UCDAVIS

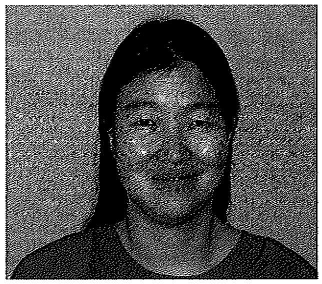
Physics Newsletter

Number 11 *A Newsletter for University of California, Davis, Physics Alumni* *2003*

From the Chair...

It's a privilege to be the new department chair of such a thriving department. Our former chair, Winston Ko, has become our new Dean of the Division of Mathematical and Physical Sciences. We now have 37 faculty members. Four new faculty members joined our department in 2002-03 and are profiled in this issue of the newsletter: Chris Fassnacht, Nemanja Kaloper, Lori Lubin, and John Rundle. The first three complete the initial buildup of our excellent cosmology program, which has doubled in size in the last year. Rundle is the new director of the Center for Computational Science and Engineering (CSE). The CSE is currently beginning to hire new faculty, some of whom may turn out to be computational physicists.

In addition, Tony Tyson, a distinguished astrophysicist from Bell Laboratories who is a member of the National Academy of Sciences, has joined our faculty and will arrive on campus in July, 2004. His wife, Patricia Boeshaar, has also joined our faculty as a Senior Lecturer and will be a key person in building up in our undergraduate astrophysics program. It also looks likely that a senior condensed matter experimental physicist, who is also a member of the National Academy of Sciences, may join our faculty in early 2004.



Professor Shirley Chiang

Our fifth floor expansion project is nearly complete. Although we have had to live with a lot of noise and disruption over the last year, the new space is extremely necessary, and the renovation is looking great. The additional 4,400 square feet will provide additional space for the cosmology and nuclear groups, the CSE, and computer support.

Alumni are invited to attend the Cosmology Program Open House, which will be held on Monday, September 29, 2003, from 1:30 to 5:00 p.m., on the fifth floor of the Physics/Geology building. A special public lecture will be given by Dr. Michael Turner, University of Chicago and Fermi National Accelerator Laboratory, on "The Dark Side of the Universe: Beyond Stars and the Starstuff We Are Made Of." As Turner is the new Assistant Director for Mathematical and Physical Sciences at the National Science Foundation (NSF), we hope to highlight some of our NSF-funded work in the department for him during his visit.

Inside This Issue

Research News

Student News

Faculty News

After losing James Wells to the University of Michigan, we have begun the High Energy Frontier Theory Initiative (HEFTI), which calls for the hiring of three faculty members, one senior and two junior, in the next few years. We have recently made an offer to an eminent senior high-energy theorist.

This fall, the department will be working on developing a new academic plan, which will extend at least to 2008, the centennial year for UCDavis. We will work on articulating our vision for the department, including our plan for hiring faculty.

Our instructional program is booming, as student enrollment continues to grow. In 2002-03, we taught 2,670 students in Physics 7; 2,546 in Physics 9; and 200 in Physics 9H. In addition, beginning in 2002, we significantly expanded our summer program. This summer, we are teaching 809 students in Physics 7; 206 in Physics 9; and 75 in Astronomy 10. We had 139 Physics majors, as of Spring 2003, with 21 students receiving Bachelor's degrees in 2002-03. We have also had a significant increase in the number of graduate students. We will have 27 new

(continued on back page)

50th Anniversary Alumni Dinner Planned

Mark your calendars now for a special Alumni Dinner scheduled for Saturday, **October 25, 2003.** Help us celebrate the department's 50th anniversary in style! Enjoy a faculty vs. alumni softball game, tour the department, and relax in the company of your friends and former classmates.

Invitations have been mailed. You can also find information at: http://www.physics.ucdavis.edu/alumni-dinner/

We look forward to seeing you in October!

Condensed Matter Physics at Davis: History and Present Research

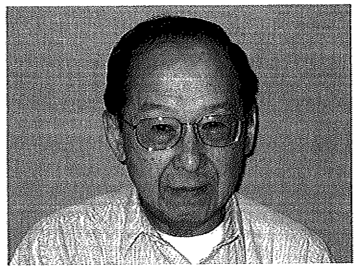
by C.Y. Fong, professor

To celebrate the 50th anniversary of the Physics Department at UCDavis, Winston Ko asked me to recapitulate the history of the condensed matter physics group. In this article, I shall first do the recapitulation. Then I shall show the progress by presenting brief descriptions of the state-of-the-art research carried out by the various subgroups.

In 1951, when the agriculture experimental station of UC Berkeley at Davis became a general campus, it had a single Mathematics and Physics department. The Physics Department became independent in 1953. Initially, the department consisted entirely of nuclear physicists. In 1965, the nuclear group became interested in experiments involving polarized nuclear targets. They hired O. Leifson, who had just finished his Ph.D. thesis on dynamic polarization of nuclear spins through nuclear electron dipolar coupling. Professor Leifson's laboratory was in the basement of Young Hall.

This was the dawn of condensed matter physics at UCDavis. Shortly after, the department added C. Garrod, whose interest was in statistical physics. By the end of 1968, I joined the department as a solid-state theorist in the sub-area of electronic and optical properties of solids. Just about a year later, W. Potter, whose thesis was on the subject of polarizing nuclear spins using an ingeniously designed turbine rotating the samples at 1iK under a high magnetic field, joined the department to collaborate with Leifson. Professor Leifson decided to leave UC Davis in 1972, and L. Corruccini was hired in 1973 to replace him, in part because his expertise allowed him to use equipment owned by the department. Professor Corruccini's field is low temperature physics, specializing in liquid helium and spin systems. In 1976, L. Coleman initiated a new sub-area, infrared physics. By that time, the basement of the Physics/Geology building had many interesting experiments going on.

For the next ten years, however, there was no expansion in the area of condensed matter physics. In 1986, the Dean of College of Letters and Science, L. Mayhew, decided to strengthen the Physics Department. An



Professor Ching-Yao Fong

external advisory committee was formed, consisting of five internationally known physicists: R. Blankenbecler (UC Santa Barbara, high energy), S. Drell (Stanford University, high energy), L. Falicov (UC Berkeley, condensed matter), J. Rasmussen (Lawrence Berkeley National Laboratory, nuclear), and L. Sham (UC San Diego, condensed matter). The committee recommended to the Dean that the Physics Department should expand first in the area of condensed matter physics, especially in theory.

The department responded by hiring R. Shelton to be the chair. Hiring was then concentrated in the area of theoretical many-body physics: R. Scalettar and G. Zimanyi in Monte Carlo techniques and the Hubbard model, and R. Singh in statistical mechanics and series expansions. Their interests were concentrated in high temperature superconductivity. To strengthen experimental condensed matter physics, D. Webb and X. D. Zhu joined the department to expand into the sub-areas of transport properties of matter and application of lasers to surface physics. The department also had the opportunity to hire C. Fadley, whose specialty is in X-ray spectroscopy and surface physics, as a joint appointment with Lawrence Berkeley National Laboratory.

After serving five years as the chair of the Physics Department, Shelton moved up to become the Vice Chancellor of Research. He negotiated with the Dean for another condensed matter physicist to replace him. We were fortunate to have B. Klein, who was branch chief of the theory group at the Naval Research Laboratory (NRL), as the next chair. He managed to recruit S. Chiang from IBM Almaden Research Center. Professor Chiang is an expert in scanning tunneling microscopy. With Professors Chiang, Fadley and Zhu, our department became strong in surface science.

Professor Klein also organized many researchers in condensed matter physics from all of the UC campuses and Lawrence Livermore and Los Alamos National Laboratories, and secured a Campus Laboratory Collaboration (CLC) grant from the UC President's office. The CLC grant provided an opportunity for faculty members, postdoctoral research associates, and graduate students at the UCDavis campus to interact vigorously with colleagues at other campuses and national laboratories. Later, D. Cox from Ohio State University and W. Pickett from NRL joined the department. Professor Cox is famous in strongly correlated materials. Professor Pickett is very well known in electronic structure of condensed matter. The addition of R. Zieve to the department further enhanced the area of low temperature physics.

After Professor Klein took the position of vice provost, our new chair, Professor Ko, strengthened the area of nanoscience, using the nanoinitiative on campus to recruit K. Liu from UC San Diego. Since his arrival, Professor Liu's research has attracted many students who have come to Davis for their graduate study.

The consequence of this development has been the establishment of several subgroups within the condensed matter physics group: biophysics, electronic structure, low temperature physics, many-body physics, nanophysics, and surface physics. Each is carrying out many interesting projects in the forefront of research. In the following, brief descriptions of each subgroup are given.

Biophysics — The biophysics efforts include developing optical techniques to scan DNA and protein chips (Zhu) and studying electronic and statistical mechanical issues in DNA damage and repair (Cox, Fong, and Singh). In addition, protein aggregation and incubation time in prion diseases (Cox and Singh) are being investigated. The members are all participants in the Center for Biophotonic Science and Technology, funded by National Science Foundation. Professors

(continued on page 3)

Condensed Matter Physics at Davis...

(continued from page 2)

Cox and Singh have new funding from the Department of Defense on prion diseases.

Electronic structure — This subgroup has been intimately involved in several different aspects of "knowing electrons." It has developed sophisticated algorithms to predict with reasonable accuracy when most materials will be semiconducting (Pickett and Fong), or superconducting (Pickett), or even magnetic and half-metallic (Pickett and Fong). The excitement of this research is that it contributes to tomorrow's nanotechnology and spintronics. Another strong effort (Pickett and Scalettar) is directed toward obtaining a better knowledge of "strongly interacting" electronic systems, which often shuttle and jump between semiconducting, superconducting, and magnetic states, and sometimes display large discontinuous (and rather mysterious) changes in volumes as the pressure is varied.

Low temperature physics — One of the research efforts in low temperature physics focuses on resolving a longstanding issue about what order would be induced by dipolar interactions (Corruccini). Combining with the effect of magnetic frustration, this topic is related to exotic "quantum fluctuation" phenomena.

The so-called "heavy fermions," whose mass can be more than 200 times the mass of a free electron, exhibit fascinating new behaviors. The experimental effort in Zieve's laboratory is to understand why small changes in low pressure have dramatic effects in superconducting and magnetic properties. Another endeavor by Zieve is to understand the turbulent motion in superfluid helium below 2° Kelvin.

Many-body physics — The current interests of the many-body subgroup include studies of vortex dynamics in superconductors, optically trapped atoms, and magnetic hysteresis (Scalettar and Zimanyi). The development of new algorithms that make the distinction between "electronic structure" and "many-body" approaches lose significance is underway (Pickett and Scalettar). One such approach has a tongue-twisting acronym, which reflects the merger: Local density approximation plus dynamic mean field theory in the sense of quantum Monte Carlo approach (LDA+DMFT).

Molecular dynamics simulations to study "threshold behaviors" in model glasses are also being carried out (Webb).

Nanophysics — Two subgroups are involved in nanophysics. The study of spin-dependent transport in nanostructured materials (Liu) investigates the interactions between spin and charge under the effect of confinement and of reduced dimensions. The other subgroup (Fong) is carrying out first-principles study of doping semiconductor quantum dots with magnetic elements for possible medical applications.

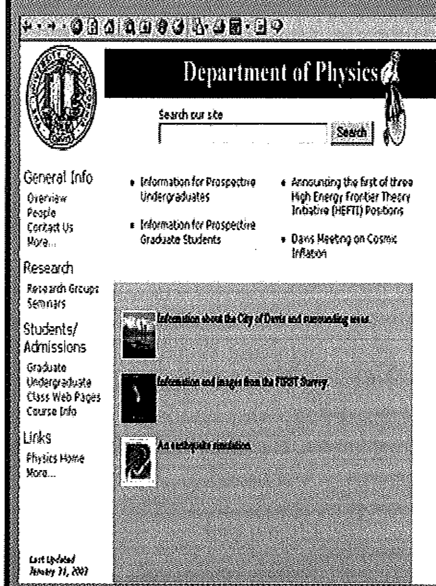
Surface physics — The surface physics research in the department spans a wide range of phenomena and techniques, from spectroscopy to microscopy, with emphasis on magnetism. Unique facilities, such as soft X-ray synchrotron radiation, at the Advanced Light Source (ALS) at LBNL (Fadley), are used to do angle-resolved X-ray photoemission spectroscopy, X-ray photoelectron diffraction, and electron holography of high-temperature electronic phases in the colossal magnetoresistive oxides such as, $La_{(1-x)}Sr_{(x)}MnO_3$. Another novel soft X-ray standing wave technique (Fadley) has been developed for studying the magnetism of buried solid-solid interfaces, and this is being applied to multilayer magnetic structures relevant to magnetic read head and data storage. Specifically, interfaces related to giant magnetoresistance, tunnel resistance, and exchange bias are being studied. Photoemission electron microscopy to observe magnetic domains, and X-ray magnetic linear dichroism to study the magnitude of the magnetism as a function of film thickness and composition, are being carried out at LBNL (Chiang).

On campus, there is also state-of-the-art equipment including ultrahigh vacuum scanning tunneling microscopy (STM) and low energy electron microscopy (LEEM), used by Professor Chiang to image molecular adsorbates for chemical reactions, nucleation and growth phenomena in metal on metal epitaxy, atomic adsorbates on metals, and phase transitions on surfaces. For example, the STM permits the imaging of individual molecules near step edges before and after the reaction occurs, and is used to study the decomposition reaction of furan (C_4H_4O) on Pd(111) as a function of temperature.

Modern optical techniques for probing structures and kinetic processes at surfaces and interfaces are another endeavor within this subgroup (Zhu). Professor Zhu developed a scheme to combine STM and LEEM to complement his optical study of motions of atoms and atomic step edges on crystalline solids, as well as an oblique-incidence optical reflectivity difference technique for studying thin film kinetics.

In summary, the condensed matter physics group at UCDavis started with a project of polarized nuclear targets. After 35 years, the group now consists of many sub-areas carrying out forefront research. We are in an exciting period, and hope that we shall continue to move in new directions to sustain the excitement forever. ❖

Physics Department Home Page



For more information about the UCDavis Physics Department, visit our home page at: http://info-physics.ucdavis.edu/

Cosmic Inflation Meeting

by Andreas Albrecht, professor

Last March most of the world's top cosmologists converged on Davis to participate in the *Davis Meeting on Cosmic Inflation.* The participants enjoyed an impressive array of exciting talks, and the lively discussion and debate continued late into the night in the local restaurants, bars and coffee shops. Dean Rock, one of the key visionaries behind the buildup of cosmology at UCDavis, opened the conference on March 23rd. That evening Stephen Hawking presented the first of his two sold-out public lectures at the Mondavi Center and charmed and challenged an enthusiastic audience with the idea that our universe might be a "brane" in a higher dimensional space. That same evening the originators of cosmic inflation theory gathered over dinner at the Katmandu Kitchen to assess Hawking's very provocative plenary talk at the conference that morning. Yes, the list of speakers read like a Who's Who of modern cosmology research, but the real stars of the show were a theory (cosmic inflation) and a brand new dataset, the full-sky microwave map produced by NASA's Wilkinson Microwave Anisotropy Probe (WMAP) satellite and released just a month before the conference.

What is cosmic inflation theory? Cosmologists study the origins and evolution of the universe. For many years now, the "hot big bang" has provided the basic picture of the universe as it evolved from a very hot dense plasma at early times, allowing stars, galaxies and planets to condense out as the universe expands and cools. But cosmologists have always found something very strange about the starting point of the big bang theory. To achieve consistency with the observed state of the universe today, one needs to assume a starting point for the big bang that is precariously balanced in a state highly disfavored by the cosmological equations: Gravity wants to pull matter together and make it more clumpy (ultimately to form one giant black hole). But the universe starts out extraordinarily smooth. The equations of gravity try to amplify any small "curvature" the universe may have, causing it to rapidly curl up either with negative curvature (like a potato chip) or positive curvature (like a sphere). But the real universe started out so precisely balanced in a "flat" state (zero curvature), that even today any deviation from flatness is unmeasurable even using the most modern technology. It is as if the universe has been perched like a pencil on its point, and balanced so precisely that it has hardly started to fall, even after 14 billion years!

The Davis meeting on Cosmic Inflation.

About twenty years ago, cosmic inflation theory was invented. Its goal is basically to explain how the pencil got so precisely balanced on its point. Inflation posits a new state of matter (a so-called "potential dominated" state) that could exist in the early universe, and which actually reverses the dynamical processes discussed above, so that curvature tends to flatten out on its own, and clumpy matter tends to smooth out into a more homogeneous state. If such a state of matter existed in the early universe, the universe is said to have undergone a "period of inflation" (named after the extremely rapid expansion that goes with this special state). Inflation is the hand (or perhaps high precision robot) that carefully places the pencil in a perfectly balanced upright state.

So what is exciting today about this 20 year old theory? To begin with, to fully understand and test the idea of cosmic inflation, one must probe the deepest unsolved problems in physics and cosmology: What is the fundamental theory of quantum gravity and matter? Is that theory able to accommodate the special inflationary state? Is the universe infinite, extending forever with more stars and galaxies, just like the ones we see, or is our observed universe merely an island adrift in a chaotic sea of something unimaginably different? Interestingly, much progress has been made on these and related questions over the last 20 years, and our meeting proved to be well-timed to debate the current status of these and related questions.

Probably the most celebrated participant at our meeting was the new data from NASA's WMAP, just announced this February 11th. The WMAP satellite is stationed in the depths of outer space (four times as far from earth as the moon). It is systematically mapping out subtle microwave signals from the very edge of the observable universe, signals that convey information about the very earliest stages of cosmic history. The February release of the first year data has already proven to be a gold mine for many aspects of cosmology, especially for cosmic inflation theory.

Despite the fact that there are still important unanswered theoretical questions about cosmic inflation, the theory is well enough understood to makes a whole host

(continued on page 5)

Cosmic Inflation

(continued from page 4)

of observable predictions. It turned out that the impressive new WMAP data had the potential to falsify inflation in a number of different ways. But as things turned out, inflation passed with flying colors. This added a sense of celebration to the meeting.

Many participants of *Davis Meeting on Cosmic Inflation* regarded the meeting as a turning point: the start of the much-heralded era of "precision cosmology." This was the first conference after the release of the WMAP data, a data set at least an order of magnitude more powerful than any other existing cosmological data set. The whole flavor of the field has changed, now that even subtle theoretical debates can be put before the ultimate judge (namely Nature) for a final ruling. The WMAP data has raised the bar, and much of the discussion looked toward the future, as we discussed and debated which new proposed experiments and facilities would provide the best opportunities supercede the success of WMAP and bring the field into a new era of even higher precision.

We are proud that such a special event in the development of cosmology took place here at Davis. It gave us a chance to thank the many colleagues from around the world who have assisted with our buildup through their advice and support, and to celebrate the formation of our cosmology program here, along with the fantastic advances in our field.

Special thanks: The *Davis Meeting on Cosmic Inflation* was supported by The UCDavis Office of Research, the UCDavis Division of Mathematical and Physical Sciences, and the Physics Department, as well as by DOE, NASA, and NSF.

Further info: You can learn more at the website: http://inflation03.ucdavis.edu/ which includes copies of the speakers' slides and proceedings contributions. You can learn more about the WMAP results at: http://map.gsfc.nasa.gov ❖

Workshop on Magnetism, Hysteresis, and the FORC Method

by Kai Liu, Richard Scalettar, and Gergely Zimanyi, professors

On April 25-27, 2003, Kai Liu, Richard Scalettar, and Gergely Zimanyi in the Physics Department, and their colleagues in Geology, Chris Pike and Ken Verosub, organized a workshop on Magnetism, Hysteresis, and the FORC Method, at the Buehler Alumni Center of the University of California, Davis. Please see:
http://forc.ucdavis.edu/workshop.shtml.

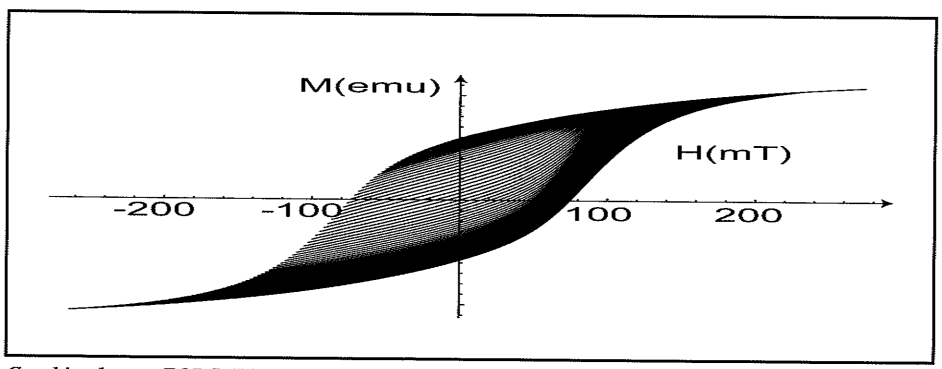
The workshop brought together people working on -

- Experimental studies of magnetization reversal and hysteresis in magnetion nanostructures, magnetic recording media, and bulk/ natural magnetic materials;
- Phenomenological hysteresis modeling, using e.g. Preisach approaches;
- Micromagnetic calculations and simulations of spin glasses, random field Ising models, dipolar systems, and reversal mechanisms;
- Applications of the FORC (First Order Reversal Curve) technique to magnetism and hysteresis.

At the workshop, participants had the opportunity to discuss current issues in magnetism and hysteresis and to become informed about the FORC method and its applications. The FORC method, based on an analysis of partial hysteresis curves, is a new technique that probes the details of the magnetization reversal. It has already been used to study natural geological samples, magnetic recording media and other magnetic nanostructures.
(For a more complete discussion, please see: http://forc.ucdavis.edu/forc.shtml and the attached documents.)

About 70 participants from academia, government laboratories, and industrial laboratories attended the conference. The participation of the speakers and students was covered by grants from the National Science Foundation, the University of California Digital Media Program, and the UCDavis Office of the Vice-Chancellor for Research. The talks are available on a compact disc.

The list of invited speakers included: D. Belanger (UC Santa Cruz); A. Berger (Hitachi); C. Carvallo (Toronto); C. L. Chien (Johns Hopkins); K. Dahmen (Illinois, Urbana); E. della Torre (George Washington); J. Feinberg (UC Berkeley); G. Friedman (Drexel); M. Funaki (NIPR; Japan); H. G. Katzgraber (ETH); G. Kenning (UC Riverside); D. Landau (Georgia); K. Liu (UC Davis); A. Mazaud (LSCE; France); M. McElfresh (Livermore); A. Middleton (Syracuse); T. Mullender (Utrecht); A. Muxworthy (Edinburgh); P. Norblad (Uppsala); M. Novotny (Mississippi); J. Peck (Akron); C. Pike (UCDavis); A. Roberts (Southhampton); I. K. Schuller (UC San Diego); G. Scott (UC Berkeley); L. Spinu (New Orleans); A. Stancu (Iaon Cuza); B. Terris (Hitachi); K. Verosub (UC Davis); F. Wehland (Tuebingen); D. Weller (Seagate);M.Winkelhofer (Southhampton); and J. Zhu (Carnegie Mellon). ❖



***Graphic above:* FORC (First Order Reversal Curve), based on an analysis of partial hysteresis curves, is a new technique that probes the details of the magnetization reversal.**

Stephen Hawking Visit

by Andreas Albrecht, professor

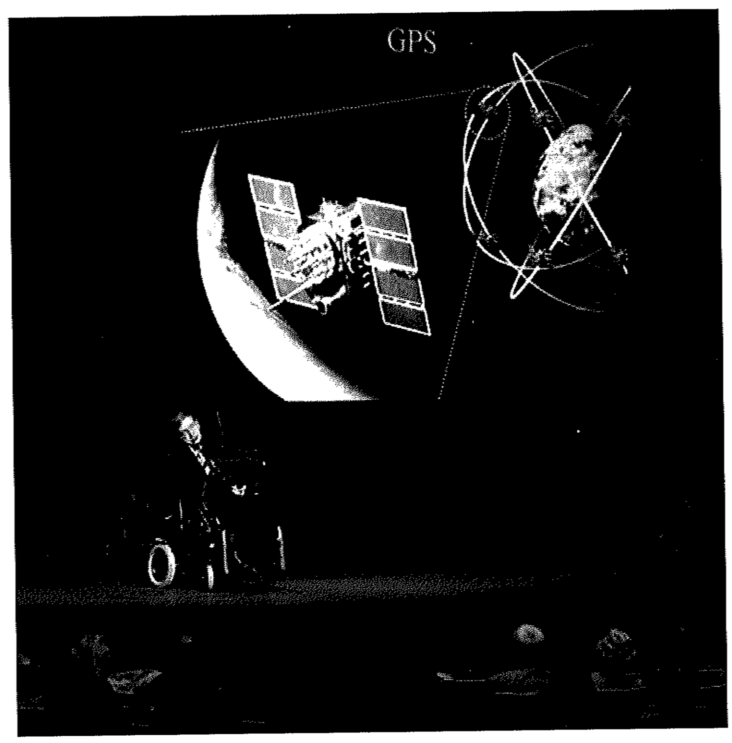
If you stop someone on the street and asked that person to name one living scientist, Stephen Hawking's name would surely come up more than any other. With appearances in everything from Star Trek to The Simpsons to his own TV series, Stephen Hawking enjoys celebrity status that greatly exceeds that of many "full time" celebrities. As scientists we are extremely fortunate that Hawking enthusiastically and very effectively takes on the role of scientific "ambassador" to the public. And the public is also fortunate that there is such an extraordinary scientist willing to take on this role.

When Hawking agreed to participate in the *Davis Meeting on Cosmic Inflation*, we knew his plenary talk would be a highlight of the conference. But no one fully understood at the time what a fantastic hit Hawking would be with the public. The conference organizers urged UCDavis Presents to invite him to give a public lecture, but they were cautious: They had never imagined a scientist filling the 1,800 seat Barbara Jackson Hall. Thanks in part to the initiative of Dean Rock and the Vice Chancellor for Research, our department's own Barry Klein, the public lecture was finally scheduled. Next thing we knew, that lecture had sold out before the season ticket sales were even finished, and the buzz among the Davisites and students was that the "little guy" got left out of the great Hawking event. Fortunately, Hawking kindly agreed to stay on for a few days after the meeting and to give a second lecture. This lecture also sold-out in due course, but at least everyone had a fair crack at a ticket.

Hawking's first lecture, entitled "Brane New World," introduced the amazing ideas behind the latest attempts at producing a "Theory of Everything," that is, a unified theory describing all fundamental physics. Hawking explained how our three familiar dimensions of space could be a "brane" (derived from *membrane*) in a higher dimensional space. He discussed what cosmology might look like in this picture: Perhaps "brane bubbles" could form, with us living on the (three-dimensional) "surface" of one of them, and perhaps parallel brane branes collided to make the hot big bang (and idea popular with some, but not with Hawking). Hawking also discussed how the new LHC particle accelerator under construction at CERN could discover evidence for the extra dimensions.

Professor Stephen Hawking, Cambridge University

The second public lecture, entitled "Gödel and the End of Physics," asked an even deeper question: Can we expect the quest for a Theory of Everything to come to an end, with a final theory that answers all fundamental questions? Hawking related this question to Gödel's Theorem, which revolutioned mathematics by showing any logical system is necessarily incomplete. You can pose self-referential questions like "the barber of Corfu shaves every man who does not shave himself. Who shaves the barber?" which cannot possibly be answered. Hawking's conclusion was that, just as Gödel showed us that there will be not complete logical system in mathematics that answers all questions, so to will there always be interesting open questions about fundamental physics waiting to be answered. This was quite an about face for Hawking, who until recently had been predicting that arrival of the ultimate Theory of Everything was just a few years off. But that sort of thing does not bother Hawking, who thrives more on the thrill of learning and discovery than on any need for a linear progression in his own thinking.



Stephen Hawking onstage at the Robert and Margrit Mondavi Center.

Hawking has a reputation as quite a fun-loving guy, and he lived up to that reputation while in Davis. On several nights, he could be seen hanging out at the G Street Pub, and he could be found roaming in the arboretum and visiting coffee shops (for tea of course).

Perhaps the most profound comments from Hawking came at a luncheon in his honor at the Chancellor's residence. After lunch Hawking made some brief remarks to the assembled group of members of the campus community as well teachers and students from area public schools. He admonished everyone not to forget the scientist that is present in all of us, especially when we are young, and urged us all to "always ask why." ❖

Computational Research Team

by Richard Scalettar and Warren Pickett, professors

Since early times in the theoretical study of condensed matter systems, there have been two distinct, complementary, and sometimes adversarial approaches. On the one hand, methods were developed and concerted computational efforts were expended in addressing real materials (as exemplified by Slater's group) and formalisms were extended for the purpose *Hohenberg-Kohn-Sham DFT*. Out of respect for the untenable "real many-body" problem, it proved necessary to approximate the treatment of interactions, and in a way that made the approach inapplicable to strongly correlated insulators (for example). On the other hand, there was an effort (exemplified by the work of Hubbard and Mott) to simplify the situation from that of specific identifiable materials, but to retain strong interactions within a bare-bones model. Over the past half century there has been tremendous development, and a great deal learned, from each of these viewpoints.

With very few exceptions, practitioners in one of these areas have been, in the past, at best observers in the other arena, partly because of the different expertise that each required, partly due to partisanship, but mostly due to the inability to conceive of any real possibility that the two camps could find common, fertile ground. During the past decade or so, however, much has changed to begin bringing these subdisciplines together. High temperature superconductivity became a common focus, where electronic structure approaches without correlation effects could not begin to make sense of some parts of the phase diagram, and many body models could not hope to address the (material dependent) experimental data. Both camps had to focus on the data and had to begin to communicate seriously. This same era saw the progression from the supercomputer (Cray in early 1980's) to the supercomputer center and the accompanying great increase in computational power, an increase whose continued growth can be foreseen for at least a decade. This merging of the required ingredients with strong computational effort will open up the full periodic table to realistic modeling and ultimately to full predictive capability.

On January 18-19, 2003, the Condensed Matter Theory group in the Physics Department at UC Davis organized a meeting to prepare a proposal for the creation of a Computational Research Team (CRT) on "Predictive Capability for Strongly Correlated Systems," (http://leopard.ucdavis.edu/rts/cmsn/index.html) whose goal is to take advantage of these recent developments to attack problems ranging from superconductivity to transition metal oxides, which include the most promising components of new spin electronics applications, to intermetallicc compounds whose quantum critical behavior has given rise to some of the most active areas in condensed matter theory.

This CRT would be part of the broader effort of the Basic Energy Sciences Division of the Department of Energy "Computational Materials Science Network" (CMSN), which was established in 1999. The mission of CMSN is "to advance frontiers in computational materials science by assembling diverse sets of researchers committed to working together to solve relevant materials problems that require cooperation across organizational and disciplinary boundaries."

The final team includes quantum chemists, theoretical solid state chemists, in addition to members with varied background in theoretical materials physics. The institutions participating include: College of William and Mary; Cornell University; New Jersey Institute of Technology; Ohio State University; Rutgers University; University of California, Davis; University of California, Irvine; University of California, Los Angeles; University of Cincinnati; University of Illinois; Urbana; University of Tennessee; Lawrence Livermore National Laboratory; Los Alamos National Laboratory; Oak Ridge National Laboratory;and Sandia National Laboratory.

If funded by the Department of Energy, Principal Investigators Warren Pickett and Richard Scalettar of UC Davis will lead this CRT. ❖

Is There Life after Graduate School?

by Steven Carlip, professor

It used to be simple. You finished your Ph.D., went on to a postdoc position, and then got hired by a university, a national lab, or a company doing physics research and development. Roughly a third of all physics Ph.D.s went into higher education, a third into the national labs, and a third into big industrial labs. There were always exceptions – the physicists who helped found molecular biology, for instance – but the standard career path was pretty clear.

Life has changed. There are about 1,350 new physics Ph.D.s granted in the United States each year, along with roughly 3,000 physics postdocs, most of them looking for permanent jobs. But in the year 2000,fewer than 150 new graduates and postdocs were hired into faculty positions in the U.S. The situation in the national labs and the big corporate labs is not much better: cuts in funding and a shift toward short-term "development" work have eliminated many of the traditional jobs for physicists.

This doesn't mean new physics Ph.D.s end up jobless. The unemployment rate for recent physics Ph.D.s is far below that for the country as a whole. But most new graduates have to search farther afield for good, satisfying jobs, and have to be flexible in a way past generations weren't.

Unfortunately, it's not so easy for physics students to learn how to do this. Their professors, after all, are people who succeeded in the academic career track, and while a few faculty members at UCDavis have had jobs outside academia, most have not.

To offer students at least a taste of the available choices, Professor Steve Carlip has run a seminar for the past few years on

(continued on page 8)

Is There Life after Graduate School?

(continued from page 7)

"career options for graduate students."

The seminar brings in people from industry, government, and other careers outside research universities to talk about their work, and about how they ended up where they did.

This year's speakers include a physicist who works on centrifuge design at a medical instrument firm; another with 30 years of experience in the semiconductor industry; another who went from a high energy theory postdoc to a job at a computer company; and another who teaches at a state college (a different enough environment that many UCD students don't know much about it). Past speakers have talked about medical physics, jobs on Wall Street, high school teaching, Internet start-up companies, and patent law.

We can always use more speakers. If you are a physicist with a career outside academia with a job you enjoy, and you'd like to talk to UC Davis graduate students about it, please get in touch with Steve Carlip (carlip@physics.ucdavis.edu). ❖

Degrees Awarded

Ph.D Degrees Awarded

September 2002 – June 2003

Robert Endres – "*Theory of Electron Transfer and Molecular States in DNA*"
*Postdoc Research Assistant at the Joint Institute to Computational Science, Oak Ridge National Laboratory

David Everitt – "*Imaging of Tissue-like Media with Diffuse Light: Analysis and Optimization of a Diffuse Photon Tomography*"
*Adjunct Faculty Member, American River College, Sacramento, CA

Thomas Farris – "*Searching for the CP-odd Higgs at a Linear Collider*"

Dustin Froula – "*Experimental Studies of the Stimulated Brillouin Scattering Instability in the Saturated Regime*"
*Plasma Physicist at Lawrence Livermore National Laboratory

Shrihari Gopalakrishna – "*Aspects and Probes of Supersymmetric and Extradimensional Beyond the Standard Model Theories*"
*Postdoc Researcher at Michigan State University

Ian Johnson – "*Photon and Pi 0 Production in 197 Au + 197 Au Collisions at Center of Mass Energy of 130 GeV per nucleon*"
*Postdoc Researcher at Lawrence Berkeley National Laboratory

Montiago LaBute – "*Strong Electron Correlations in Biomimetic Transition Metal Molecules*"
*Postdoc Research Associate at Los Alamos National Laboratory

Roger Miller – "*Ultraviolet Extinction in Boundary Layer Aerosols: Chromatic Variations in Size and Time Resolved Particulate Matter Collected on Teflon Filters and Greased Mylar Strips*"
*Assistant Professor at State University New York, Potsdam

Richard Snavely – "*Physics of Laser Driven Relativistic Energetic X rays Proton Beams and Relativistic Electron Transport in Petawatt Laser Experiments*"
*Physicist at Lawrence Livermore National Laboratory

James Van Meter - "*A New Technique for Deriving the Post-Munkowsician Equation of Motion of a Blackhole*"
*Research Associate at NASA Goddard Space Flight Center

Master's Degrees Awarded

June 2002 – December 2002

Zachary Hannan .... MS
Kevin Kelley .... MS
Mark McKinnon .... MS
Roppon Picha .... MS
Trevor Price .... MS
Tiffany Wilkes .... MS

Bachelor's Degrees Awarded

Honors at graduation are awarded to students who have a grade point average in the top eight percent of the college. The Departmental Citation (DC) award is given to students in recognition of their excellent academic record and undergraduate accomplishments. The Saxon-Patten Prize (SPP) in Physics is a monetary award given to a student who has achieved an excellent academic record and who shows interest and promise in continued work in physics and/or related physical sciences.

April 2003

Shirley R.Q. Hong .... BS
Degree in Applied Physics
Carie L. May-Bowers .... BS
Degree in Applied Physics
Matthew C. Sudano .... BS
Awarded DC and SPP
Fernando A. Torres-Mozquieda .... BA
Awarded DC

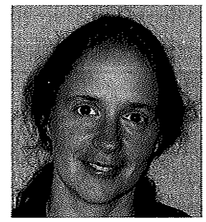
❖

Faculty Highlights

We are pleased to announce that **Professor Winston Ko** has been named as Dean, Division of Mathematical and Physical Sciences in the College of Letters and Sciences, effective July 1, 2003. As dean, Professor Ko will be the division's chief academic and administrative officer. He will have responsibility for the division's academic leadership and management of its faculty and staff, physical facilities, and budget. Professor Ko will remain a faculty member of the Physics Department. Please join us in wishing him the best in his new campus position. **Professor Shirley Chiang** has been appointed as the new Chair of the Physics Department.

Professor Steven Carlip is the Physics Department's new Vice-Chair, Graduate Program, effective July 1, 2003. We enthusiastically welcome Dr. Carlip, who is replacing **Professor Richard Scaletter**. Professor Scalettar has stepped down to focus on his research program. We greatly appreciate Dr. Scalettar's dedicated service to the department as vice-chair for the past five years.

Professor Rena Zieve has received the Chancellor's Award for Excellence in Mentoring Undergraduate Research In her seven years at UCDavis, Dr. Zieve has mentored 13 undergraduate students. Several of these students wrote letters of support. It was clear that they all valued their experience working with Dr. Zieve and considered that experience to have made a difference in their lives and careers. The prize carries an award of $500 for her research program.



Rena Zieve

Professor Charles Fadley has been awarded the honorary title of Distinguished Professor. This new title is designed to recognize outstanding faculty in the professional series who have achieved the highest level of scholarship. Congratulations Professor Fadley!

Professor Charles Fadley was commended for his pioneering work on X-ray photoelectron diffraction to determine surface structures. Using synchrotron radiation, he has continued to develop revolutionary surface analysis techniques, such as the recent application of X-ray standing waves to probe buried interfaces. The *Journal of Electron Spectroscopy and Related Phenomena* dedicated Volume 126, in October, 2002, to Professor Charles S. Fadley and Dr. Neville V. Smith of Lawrence Berkeley National Laboratory, on the occasion of their recent 60th birthdays.

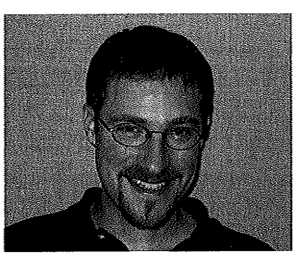
Introducing...

Christopher Fassnacht

Ph.D. – California Institute of Technology, 1999

Assistant Professor, Cosmology

Professor Fassnacht joined the department in July, 2002



General relativity theory predicts that a light ray passing by a massive object will be deflected, a phenomenon known as gravitational lensing. With the advent of larger telescopes and the improvement of detector technology, many instances of astrophysical gravitational lensing have been found. The lensing of a distant object by a more nearby one leads to distortion and magnification of the image of the background object. In special cases, when the background source, the lensing object, and the observer are particularly well aligned, more than one image of the background source is formed. These multiple-image, "strong" gravitational lenses are not only fascinating objects in their own right, but can serve as powerful tools for probing cosmology.

One of my major areas of research uses gravitational lenses as tools to measure the Hubble Constant. The Hubble Constant is one of the fundamental parameters in cosmology, giving an expression of the current rate of expansion of the universe. The value of Hubble Constant, along with quantities related to the mass density and "dark energy" content, provides the age of the universe. Because it provides the means for converting recession velocities into distances, the Hubble Constant is also the crucial component needed to convert the measured quantities in astrophysics (e.g., angles, fluxes, etc.) into the physical quantities (lengths, luminosities, masses) that are needed to understand distant objects. In spite of the importance of the Hubble Constant to cosmology and astrophysics, it is only in the last few years that astrophysicists have started to approach a consensus on its value. Gravitational lenses provide a method for measuring this value that is completely independent of other methods and thus provides an important check on the traditional "distance ladder" methods. My research program has provided one of only eight measurements of the Hubble Constant using gravitational lenses, and I am actively involved in collaborations to increase the sample of lens-based measurements of the Hubble Constant.

(continued on page 10)

Introducing...

(continued from page 9)

In order to measure the Hubble Constant with a lens system, it is necessary to accurately quantify the mass distribution in the lens. It appears that many lensing galaxies are located in locally overdense regions of the universe, namely in compact groups of galaxies. I have begun a program to search for such groups associated with lens systems in order to determine their contribution to the overall lensing gravitational potentials. This program has the added benefit of providing a sample of galaxy groups lying at higher redshifts – and hence, at earlier times in the history of the universe – than can be found by other methods. By comparing the lens-related sample to local samples of galaxy groups, I will be able to study the evolution of these groups, which may be the most common sites of galaxy mergers. Such mergers in groups may explain the changes in galaxy morphology and star formation rates that are seen over the last 50% of the age of the universe. I am also using the Chandra X-ray satellite to study the properties of the diffuse and hot X-ray emitting gas contained in the common gravitational potential well of the group. The gas properties are related to the total mass of the group. Local groups of galaxies are dominated by the mysterious "dark matter," but little is known about the properties of groups at earlier times.

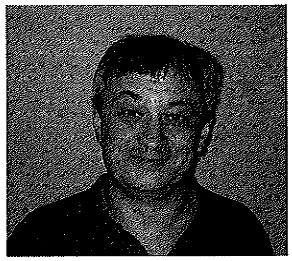
Another facet of my research is the search for new gravitational lenses. A decade ago, only 20 or so strong lens systems were known. Only by increasing the sample of known lenses can we hope to understand possible systematic errors in the use of lenses as cosmological tools. With my colleagues, I conducted a large search for lenses using the Very Large Array radio telescope. This search produced 15 new lenses. I am now participating in a search for lenses in a deep optical and infrared imaging survey with the new camera on the Hubble Space Telescope. Unlike other methods of studying distant galaxies, lensing provides direct information about the distribution of all the mass of the lens, not just the light-emitting matter. Thus, the growing sample of lens systems provides a unique path to understanding the structure and evolution of galaxies of the last 40-50% of the age of the universe. These fascinating objects provide the tools for much exciting exploration in cosmology and astrophysics.

Nemanja Kaloper

Ph.D. – University of Minnesota, 1992

Assistant Professor, Cosmology

Professor Kaloper joined the department in July, 2002



Many new discoveries in cosmology and fundamental physics have startled us, leading to even greater puzzles than before. We now know that the conventional matter comprises only a minute fraction of the total contents of the universe, while most of it is poorly understood dark matter and dark energy. We also know that the Standard Model of particle physics, extremely successful at low energies, is incomplete. Its extensions predict the existence of new forces and new particles, and efforts to unify the standard model with gravity, such as in string theory, even suggests new dimensions of space. The energy barriers faced by terrestrial experiments make the direct explorations of the physics beyond the Standard Model very challenging. This makes the interface between particle physics and cosmology an acutely important field. While the expected new elements of nature are invisible in the current lab experiments, they must have played a very important role in the very early, hot universe, when typical energies were much higher than today. Thus they must have left their fingerprints in the dark matter and energy, which we now observe. Studying the structure of the universe should therefore also reveal the new physics which lies beyond the TeV frontier.

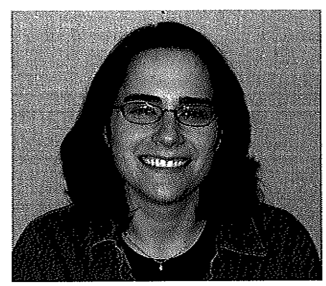
My research aims to explore novel connections between cosmology and the new physics beyond the Standard Model. I plan to use the Cosmic Microwave Background as a probe of the new physics near the scale of inflation, which could leave a small but detectable imprint in the CMB anisotropy. Such high energies may never be tested by any laboratory experiments. I further intend to elaborate a completely new explanation of the observed dimness of Type IA supernovae based on dynamical conversion of photons into axions, without cosmic acceleration, which I proposed recently with my collaborators. This completely changes the nature of dark energy, and predicts a new particle, an ultralight axion. Further, I plan to investigate the possibility that dynamics of extra dimensions can generate the primordial seed for extra-galactic magnetic fields, currently a challenging puzzle.

Lori Lubin

Ph.D. – Princeton University, 1995

Assistant Professor, Cosmology

Professor Lubin joined the department in July, 2002



Clusters of galaxies are the largest gravitationally-bound objects in the Universe. They form at the intersections of the huge filaments and walls of matter that make up the large scale structure of the universe. They have three major components: (1) hundreds or thousands of galaxies containing stars, gas, and dust which shine brightly in the visible; (2) diffuse intracluster gas that is so hot (30-100 million degrees Celsius) that it emits very strongly in the x-ray; (3) dark matter, a mysterious form of matter that has so far escaped direct detection with any type of telescope but makes its presence felt through its gravitational pull on the galaxies and the hot gas.

Although the stars and intracluster gas contribute a large amount of mass to the cluster, measurements of total cluster masses (a staggering 10^14 to 10^15 solar masses)

(continued on page 11)

Introducing...

(continued from page 10)

suggest that 10 times more mass is needed to bind the cluster together, implying that dark matter must comprise 90% of the cluster's mass.

Because clusters contain a significant fraction of the baryons and the dark matter in the universe, they provide a powerful probe of the nature of galaxy formation, the origin of large-scale structure, and cosmology in general. Therefore, quantifying the abundance and dynamical state of clusters is key to understanding the formation of clusters and the evolution of the galaxies within them. With the advent of sensitive x-ray and optical satellites and large ground-based telescopes, it is now possible to extend cluster studies up to redshifts greater than approximately one. Because light has a finite travel time, radiation from objects at these redshifts was emitted approximately seven billion years ago, at which time the universe was half of its current age. Consequently, we are able to use the universe as a time machine and observe these remarkable structures during a period when they were considerably younger and more dynamically active. At these redshifts, the study of massive clusters provides particularly important constraints on the physical processes that dominate the formation of their member galaxies (and on cosmological parameters) because the amplitude of evolutionary effects and the differences between competing theories are quite large. By studying distant clusters, we can constrain the theories that govern the behavior of the galaxies, gas, and dark matter in these massive systems.

My research seeks to do just that. Capitalizing on the new generation of ground and space-based facilities, I am coordinating an extensive, multi-wavelength survey of a large sample of massive clusters, and even larger scale clusters of clusters (superclusters), at redshifts of $z > 0.6$. My large observational effort includes multi-band photometry and multi-object spectroscopy with the Keck 10-meter telescopes, high-angular-resolution optical and near-infrared imaging with the Hubble Space Telescope, and x-ray observations with the Chandra and XMM satellites. I am using these data to quantify the relation between cluster x-ray and optical properties, explore galaxy properties over a wide range of local environments, and study the relationship between clusters and their surrounding large-scale structure.

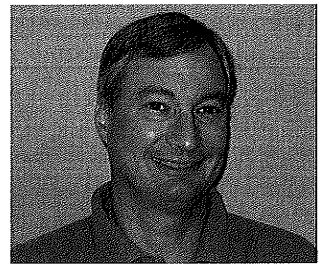
Although the major cosmological parameters, such as the matter density and the current expansion rate, have now been measured, the complicated process of going from minute fluctuations in the primordial power spectrum to the small and large-scale structures (like galaxies and clusters) that we see today is still far from certain. Even though there is a general consensus that clusters form through the merging of smaller sub-clusters, cluster evolution is inherently complex both because clusters are not closed systems and because the three main mass components evolve differently. As a result, we still do not know exactly how or when the different cluster components are affected by the formation process or what physical mechanisms determine galaxy properties in the cluster environment. By using galaxy clusters to record the progression of hierarchical structure formation and to quantify galaxy evolution over a cosmologically significant timescale, I am beginning to characterize these important details. The ultimate goal of my research program is to use high-quality, multi-wavelength observations of young, massive clusters to place significant constraints on the theories that govern the growth of structure and the evolution of galaxies in the universe.

John Rundle

Ph.D. – University of California, Los Angeles, 1976

Interdisciplinary Professor of Physics, Civil Engineering, and Geology; Director, Center for Computational Science and Engineering

Professor Rundle joined the department in July, 2002



Our group focuses on developing the theoretical and computational methods needed to understand driven, non-equilibrium threshold systems. Examples include neural networks, earthquake models, sandpile models, driven foams, de-pinning transitions in sliding charge density wave systems, and vortex lattices in superconductors. We are particularly interested in developing the computational tools necessary to simulate these high-dimensional complex systems within the context of modern, web-based, high performance computing methods using Beowulf clusters and other types of parallel, SMP machines. We view the development of the emergent Semantic Grid as a particularly promising technology, and we are pursuing the development of emergent computational paradigms. Computational simulations thus represent a major tool and a major focus of our research. Much of our work is concerned with a particularly important threshold system in nature, earthquake fault systems.

Here we focus on a systems approach to the development of Stress Evolution Simulations (SES) of earthquake fault systems, with a view towards developing the software and theoretical infrastructure needed to understand and predict these potentially catastrophic events. Emergent computing for SES arising from the Semantic Grid will incorporate certain key capabilities to produce the desired effect of digital brilliance. The latter term refers to the sudden appearance of dramatically enhanced computational capability as the network of computers, software, and human resources pass a critical threshold level. This sudden increase in capability can be understood as a kind of first order phase transition arising from the existence and improvement of the Semantic Web. Characteristics of digital brilliance include greatly enhanced coupling of code execution with code performance, the supporting and fusing of multiple observational sources, and the capability to simultaneously reconcile computations at multiple length and time scales. ❖

Welcome Graduate Students

The Physics Department welcomed 22 new graduate students into our program in Fall 2002. For Fall 2003, we are pleased to welcome another 27 new students into our program.

Fall 2002

Paulo Afonso, University of Lisbon, Portugal
Cary Allen, Mesa State College
Austin Calder, UC Santa Barbara
Adam Getchell, UCDavis
Uriel Giveon, Telaviv University
Albert Greer, San Francisco State University
James Holliday, University of Illinois, Urbana
Ming Hong, Peking University
Amy Lazicki, University of the Pacific
Michael Lee, University of Colorado at Boulder
Leilah Ma, The Ohio State University
Samuel Maquilon, UC Los Angeles
Daniel Osborn, Harvey Mudd College
Jianping Pan, University of Louisville
Norman Paris, San Jose State University
Long Pham, UCDavis
Lu Song, University of Louisville
Ingrid Stoltmann, UCDavis
Abhijit Tripathi, University of Cincinnati
Tanya Urrutia, Potsdam University- Germany
William Ward, Portland State University
Meng Wei, University of Florida

Fall 2003

Augusta Abrahamse, American University
Maziar Afshar, San Jose State University
Ilke Arslan, University of Illinois, Chicago
Matthew Auger, Brandeis University
Mark Bowen, San Francisco State University
Brandon Bozek, Florida State University
Tyler Bryant, San Francisco State University
Daniel Collins, University of Virginia
Sean Corum, Augustana College
Randy Dumas, UC San Diego
Perry Gee, California State University, Sacramento
Daniel Hale, Michigan State University
Natha Robert Hayre, San Jose State University
Juan Carlos Idrobo, University of Illinois, Chicago
Yan Jing, University of Illinois, Chicago
Derrick Kiley, UCDavis
John Mahoney, California State University, Chico
Cory Mullet, Eastern Menonite University
Jennifer Neureuther, Sweet Briar College
Dana Nuccitelli, UC Berkeley
Marina Papenkova, UC Berkeley
David Santo Pietro, University of Nevada Las Vegas
Tyana Stiegler, Sonoma State University
Daniel Thorn, UC Berkeley
Jordan Van Aalsburg, UC San Diego
Robert Yager, Southern Oregon University
Erik Ylvisaker, Southern Oregon University

We'd Like to Hear About You!

Please return this form with news about yourself to be included in future newsletters. We are very interested in how you are doing and where your career has taken you. Please take a few minutes to respond.

Name:____________________ Class of:________ Degree(s):________________

Address:____________________________________

Email Address:________________________________

Current Employment

Company/School: ________________ Position Title: ________________

Address: ____________________________________

Other News

____

Items you would like to see in future newsletters

____

Please mail to: University of California, Davis, Physics Department, One Shields Avenue, Davis, CA 95616,
Attention: Newsletter Assistant

From the Chair...

(continued from page 1)

students enrolling in Fall 2003, bringing our total up to 118.

The Davis Meeting on Cosmic Inflation was held from March 22-25, 2003 (see newsletter article on page 4). Andreas Albrecht was the chair of both the Program Committee and the Local Organizing Committee. Renowned physicist Stephen Hawking spoke at the conference and also gave two public lectures at the new Mondavi Center for the Performing Arts.

Richard Scalettar, Kai Liu, Gergely Zimanyi, and Ken Verosub (Geology) organized a conference on "Magnetic Hysteresis and the First Order Reversal Curve (FORC) Method" from April 25-27, 2003 (see newsletter article on page 5).

Finally, I would like to thank our wonderful staff for their support. Such a large department can only function successfully

Physics Department faculty from left to right: Drs. J. Anthony Tyson; Patricia Boeshaar; and Winston Ko, Dean, Mathematical and Physical Sciences

through their efforts. Tracey Brooks is the new Business Office Manager, replacing Sonya Wilkerson, who moved to Oregon. Unfortunately, our excellent department manager, Teresa Overstreet, has announced her imminent retirement after nine years with us. We wish her tranquility in her new life away from the department. Also, congratulations to Erin Reis in the Student Services Office on the birth of her daughter, Hannah.

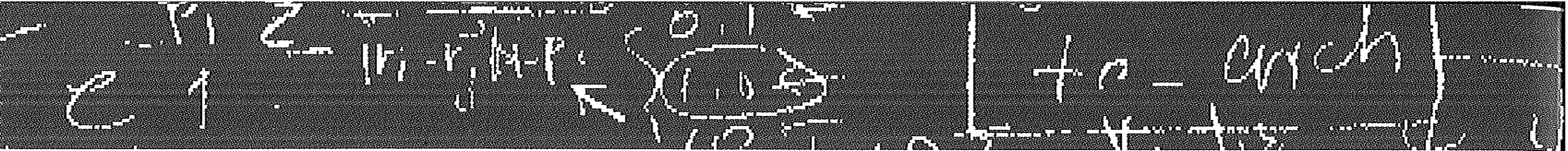
We hope many of our alumni can join us for the Alumni Dinner to celebrate the 50th Anniversary of the UCDavis Department of Physics on Saturday, October 25, 2003, at the Buehler Alumni and Visitor Center. (See box on page 1). We plan to have an afternoon softball game (faculty versus alumni), department tour, wine and cheese social hour with poster session, followed by dinner. Please check your mailboxes for the invitation. We look forward to seeing you there!

Sincerely,

S Chiang

Shirley Chiang

❖



UCDAVIS
Physics Newsletter

is a publication of the UCDavis Department of Physics. It is published to provide information about the teaching, research, and service activities of the department. For subscription information contact the Physics Department, University of California, One Shields Avenue, Davis, CA 95616; telephone: (530) 752-4088; fax: (530) 752-4717; e-mail: newsletter@physics.ucdavis.edu

Department Chair: **Shirley Chiang**; Department Vice Chair, Undergraduate Program and Administration: **Wendell H. Potter**; Department Vice Chair, Graduate Program: **Steven Carlip**

Physics Department
University California, Davis
Davis, CA 95616

Nonprofit Org.
U.S. Postage
PAID
UC Davis