UCDAVIS
Physics Newsletter

Number 9 — *A Newsletter for University of California, Davis, Physics Alumni* — *2000*

From the Chair

The 31.5 FTE faculty we now have in the department is a rather magical number. It is the historical maximum we reached ten years ago in 1990. Then came the second phase of the Voluntary Early Retirement Incentive Program (VERIP) and the retirements of Professors Jungerman, Peak and True. We managed to recover to **31.5** again in 1992, only to face the third phase of VERIP in 1994 and the retirements of Professors Cahill, Draper, Erickson, Garrod and Reid. This year with the arrival of Assistant Professors Ferenc and Wells, we are again at **31.5**! This signals the completion of the rebuilding of our faculty. From now on we are charting new territory — not just in number, but also in excellence.

We will start the expansion with a bang by recruiting in cosmology and experimental particle physics. In a recent speech, NSF Assistant Director for Mathematical and Physical Sciences Bob Eisenstein said, "An ultimate understanding of physical laws that govern the universe can only be realized by investigating both the smallest and the largest structures in nature, namely, subatomic particles and the universe itself." Not only are we recruiting at both ends of this spectrum, particle cosmology actually magically links these two ends together! Assistant Professors Ferenc and Wells are two great additions to the department. They were both in the news in February – Ferenc for his role in an exciting CERN announcement of a new state of matter and Wells for winning the prestigious Sloan Fellowship. They set the standard for our expansion!

In addition to the regular faculty, we are fortunate to have a small number of adjunct faculty supplementing our program. In this issue we feature two new adjunct faculty members – John Byrd, an accelerator physicist and Michel Van Hove, a theoretical surface physicist. They have brought us the enrichment we were unable to have given the regular size of the department.

The biggest challenge the department faces in our expansion is space. Our space allocation has not been augmented in the past thirty years! This problem is aggravated by the fact that half of our retirements were in experimental nuclear physics, which used the Crocker Lab as the laboratory, while the new hires all need laboratory space in the physics building. A possible solution is to fully build-out the fifth floor. The south side of the fifth floor was actually constructed with such an expansion in mind. A consultant report commissioned by the administration has also indicated that the expansion is not earthquake vulnerable! We are working diligently with the administration on the funding of the build-out.

Finally, I would like to comment on our "Einstein on a Bike" logo which you have seen in our previous newsletters. We are all pleased that Albert Einstein was selected as *Time* magazine's "Person of the Century." The choice symbolizes the role of physics in leading the way in a century of "the explosion of scientific and technical knowledge that unveiled the mysteries of the universe and helped the triumph of freedom by unleashing the power of free minds and free markets." The bike symbolizes our campus' college town atmosphere and idealism. This is now the *de facto* official logo of the physics department at UC**DAVIS**. It is the symbol on our official sweatshirts (see picture at left)!

Sincerely,

Winston Ko
ko@physics.ucdavis.edu

Inside This Issue

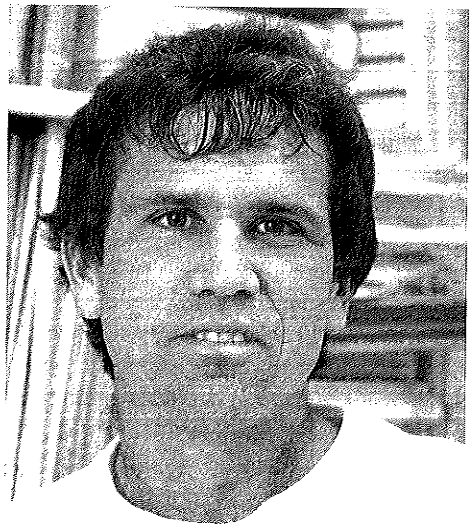
Graduate Program Begins Review

by Richard Scalettar, professor

The physics department is just beginning a review of its graduate program. The last such review was completed in the 1989-90 academic year. Information we provide will be analyzed by an ad-hoc committee of the UC Davis Academic Senate, as well as external advisors to the University of California. This review has given us the opportunity to reflect on our strengths and weaknesses, and on the many accomplishments of our department, its faculty and students, as well as on the excitement of our discipline. Below is the introductory section of the program review.

The Department of Physics is a large academic unit within the College of Letters and Science with 31.5 full-time faculty and approximately 80 graduate students as of July 1, 1999. The department is composed of two primary pillars of strength: condensed matter physics (theory and experiment) and high energy physics (theory and experiment), as well as a long-standing nuclear physics program that is still at critical mass, and a cosmology program that is half way through its first phase of building up. In the next decade, these major branches of physics will experience extremely exciting progress. New developments will include deeper understanding of the most fundamental interactions of matter (the source of mass), the nature and origin of the universe (how the universe evolved from the Big Bang), and complex microscopic systems (objects of dimensions on the nanometer scale and in uniquely controlled or novel quantum states). As in past decades, many of these advances in physics will strongly impact technology as well as the life and environmental sciences.

The UC Davis physics department is making an increasingly fundamental impact in these fields. The department ranks between 40th and 50th among physics departments nationally, and is one of the stronger physics departments in the University of California system. In several specific areas, our research efforts compare well nationally with the most highly regarded programs.



Richard Scalettar

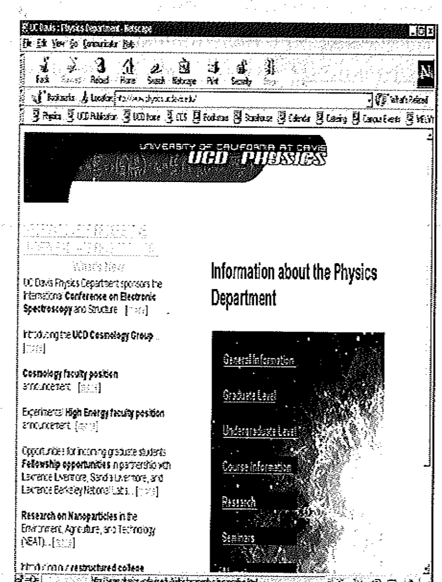
The continued excitement of physics as a discipline, coupled with the growing national and international visibility of our program, has enabled us to be quite successful at recruiting graduate students. Specifically, our graduate enrollment has increased over each of the last two years, from 65 in 1997-98, to 73 in 1998-99, to a projected 85 in 1999-00. These figures are especially significant when compared to national enrollment trends in physics graduate programs. Among the UC campuses, our graduate student to faculty ratio is behind that of Berkeley, Santa Barbara and San Diego, but ahead of Los Angeles, Irvine, Riverside and Santa Cruz.

Because physics is a very fundamental area of science, and because it develops and makes use of a wide variety of new instrumentation, innovative technology, computing and abstract concepts, its practioners, including in particular new Ph.D. graduates, have a very broad range of highly valuable skills and fundamental knowledge that leads to successful careers in a vast array of both non-academic and academic specialties. Indeed, graduates in all of our core disciplines (high energy, nuclear and condensed matter physics) have a combination of experimental, computational and theoretical analysis skills that are much in demand in industry, particularly in the nearby Silicon Valley and its close relative, the Iron Valley (where much of the magnetic storage industry resides). Physicists have also made many contributions to software and the Internet, including the invention of the World Wide Web.

The physics department's primary challenge is a severe shortage of space. We are currently at 57% of our necessary space according to the assignable space per FTE allocation formula. This situation will worsen over the next month as our new graduate students enter the program. No other department in the UC Davis Division of Mathematics and Physical Sciences is below 75%, and several are over 90%. This space shortage is affecting our ability to bring in top experimentalists, and creating an imbalance of theory and experiment in our faculty. Since experimentalists typically bring in considerable extramural funds and support many students, this problem has serious implications for the program and the campus.

As long as science remains the key to economic progress, physicists will find many fulfilling career opportunities. As a department, we must continue our commitment to making sure that our graduate student training emphasizes the breadth of fundamental knowledge and skills needed to ensure these opportunities. ❖

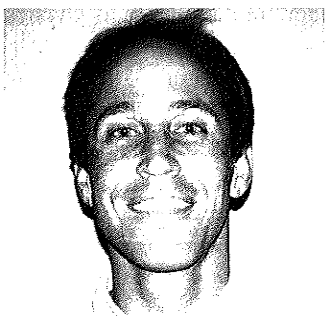
Physics Home Page



For more information about the UC Davis physics department, browse through our World Wide Web home page at: <http://www.physics.ucdavis.edu>

UC Davis Students at Lawrence Livermore National Laboratory

A number of UC Davis graduate students have recently won fellowships to work at Lawrence Livermore National Laboratory (LLNL). Here they briefly describe their projects.



MATT ENJALRAN

For the first half of the Ph.D. program, my research focused on the development and study of models of frustrated magnetic insulators. This work was done in collaboration with Professor Richard Scalettar in the physics department and Professor Susan Kauzlarich in the chemistry department at UC Davis. In the fall of 1998, I began a new project which took my research in the direction of correlated fermion systems. In particular, the work uses quantum Monte Carlo techniques and mean field theory to study magnetic phase transitions in disordered electron models. Work in this area has brought our group at UC Davis into a collaborative project with Dr. Malvin Kalos at LLNL. Dr. Kalos has worked extensively on Monte Carlo applications to many-body systems in condensed matter, nuclear and statistical physics. The focus of our joint effort is to develop quantum Monte Carlo methods for interacting Fermi systems, continuous and discrete, in order to investigate the physics of these models in regions of parameter space that are inaccessible by current techniques.

MARISSA GRITTER

I did my undergraduate work at Gustavus Adolphus College in St. Peter, Minnesota. I was involved in several different research projects in astrophysics, solid state physics, physics teaching and nuclear physics over the course of my time there. Since I am a first-year graduate student with no previous ties to Lawrence Livermore or UC Davis, my responsibilities this year involve taking the standard sequence of graduate courses and figuring out which projects at LLNL interest me for thesis work.

SHON PRISBREY

I did my undergraduate work at Brigham Young University, Provo, Utah. I did research in condensed matter/thin films with Dr. David Allred and Dr. Stephen Turley. This involved theoretical and laboratory experiences to determine the oxidation rate and thickness of uranium to uranium oxide, as well as other capping layers for a multilayer thin film to reflect at 304 angstroms and anti-reflect at 584 angstroms. It was fun to help build anti-periodic thin films. I then worked at Lawrence Livermore National Laboratory in the Information, Science and Technology program under the Lasers directorate. I was involved in the growth and measurement of defects on Mo/Si multilayer films with defect densities on the order of 10^{-2} measured at >100 nm Poly-Styrene Latex Sphere Equipment. I also used Atomic Force Microscope and Scanning Electron Microscope (equipped with x-ray Photoelectron Spectroscopy for chemical analysis), as well as having some experience using the Advanced Light Source at Lawrence Berkeley National Laboratory.

I am very interested in several aspects of condensed matter, and I have the desire to do my Ph.D. research with a mixture of theory and laboratory work. I am still interested in thin films, but I am also leaning towards work with surface characteristics.

GAYLE THAYER

I completed a B.S. in Physics at UC Santa Barbara in June 1996 and immediately proceeded to work for Professor Shirley Chiang at UC Davis, where I began course work in the physics department's Ph.D. program that fall. In Shirley's lab I worked on building and debugging a variable temperature Scanning Tunneling Microscope (STM) and surface analysis system. These one and one half years in her lab were invaluable to my education and my experience in vacuum technology, STM and surface science in general. In April 1999 I was fortunate to be the first to receive a Student-Employee Graduate Research Fellowship (SEGRF) to work at Sandia National Laboratory in Livermore with Dr. Bob Hwang and Dr. Andreas Schmid in the Thin Films and Interfaces group. Since I had already completed my coursework and exams and had spent some time in laboratory research, my fellowship is for two years only. Currently, I have been in Livermore for seven months and have completed work on building and debugging a room temperature STM, and now am studying a two-phase surface alloy system. The system is 1 ML Ag/Co alloy on a Ru crystal, and we have found the alloy segregates into two distinct equilibrium phases dependent on stoichiometry and temperature. The opportunity to work in this group is unique because, although I am an experimentalist, the group includes many theorists who work directly with me on the system I am studying. This is very exciting, and I hope that the collaboration this fellowship has allowed will produce a real quantitative understanding of the interactions in the system we are studying.

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UC Davis Students at Lawrence Livermore National Laboratory

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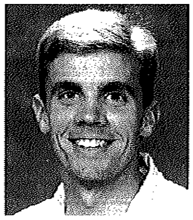


TREVOR WILLEY

I graduated from Utah State University in 1997, and started graduate work there for a year under the last year of my athletic scholarship in cross country and track. I am currently a second year student in the UC Davis physics department. After completing my final year of classes this year, I will begin working in a collaboration between Dr. Charles Fadley at UC Davis and Dr. Louis Terminello at Lawrence Livermore National Laboratory. Most of my research will actually be at the Advanced Light Source at the Lawrence Berkeley National Laboratory, using synchrotron radiation for x-ray photoelectron spectroscopy and x-ray emission (fluorescence) spectroscopy.

JERRY WHALEN

I work for Dr. Robert Becker at the Institute for Geophysics and Planetary Physics at Lawrence Livermore National Laboratory. I am currently working on two projects in an effort to find a project that can actually be completed in the four years this fellowship gives me. The first project involves studying the spectra of narrow line Seyfert 1 galaxies. Narrow line Seyfert 1 galaxies are a class of Active Galactic Nuclei (AGN) that have an optical counterpart (i.e., when I point a telescope in its direction, I see a galaxy, usually elliptical or spiral). AGN are characterized by small size (on the order of a parsec) and high energy output (up to 10^4 times as great as an average galaxy). The common belief is that these AGN are powered by supermassive black holes, which are, of course, inherently interesting. The second project I am working on is an effort to catalog galaxy clusters with the use of "bent doubles." Many of the AGN I described above have twin jets of relativistic plasma shooting out along the axis of rotation. We have about 400 examples of jets that instead of simply shooting out along the axis of rotation, are instead swept back, or "bent" at an angle. It is believed that this phenomenon is created by the motion of the AGN galaxy with respect to a galaxy cluster. The space between galaxies in a cluster is filled with a hot gas which could provide a suitable medium to bend my AGN jets. So far this hypothesis appears to be true, and this method could provide a useful tool for finding new clusters. ❖

Welcome Graduate Students

The department is proud to welcome the following new students to our graduate program:

Kristopher Andersen - California State University, Fresno
Sayandeb Basu - University of Cincinnati
Monica Borunda - International Centre for Theoretical Physics (Trieste, Italy)
Clay Bratton - San Jose State University
Robert Endres - University of Gottingen
Marissa Gritter - Gustavas Adolphus College (St. Peter, Minn.)
James King - University of Nevada, Las Vegas
Jason Knight - University of New Mexico
Agusta Loftsdottir - University of Iceland
Gang Luo - Illinois Institute of Technology
Ting Luo - Peking University (China)
Peter Marleau - California State University, Stanislaus
Shon Prisbey - Brigham Young University
Brian Sell - Mount Union College (Alliance, Ohio)
Yong-Seon Song - Imperial College of Science (United Kingdom)
Melikhan Tanyeri - Bogazici University (Turkey)
Manuel Toharia - Universite du Quebec
Guangmao Xing - Shandong University (China)
Steven Yount - University of California, Santa Barbara

Physics Club Officers 1999/2000

President - Aaron Thompson
Vice President - Luke Donev
Treasurer - Daisy Raymondson

Astronomy Club Officers 1999/2000

President - Jason Cosman
Vice President - Daisy Raymondson
Events Coordinator - Roger Littge
ASUCD Rep - Laurel Bredthauer
Web Master - Ryan Poling

Ph.D. Degrees Awarded

Summer 1999

William Caskey
"Transverse Flow in 2-8 AGeV Au+Au at the BNL AGS"
Postdoctoral position in High Energy Experimental Group, UC Davis

Gus Hart
"Electronic Structure Studies of Materials Properties and Stability in Transition Metal-Metalloid Compounds"
Postdoctoral Research position at the National Renewable Energy Laboratory, Golden, CO

Johan van der Noordaa
"Magnetic Susceptibility of the Rare Earth Two-Beam Accelerators"
Postdoctoral Physicist position, California State University, Fresno

Fall 1999

Steven Lidia
"Studies of Beam Dynamics in Relativistic Klystron Two-Beam Accelerators"
Postdoctoral Physicist position, Lawrence Berkeley National Laboratory, Berkeley, CA

John Pask
"A Finite-Element Method for Large-Scale Ab Initio Electronic-Structure Calculations"
Postdoctoral Researcher position, Naval Research Laboratory, Washington, DC

Master's Degree Awarded

Summer 1999

Daniel Lattimore
"A 2D Multi-Band Hubard Model in Mean Field Approximation"

Bachelor's Degrees Awarded

September 1999

Paul Gomez, BS

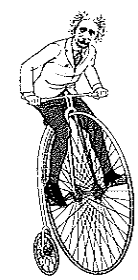
December 1999

Merlin Davis, BS

Donovan May, BS

Kailen Neff, BS

Adrian Valadez, BS



Introducing...

Daniel Ferenc

Ph.D. - University of Zagreb, Croatia, 1992

Experimental Nuclear Physics, Relativistic Heavy-Ion Physics

Professor Daniel Ferenc joined the department in July 1999.

Since the Big Bang, the universe has evolved through a sequence of different phases characterized by very high energy densities and temperatures. In spite of the fact that the average density is now much lower, it is still possible to perform experimental studies of matter in extreme conditions resembling those of the universe the first split second after the Big Bang. Such conditions may be recreated in (or around) very massive compact cosmic objects like neutron stars or black holes, or, just for a glimpse, in collisions of relativistic nuclei.

Since I have participated in both research activities, the most general description of my research field could be: a study of matter in extreme conditions.

Relativistic nuclear collisions have been studied for decades in cosmic ray interactions. A rapid development of Quantum Chromodynamics (QCD), the theory of strong interaction, has created a renewed interest in nuclear collisions as a possible way of creating "the simplest QCD matter" — the deconfined Quark-Gluon Plasma (QGP). Numerical QCD simulations have indicated a phase transition between the simple QGP phase where the elementary particles — quarks and gluons — are the constituents, and the "complicated" hadronic phase where the quarks and gluons are confined within individual hadrons (like nucleons and mesons). This transition should take place at a temperature of around 10^{12} degrees Celsius, and probably happened around 10^{-5} seconds after the Big Bang.

Since 1986 I have participated in the relativistic nuclear program at CERN as a member of the experiments NA35, NA44 and NA49, that studied collisions of different nuclei from oxygen to lead at an energy of 200 GeV per nucleon. We have found that these violent "Little Bangs" are indeed very likely to contain QGP for a very short period. I was particularly involved in the study of the space-time evolution of such systems, using Bose-Einstein correlations of pions. This method provides information on the expansion pattern at the final breakup of the system. This, in turn, may be used to deduce the system properties at earlier times, in a similar way the cosmologists learn about the early history of the universe from the Hubble expansion pattern seen at the present time.

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Daniel Ferenc

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Convinced by these results, nuclear collision experimentalists at CERN will devote their 1999 beam time to a low energy run with lead ions at 40 GeV per nucleon. The aim is to study the onset of the anomalous phenomena seen at the full energy and to fill in the gap between the existing results from CERN and Brookhaven. We are almost prepared to take the first data at a ten times higher collision energy in the experiment STAR at the new Relativistic Heavy Ion Collider (RHIC) at Brookhaven. During my work at CERN I also actively participated in the ALICE project for the future Large Hadron Collider (LHC) at CERN.

As noted already, another way of studying matter in extreme conditions is to study certain classes of compact cosmic objects. Extreme temperatures or densities inside or around such massive objects are generated by an enormous gravitational force.

A new generation of Atmospheric Cherenkov Telescopes (ACT) has been developed to study such objects. When a cosmic gamma ray originating from an object of interest strikes the Earth's atmosphere, it can initiate a shower of particles. ACTs are ground-based experiments designed to detect Cherenkov light emitted by thousands of charged particles in such a shower. ACTs of a new generation are based on new photo sensors for Cherenkov photon detection, which comprise high quantum efficiency and fast response time. As a member of the MAGIC ACT project I have participated in the very exciting development of those sensors, in particular the so-called Hybrid Photon Detectors (HPD). Recently I have developed innovative HPDs for MAGIC, but also for the LHCb experiment at CERN, and for the underwater neutrino project AQUARICH, proposed by Tom Ypsilantis. The latter two HPDs have already been produced and successfully tested. There is a rapidly growing interest in this technology, not only in high energy physics and astrophysics, but also in biological and medical sciences.

Within the wide class of compact cosmic objects observable by ACTs in the high energy gamma ray spectrum, Active Galactic Nuclei (AGN) are among the most interesting. The current model is of a spinning supermassive black hole, containing typically 10^9 solar masses, with an accretion disk — a torus of material swirling around to feed the hole and the two "hyper relativistic" jets (Lorentz factor more than 100) that escape at the poles and shoot deep into the extragalactic space. High energy gamma rays created close to the black hole horizon seem to be able to escape along those jets, and bring important information about the physics of these exotic objects. We expect to measure time variation, energy spectrum and other properties for many AGNs that are properly oriented to shoot one of their jets towards us. The crucial breakthrough of the new generation ACTs is the lowering of the observation energy threshold, even down to 10 GeV, as in the MAGIC experiment. This will allow us to "see" AGNs very far away, since gamma rays in this energy range are not strongly attenuated in space by the photon-photon interaction with the cosmic background radiation, unlike gamma rays of higher energies. Such a low energy detection will be achieved by the new generation photo sensors.

Another important topic on the menu of the MAGIC experiment is the gamma ray bursts, violent flashes that deliver more energy in a few seconds than a typical galaxy emits over a few days. Recent studies indicate that the sources of some typical bursts are far from our galaxy, which suggests an enormous overall energy release (perhaps 10^{52} ergs). Gamma ray bursts may be caused by hypernovae explosions that lead to a collapse into a black hole, or by merging binary stars when they collapse into a black hole.

By opening a new window in the gamma ray spectrum — the only unexplored range in the cosmic electromagnetic radiation — MAGIC will certainly contribute to a better understanding of these and some other puzzling phenomena. It is important to note that this experimental breakthrough is directly linked to the development of a new generation of photo sensors, which is still under way.

CERN Announced Evidence of a New State of Matter

On February 10, Professor Luciano Maiani, Director General of CERN, the European Laboratory of Particle Physics, announced "The combined data coming from the seven experiments on CERN's Heavy Ion program have given a clear picture of a new state of matter. This result verifies an important prediction of the present theory of fundamental forces between quarks. It is also an important step forward in the understanding of the early evolution of the universe. We now have evidence of a new state of matter where quarks and gluons are not confined. There is still an entirely new territory to be explored concerning the physical properties of quark-gluon matter. The challenge now passes to the Relativistic Heavy Ion Collider at the Brookhaven National Laboratory and later to CERN's Large Hadron Collider."

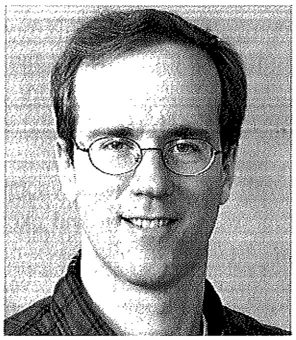
Two points in this announcement deserve special attention here. The first point is that a clear picture of a new state of matter is only possible in the combined data of several experiments, rather than as the result of a single experiment. It is like putting together pieces of a puzzle in order to see the picture. Professor Daniel Ferenc, who came to UC Davis from CERN last year and was involved with a couple of the experiments, put the puzzle together (with Ulich Heinz, who gave the main physics talk during the CERN announcement, and Carlos Lourenço) in a review article that appeared in the March 1998 issue of CERN COURIER, "Hunting down the quark-gluon plasma." The second point is the acknowledgements by CERN of the upcoming role of the higher energy American machine, the Relativistic Heavy Ion Collider (RHIC). UC**DAVIS** faculty are heavily involved with a RHIC experiment, STAR.

James Wells

Ph.D. - University of Michigan, Ann Arbor, 1995

Assistant Professor, Theoretical Particle Physics

Professor James Wells joined the department in July 1999.



All detected elementary particles can be classified as either matter fermions or vector bosons. The matter fermions are quarks and leptons, which are the constituents of known matter (neutrons, protons, oxygen atoms, camels, etc.). The vector bosons are the particles that transmit the four fundamental forces between the matter fermions. Some vector bosons are massless (the graviton of the gravitational force, the gluons of the strong force and the photon of the electromagnetic force), while others are massive (the W and Z bosons of the weak force). This classification of particles is the basis of the standard theoretical framework of elementary particle physics.

There are several unsolved mysteries associated with the above description of nature. First, how do particles get their masses? The answer to this question is not known and is perhaps the most pressing issue in particle physics. There are many theories that attempt to explain this mystery, but none of them has as yet been verified by experiment. The upcoming experiments at the Tevatron at Fermilab, near Chicago, and the Large Hadron Collider at CERN in Geneva, Switzerland, should provide important clues. One of my research programs is to develop theories of mass generation and to elucidate how they can be confirmed or rejected by experimental data expected in the near future.

Another pressing question in particle physics is why each of the four forces have different strengths, and in particular, why the gravitational force is so much weaker than all the other forces. To answer this question satisfactorily appears to require an explosion of new symmetries and particles in nature that have not yet been detected in high-energy collider experiments. I have studied several approaches to this problem, including supersymmetry, supergravity, grand unified theories, Kaluza-Klein theories of large extra spatial dimension and string theory. In fact, all of these elements may be required for a fully self-consistent theory.

There are many other interesting theoretical issues that have yet to be understood. These include the properties of time reversal in physical theories, particle dark matter in the universe, chiral symmetry breaking in quantum chromodynamics (strong force) and more. In all cases, my emphasis is to correlate theory with experiment in order to determine the laws of nature.

James Wells Receives Sloan Fellowship

Congratulations to Assistant Professor James Wells, recently honored nationally with an Alfred P. Sloan Research Fellowship. This is a very competitive award involving nominations for most of the very best scientists from around the country. The fellowship awards $40,000 over two years in support of outstanding researchers early in their academic careers. The fellowship program grants 100 awards annually in seven fields.

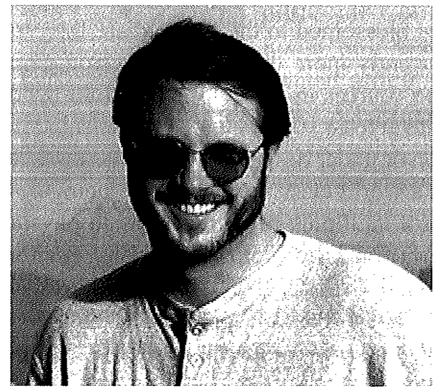
Professor Wells joined the UC Davis physics department in 1999. One of his primary research goals is to understand why particles have mass. He has played a leading role in making predictions for what will be seen in high-energy collisions if supersymmetry is a correct description of nature.

John Byrd

Ph.D. - Cornell University, 1992

Adjunct Asstistant Professor, Accelerator Physics

Dr. John Byrd joined the department in July 1999.



The particle accelerator has been one of the most successful research tools in the history of science. The increase in variety, number and size of accelerators has paralleled the growth of physics over the past 50 years. Today, these machines have applications from exploring the structure of subatomic particles to treating tumors. In fact, a good fraction of this department uses or relies on the results at accelerators as part of their research. As the demands on the energy, intensity and performance of accelerators have grown, the science of understanding and designing them has emerged as a field in its own right, with research ranging from nonlinear dynamics and chaos to the engineering of superconducting magnets.

At Lawrence Berkeley National Laboratory, the birthplace of the cyclotron, we are continuing to explore the frontier of accelerator physics in a variety of areas. We are involved in the design of several machines, such as the Next Linear Collider based at the Stanford Linear Accelerator Center (SLAC), the PEP-II B-factory at SLAC, and the Large Hadron Collider at CERN, as well as conceptual designs for a muon collider. The Berkeley group is also deeply involved in developing, both experimentally and theoretically, new techniques such as laser-plasma acceleration of electron beams and the generation of x-ray pulses on a femtosecond time scale.

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James Byrd

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The centerpiece of the laboratory's accelerator research is the Advanced Light Source (ALS), a 1.5-GeV electron storage ring optimized for producing synchrotron radiation. The field of synchrotron radiation has blossomed to the level where there are currently more than 50 synchrotron radiation sources in operation around the world with at least 10 more either under construction or under design. The ALS has emerged as a world class facility in producing light for a multitude of applications in physics, surface science, biology, chemistry, environmental science and other fields. Such a state-of-the-art machine presents a number of challenges to the accelerator physicist. For example, the vertical position of the beam must be kept stable within one micron over the 200-meter circumference of the ring for hours at a time! In addition to maintaining continuous operation of the machine, we use the ALS as a testbed for a number of areas in accelerator research such as nonlinear and chaotic dynamics, beam instabilities, novel diagnostics, a production of short bunches for generating coherent infrared radiation.

Much of my research is concerned with understanding and overcoming intensity limitations in electron storage rings. In modern storage rings, such as the PEP-II B-factory or synchrotron radiation sources like the ALS, the electron (or positron) beam is so intense that it is inherently unstable due to effects such as its electromagnetic interaction with the surrounding vacuum chamber. The instabilities can involve long-range interactions between the many bunches or between the electrons within a bunch. Additional interesting effects arise from the interaction of the electron beam with the positively charged residual gas ions. Avoiding or controlling these instabilities is crucial to the successful operation of these machines. At the ALS, we have developed analog and digital feedback systems to control the instabilities driven by long-range interactions. These have since been adopted at several other accelerators. We are also continuing to study new techniques such as application of nonlinear forces on the beam to provide natural damping. All of this research is done using a combination of experimental, theoretical and numerical tools. However, I must admit that most of the fun is had sitting at the controls of this $100 million machine.

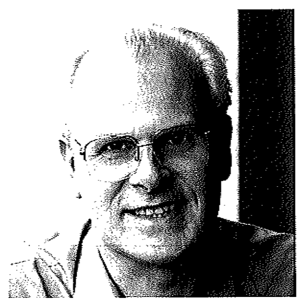
In addition to activities on the ALS, our group is thinking about new radiation sources to be built. The accelerator community is currently defining the next generation synchrotron radiation source. Several new concepts will be tested around the world over the next five years, providing many opportunities for innovation.

Michel A. Van Hove

Ph.D. - University of Cambridge, 1974

Adjunct Professor, Theoretical Surface Science: "Theory of the Experiment"

Dr. Van Hove joined the department in July 1998.



Surfaces and interfaces of condensed materials present a wide range of scientific opportunities in modern science and technology, from physics and chemistry to mechanical engineering and biology. Applications include semiconductor devices, magnetic storage media, chemical catalysis, corrosion, batteries, environmental processes, sensors, friction, mechanical wear, polymer films and biological membranes.

Basic to the understanding of the properties of surfaces and interfaces is their atomic-scale structure, including geometric, electronic and magnetic aspects. A major challenge is to extract such information from experiment, because of the minimal amount of material involved, typically a few atomic monolayers against a background of macroscopic amounts away from the surface or interface. This calls for special measurement techniques, as well as "theory of the experiment," to simulate how the information is gathered by these techniques. Theory of the experiment is the focus of my research, which I conduct primarily at Lawrence Berkeley National Laboratory (LBNL) in Berkeley.

Experimental probes of surfaces and interfaces include photons and electrons. An important approach for obtaining structural information is diffraction of those photons or electrons: diffraction exploits the wave character of photons and electrons to pick up structural information that can later be extracted by suitable computer modeling. X-ray diffraction of high-energy photons is familiar for studying "bulk" crystals. Its theory is simple and well-established, while its experimental application to surfaces and interfaces is only practical with high-brightness synchrotron radiation sources. A modern and exciting approach for certain applications is x-ray holography, and we are involved in its development.

Electrons have the advantage over photons in that they can be made more "surface sensitive"; they have a short penetration depth of only a few atomic monolayers at suitable energies, while photons penetrate far deeper in the best of circumstances. On the other hand, electrons require a free surface: the surface must be adjacent to an extremely good vacuum so that the electrons can be steered from a source to the surface (as in a TV tube) or out of the surface to a detector. The short penetration depth of electrons also implies a relatively strong and complex scattering of the electrons by the atoms of the surface. Much of our work addresses these interesting challenges theoretically, in close collaboration with experiment.

One major experimental technique that we model theoretically, in collaboration with Professor Chuck Fadley's group at UC Davis and LBNL, is photoelectron diffraction. In this technique, photons impinge onto a surface and kick out photoelectrons that diffract through the surface and out to a detector. A related technique, which we are developing and using, is low-energy electron diffraction, in which an electron impinges onto and then diffracts out of a surface. We also work on the theory and application of scanning tunneling microscopy. This tool brings a solid tip within atomic distances of a surface and allows electrons to tunnel quantum mechanically between tip and surface. As the tip is scanned across the surface, an atomic-scale image of the surface can be generated; we study the information content of such atomic images by computer simulation.

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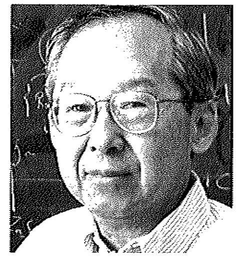
John Jungermann Recipient of Science and Religion Course Program Award

The Center for Theology and the Natural Sciences *Science and Religion Course Program*, recently announced that John Jungerman has been selected as a winner of the $10,000 Science and Religion Course Award for his course "Modern Physics, Cosmology and Religion." Selection criteria for the Course Award emphasize the intellectual integrity of both science and religion. They are intended to underline the importance of constructive conversation – neither warfare nor syncretism – for a rigorous and thoughtful study of science and religion.

Professor Jungerman's course is designed to explore ideas of modern physics using relativity and quantum mechanics to show that our world is interconnected, indeterminate, and not predictable at the level of individual particles, and is a source of spontaneous creativity – in contrast to the Newtonian view. The course also briefly discusses non-linear, self-organizing systems to explore their creativity and lack of predictability. From the vantage point of particle physics, the course also explores the Big Bang theory of the origin of the universe.

Professor Emeritus Jungerman received his Ph.D. degree in nuclear physics from the University of California, Berkeley, subsequent to wartime involvement with the Manhattan Project. He was a faculty member at UC Davis from 1951 to 1991. He was founding director of Crocker Nuclear Laboratory and served for several years as chair of our physics department.

Congratulations Ching Fong!



Physics professor Ching Fong has been elected a Fellow and Chartered Physicist by the Institute of Physics of Great Britain. Fellows are named for their high level of achievement in physics and outstanding contributions to their profession. Chartered Physicists have passed the scrutiny of the institute's council for their education, experience and professional responsibility.

Dateline, December 3, 1999

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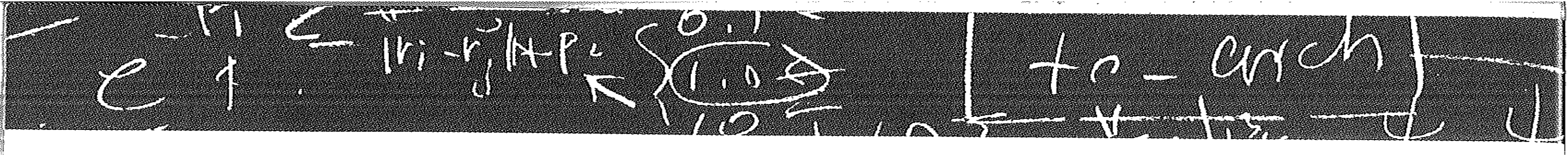
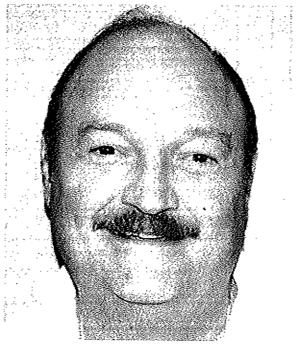


John McGrath Retires



Laboratory Manager, John McGrath, retired from the university on September 1, 1999, after more than 26 years of overseeing both the lower- and upper-division laboratories in the physics department. Some 50,000 students' and 300 TA's experiences in introductory labs were made much more valuable and pleasurable due to John's continuing devotion to the improvement (and student and TA proofing) of the hundreds of lab set-ups used (and abused) by the thousands of students using them each year.

The majority of the lab set-ups were developed and produced locally to match the exact needs of the particular courses. Sometimes the idea for a new or revised set-up came from a laboratory instructor, in which case, John frequently had the unenviable task of taking a sketchy idea and figuring out how to make something that would actually work "out in the labs." One of the amazing things about John was that he could do this and still keep that friendly disposition that we all will miss so much.

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