FESTIVAL
Saturday, October 25 – Sunday, November 3
bayareascience.org

SEGRÉ LECTURE
Professor Dr. Peter Jenni
CERN Scientist and former ATLAS
Monday, November 5, 5:00 PM
Pauley Ballroom, Martin Luther King Jr. Union ASUC

GRADUATE STUDENT POSTER SESSION
Friday, November 16, 3:00 PM
A. Carl Helmholtz Room, 375 LeConte
Berkeley Campus

START OF SPRING SEMESTER 2013
Tuesday, January 15

J. ROBERT OPPENHEIMER LECTURE
“Condensed Matter Physics: The Future,”
Monday, March 11
Chevron Auditorium at IHouse
Marvin L. Cohen
University Professor and Professor
Graduate School
Department of Physics
University of California, Berkeley

UNDERGRADUATE POSTER SESSION
April 2013 (date TBD)
375 LeConte Hall

CAL DAY
Saturday, April 20, 9:00-4:00 PM
berkeley.edu/calday

BRUNO ZUMINO’S 90TH BIRTHDAY
Sponsored by the BCTP
May 2-4, 2013

GRADUATION
Tuesday, May 21, 2:00 PM (note the change)
Zellerbach Auditorium
Berkeley Campus

START OF SUMMER SESSION
summer.berkeley.edu
Monday, May 28, 2013

INTERNATIONAL CONFERENCE ON LIGAND SPECTROSCOPY
ICOLS 2013
Sunday, June 9 - Friday, June 14
Berkeley Campus and Claremont Resort
icols.berkeley.edu
For the latest information from the Berkeley Physics Department—news on current research, special events, lecture/demos, and student activities—visit the UC Berkeley Physics Home Page.

physics.berkeley.edu