UC DAVIS

Physics Newsletter

Number 4 | A Newsletter for University of California, Davis, Physics Alumni | Spring 1997

From The Chair

Hello to everybody—I hope you enjoy the fourth edition of our departmental newsletter. In this column, I thought I'd take the opportunity to discuss how our department has expanded over the past several years and where we are going in the near future. As you will see, our department has undergone quite a bit of change.

In the early 1990s, the downturn in the California economy led to quite a bit of belt-tightening in the UC system, with three early retirement programs, known as VERIPs (Voluntary Early Retirement Incentive Program), being used to temporarily trim the faculty and staff and save money. The funding for the VERIPs came mostly from the very well-invested UC retirement funds, and to a large extent got us through the lean years. Of course, any decrease in the number of faculty—in all, about a 20 percent decrease from the three VERIPs—was bound to be short-lived, since our student "customers" were, if anything, on the increase due to the growth in the state's population. UC Davis started the regrowth very quickly last year, with over 100 faculty recruitments; this will continue over the next several years as we grow back to where we were, and likely even larger.Current plans are for the Davis campus to grow to around 30,000 students over the next five years or so. We currently have just over 26,000 students, and nearly all of the future growth is expected to be in our undergraduate program. We are particularly targeted for growth because our campus is not landlocked—we have over 5,000 acres of campus land, and can hence handle growth better than any of the other UC campuses. Since most of the undergraduates on campus take a physics course as part of their major, an appropriately large physics department is to be expected. So our department, which lost more than 10 of our faculty to the VERIPs, has had large growth in the recent past, and continued growth is expected in the future.

Since 1992, the year I became Chair, we've added seven new faculty members: Professors Cebra (nuclear physics), Han (high energy physics), and Klein, Chiang, Cox, Pickett and Zieve (condensed matter). Ten others had arrived in the previous several years; now more than half of our 31 faculty members have been at UC Davis 10 years or less! The biggest growth has been in condensed matter physics, which now encompasses approximately half of our faculty. This growth has "put us on the map" in this area as the new faculty members have very successful careers under way. The newest members, Professors Zieve and Cox, joined us in July 1996 and January 1997, respectively, and Professor Pickett is arriving this coming summer. You

(Continued on page 8)

Inside This Issue

Do you recognize this building?

The Physics/Geology building is in the process of getting a well deserved face-lift! Painters have swarmed over the building cleaning and painting, and the building hasn't looked this good in years! On your next visit to the campus, stop by the physics department!

Early History of the Physics Department, 1960s

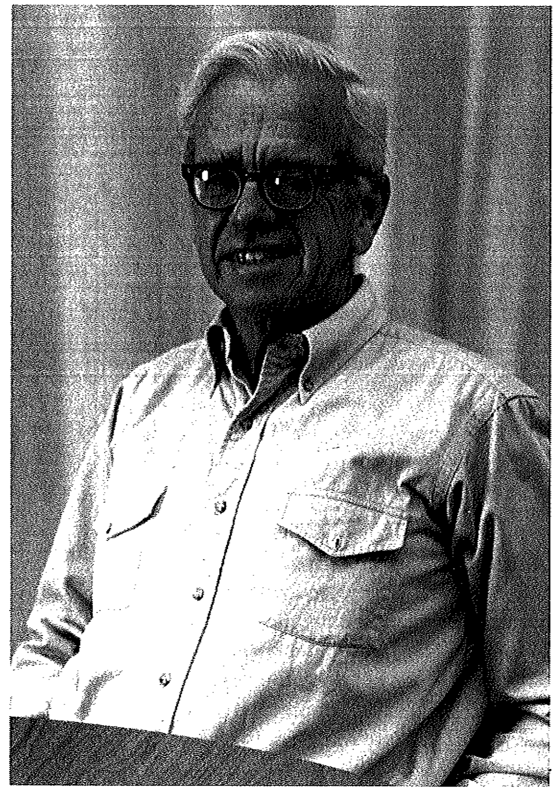
by Bill Knox, professor emeritus

It's been over a year since I wrote the first retrospective on the history of the UC Davis physics department. Since then we've had contributions from Professors Jungerman and Cahill on the early days (see *Physics Newsletter* issues #2 and #3) and from others on current activities. As we accumulate more pieces, eventually someone may be able to pull them all together into a more complete history. In the first issue I got up to about 1960, when Bill True and I arrived in Davis. UC Davis had recently become a general campus of the university and had begun to expand rapidly. Emil Mrak had just been installed as chancellor in 1959. Herb Young, a chemist, was dean of the College of Letters and Science in the early 1960s; later Larry Andrews, another chemist, took over.

The rationale of the department at that time and for the next few years was to emphasize nuclear physics, which had been abandoned by our neighbor, the UC Berkeley physics department. The Berkeley nuclear physicists had all migrated into the new field of high energy or particle physics, since they had the 184" cyclotron (which could produce pi mesons) and the Bevatron (which could produce antiprotons and other new particles). To be sure, nuclear physics was still done at the Radiation Laboratory (UCRL, now renamed the Lawrence Berkeley National Laboratory or LBNL), but it was done in the Nuclear Chemistry Division rather than the physics department. So there was a niche in which we could serve a useful purpose—advancing nuclear physics, training graduate students and spinning off technology—without directly encroaching on Berkeley's territory. At the same time, we could get technical assistance from UCRL, which was still a world class accelerator laboratory.

We felt that a cyclotron of Crocker Nuclear Lab (CNL) size was about the largest facility feasible for a new physics department. An important goal was to allow graduate students to participate in all phases of an experiment, including instrumentation and even modification and operation of the accelerator. And so it came to pass, thanks largely to Jungerman's expertise and hard work and the support of Mrak, UCRL, the AEC, the NSF, old mentors at UCB (Lawrence, Seaborg and McMillan) and colleagues at UC Davis.

The campus expanded rapidly in student enrollment and faculty in the 1960s, and the department grew as well, with one or two faculty positions each year: Jim McCray, nuclear experiment, Cal Tech, 1961; Paul Brady, nuclear experiment, Princeton, 1962; Jim Hurley, theory-statistical mechanics/plasmas, NYU, 1963; Claude Garrod, statistical mechanics/many-body theory, NYU, 1964; Glen Erickson, theory-QED, University of Minnesota/University of North Carolina/NYU, 1964; Jim Draper, nuclear experiment, Cornell/Yale, 1964; Olaf Leifson, solid state experiment, UCB/ETH Zurich, 1965; Ken Greider, nuclear theory, UCB/Yale, 1965; Doug McColm, atomic molecular experiment, Yale/UCRL, 1966; Dick Lander, high energy experiment, UCB/UCSD, 1967; Tom Cahill, nuclear experiment, UCLA/Saclay, 1967; Phil Yager, high energy experiment, UCSD, 1968; Dave Pellett, high energy experiment, University of Michigan, 1968; Rod Reid, nuclear theory, Cornell, 1969. Neal Peek helped develop the spectrometer and cyclotrons, got his Ph.D. in 1966, continued at CNL, and was later appointed lecturer in the department. Jim McCray left in 1968 to study biophysics with Brittain Chance at Pennsylvania University and then continued at Drexel University. Olaf Leifson built a polarized proton target for CNL and then went to the state Department of Energy in 1973. Ken Greider retired in 1989 and died not long after. Ian McCarthy, nuclear theory, University of Adelaide/University of Minnesota, was here some time in the early 1960s, I think, but I can't remember the exact dates. He later went to the University of Oregon, and then back to Adelaide at the new Flinders University.



Visiting researchers and postdoctoral associates contributed greatly to the strength of the nuclear program in the 1960s. So far, I can't find any official records of them. I can remember some of their names, but I am not certain about the dates or their prior or subsequent affiliations. They included: Lindsay Dodd, University of Adelaide/Yale (one of the recent candidates in our cosmology recruitment was a student of Lindsay's at the University of Adelaide); Hideki Ishizaki, INS Tokyo; Badrinathan, possibly Tata Institute, Bombay; Chin Ma, UCRL/Yale/University of Texas(?); Ross Barnett, Oxford University/University of Malaysia/Florida State University; Badrinathan, also possibly Tata Institute; Yamaguchi, University of Tokushima; Art Springer, UCB/UCRL. Let me know if you remember names, affiliations or dates more accurately, or if you can think of others from the 1960s or later times whom I have omitted.

Early nuclear physics research and the development of CNL are described in Jungerman's article in the second issue of the *Physics Newsletter*. CNL became an organized research unit (ORU) in 1965, with Jungerman as its director, and was separated from the department. Bill True remained principal investigator for the Atomic Energy Commission theory contract in the department. I became department chair from 1963 through 1966 (after Gordon Patten), and served as acting director of CNL in 1966-67 while Jungerman took a long-postponed sabbatical leave. Draper was department chair from 1966 through 1971, followed by me again. Nola Mosier was office manager from 1963 to 1968 and Virginia Rosato was here as secretary from 1966 through 1989. Mary Schenck was department manager from 1968 through 1991. Rory Tafoya came to the department in 1969 and is still here. They did all the real work of managing the department administratively and financially, complying with university regulations, scheduling classes, handling contracts, enrolling students, typing manuscripts, etc. Ken Mustard was curator of laboratory equipment, and Dwight

Wohlgemuth was curator of lecture demonstration equipment.

Before 1965, the electronic and mechanical shops of physics and CNL were combined. Ralph Rothrock headed the mechanical shop, with Jack May (1957-63), Joe Haralson and Ivan Drahun (1962-87). Robert E. Lee was head of the electronics shop, with Bob Hickerson and Frank Stone. When the 22-inch cyclotron was given to the University of Chile, Hickerson went down to Santiago for about a year to help get it back into operation. Later, Bill Cline became head of electronics, which evolved into the Digital Systems Group at CNL and eventually became an independent unit designing and servicing digital systems for the whole campus. Gene Russell arrived in 1964 and became chief of cyclotron operations. He left CNL in 1979 and unfortunately died earlier this year after a short illness. I had known him since earlier days on the 60-inch cyclotron at Berkeley.

In 1963, Jack May transferred to the agricultural engineering shop, where he built an apparatus for observing the development of chickens under enhanced gravity. They called it a centrifuge, but we called it a chicken accelerator (remember the principle of equivalence). I figured that to subject a chicken to a field of 2g, it had to be accelerated to an energy of about 10^{11} Gev. So we could always claim that we had the highest energy accelerator in the world right here on campus. Sure enough, the chickens grew sturdier drumsticks and provided other physiological data. This was the earliest of our technology transfers here on campus (just joking).

Many other lines of research on campus and elsewhere have depended upon or benefited from CNL nuclear technology (see Cahill's earlier article). In addition to the Digital Systems Group, these include trace element analysis, air quality monitoring (Lake Tahoe, national parks, etc.), non-destructive analysis of historical documents (Gutenberg Bible, Vinland Map, etc.), better radioisotopes for medical and pharmaceutical diagnosis (I-123, Tl-201, etc.), short-lived isotopes for biological studies (F-18, N-13, Xe-125, etc.), food irradiation, cancer treatment, radiation effects on components of space vehicles and many others. These deserve a more detailed article, I think.

The social scene in Davis was pretty limited in 1960. There was only one restaurant that I can remember, called the Y, located at the intersection of Russell Boulevard (old U.S. 40) and SR 113 (old U.S. 99W). It served Chinese food, hamburgers and french fries. Sometimes we would get a group together and go down to Sam's 519 Club in Vacaville for steak dinners (Rothrock's favorite hangout). They had an organ and live country music on Saturdays. Amy Patten was a great hostess of departmental receptions or dinners for visiting physicists after colloquia.

The Jungermans built a marvelous house in Elmwood about 1960. It had high ceilings, lots of open space, a swimming pool, and no wood or nails, only steel, glass, masonry and fiberglass, almost indestructible. Every Christmas they would have a great party for all of physics and CNL, and their house survived. One year someone (nameless) exuberantly drove home after the party across the lawn of the Mormon Church at the entrance to Elmwood. Gene Russell would organize family picnic outings for everyone to wineries in Napa or Sonoma. He would reserve picnic tables and arrange a wine tasting. On campus the Faculty Club held the Goose Stew in the fall, a tradition from the days when hunters would bring home enough geese and ducks for everybody. Local humorists would produce skits and parodies lampooning the administration and various faculty. They still have the Goose Stew, but it isn't the same.

When we came in 1960, even before we bought or built a house in Davis, we were lucky enough to be able to buy a small granite cabin at about 7,500 feet on Upper Echo Lake (off Highway 50 near the present Desolation Wilderness Area). It was built by the same stone mason who built the Campanile in Berkeley. Every October, after classes had settled down, the faculty and researchers would go up there for a weekend outing. We had to hike in about three miles, carrying steaks, corn, beer and other vital supplies. The setting is beautiful, usually sunny and very quiet in the fall except for an occasional coyote. Activities included fishing, chess, reading, canoeing, swimming, hiking, arguing about physics and politics, and loud snoring. Sometimes the most fit would even make it to the top of Pyramid Peak or Mt. Ralston. One year we had a foot or two of snow in October, but went on our hike anyway; we startled a beautiful buck, which went bounding off through the rocks and snow.

The sixties were turbulent years in the larger social and political context. They started promisingly with Jack Kennedy elected president, the first of the postwar generation and a possible leader of the free world. As president of UC, Clark Kerr gave more autonomy to the individual campuses. Then came the failed Bay of Pigs invasion of Cuba (1961); the Cuban nuclear missile crisis (1962); the Kennedy assassination (1963); the escalation of the Vietnam War by LBJ (1963-66); the Civil Rights march in Alabama (1965); the growth of the Free Speech and antiwar protest movements (1966); rioting in Newark and Detroit (1967); Ronald Reagan's rise to national prominence in his campaign for governor, using UC and student protest as his main target; the firing of Kerr as UC president by Governor Reagan and the regents (1967); the assassinations of Robert Kennedy and Martin Luther King (1968); and the election of Richard Nixon as president (1968), with LBJ declining to run in the face of of mounting protest. The protest movement peaked in 1969 and culminated in the Kent State-National Guard confrontation of 1970. Then Nixon began de-escalating the war in 1971, leading to our eventual withdrawal from Vietnam in 1975 after Nixon's 1974 resignation over Watergate. These were not smooth, happy times.

Meanwhile, back on the farm, Davis and UC Davis were pretty conservative places. We weren't in the eye of the hurricane, but there was some unrest. Chancellor Mrak heard through informants that the radical Students for a Democratic Society (SDS) were going to target UC Davis for demonstrations because it was too peaceful here, and because they could conveniently march from Davis to Sacramento and Governor Reagan. So Mrak and Vice Chancellor McCorkle arranged a great open forum on campus. They set up a big blackboard and six or seven open mikes on the Quad, managed by a few faculty and student leaders. Anyone could protest or harangue the crowd on any subject, although they were then open to contradiction by someone else. Every suggestion for action or investigation was written down on the blackboard, and about 20 committees were formed that anyone could join. It was a lot like a giant faculty meeting, and nothing ever came of it, of course. But it seemed to defuse the situation much more successfully than the more repressive and violent measures taken at Berkeley and elsewhere. I think it added to Mrak's reputation in UC as an effective chancellor.

Mrak was also the university's most effective liaison with the Legislature. He was down to earth and sociable and would meet and discuss problems with anyone—students, faculty or legislators. One year he and Maynard Amerine, UC Davis' renowned enologist, put on a gourmet dinner at the Sutter Club with a selection of good wines for a few key legislators. Others heard how good it was, and the next year they had to invite about a dozen more. This time everybody heard about it, so subsequently they had to turn it into a giant banquet and invite the whole Legislature. A great reservoir of good will was built up, which probably helped the

(Continued on page 4)

Early History *(continued from page 3)*

university in times of crisis.

I was on the Statewide Representative Assembly of the faculty at the height of the protest movement (in 1969, I think). I went down to a meeting at Berkeley and took a university car so I could park on campus. That was the day Reagan unleashed the National Guard to quell the big demonstrations in Sproul Plaza, close to where we were meeting. The noise of the helicopters grew louder and louder and tear gas began to drift into the room. So we adjourned early after passing a few resolutions and motions, and everybody rushed out, trying not to breathe too much. For years I had an empty tear gas canister from Sproul Plaza as a souvenir, but it is now lost. Then when I got back to my university car to go home, some protester had slashed my tires as a blow against the oppressors. So you see that a faculty member has to watch out for attacks from both above and below.

In the physics department we had a few students who wanted to sit in on faculty meetings. We said they couldn't vote or talk or attend when confidential personnel matters were discussed, but otherwise it didn't seem to make much difference. Some of the graduate students petitioned that we eliminate the language requirements for the Ph.D. in physics because they were no longer necessary and wasted valuable time. They had a point, so we discussed it in faculty meetings at length. We came up with the compromise that they could substitute Russian for either German or French. This wasn't what they had in mind at all, so we had to discuss it further. Eventually we said they could learn a computer programming language instead, which most of them found necessary anyway.

Please let us know what I have omitted and what errors in fact or interpretation I have made. I reiterate that we would like to have your own comments, views and experiences of the times. The anecdotes related above may not be exactly accurate, and the opinions expressed or implied do not necessarily represent those of the faculty, department or university, although they should. ❖

Research News

Keck Observatory

by Robert Becker, professor

The University of California has always had a strong presence in astrophysics. Although in recent times Lick Observatory (located on Mt. Hamilton, east of San Jose) has been eclipsed by newer facilities, when it was built it was at the forefront of astronomy. With the construction of two 10-meter telescopes in Hawaii (Keck I and II), UC is again the envy of the astronomical community. Yours truly had the mixed pleasure of having three nights on Keck last December. I say mixed because two of the three nights ended up too cloudy to observe. In fact, the second night seemed more like a winter night in the arctic than Hawaii. With snow and 100 mph winds, we felt lucky to get off the mountain without serious injury. The third night made it all worthwhile—clear skies and functioning equipment allowed us to study galaxies at a redshift of 0.5 with only hour long integrations. Even so, working at 13,000 feet is never boring. One member of our team had to take oxygen through a tube while the rest of us struggled through a mental fog.

The truth is that we astronomers are in awe over having Keck Observatory at our disposal. One night at Keck is equivalent to 10 nights at Lick in terms of photons collected. But in reality, we do science at Keck that could not be contemplated at Lick. In terms of dollars, the figure of merit is one dollar per second of observing time to build and operate Keck. Thank you, Mr. Keck.

Not surprisingly, there is a lot of competition to get access to Keck. Luckily, it is not a national facility. Fully 40 percent of the observing time is guaranteed to UC astronomers. Twice a year, the UC system solicits proposals for observing time from the university community. These proposals are read and evaluated by the Time Allocation Committee (TAC), which is composed of 10 astronomers from the various campuses. The TAC meets and divides up the time. Generally three times as many nights are requested as there are to distribute, so there are real losers as well as winners in the process. Even if you win, you can still lose. If your nights are cloudy, you have to start all over with a new proposal. Success one year does not guarantee success the next time. Of course, if the night is cloudy you can always console yourself down at sea level the next day.

In fact, the health risks working at 13,000 feet are real. Observers are required to spend a day at altitude (above 9,000 feet) before their observing run. Some of the other observatories on Mauna Kea require a medical exam before allowing observers up, but I guess life is cheap in California, for UC has no such requirement. In any case, there is a "hotel" for astronomers at the 9,000 foot level where we stay before and during the observing run. The hotel serves all of the observatories on the summit, so the clientele come from all over the world.

There is no question that UC is ahead of the pack in this area of research. The next biggest telescope in operation in the world today is a six-meter telescope in Russia. There are several eight-meter telescopes in construction, but no one is building anything that is competitive with Keck. There are areas of research that can only be done at Keck. This is really a golden era for astronomy at UC.

Perhaps in response to this, the Department of Physics at UC Davis has plans to recruit up to four additional astrophysicists who specialize in cosmology over the next four years. One can expect a big increase in the range of courses available to our students at both the graduate and undergraduate levels. If we hire a few more observers maybe we will have to buy a condo on the Kona coast. ❖

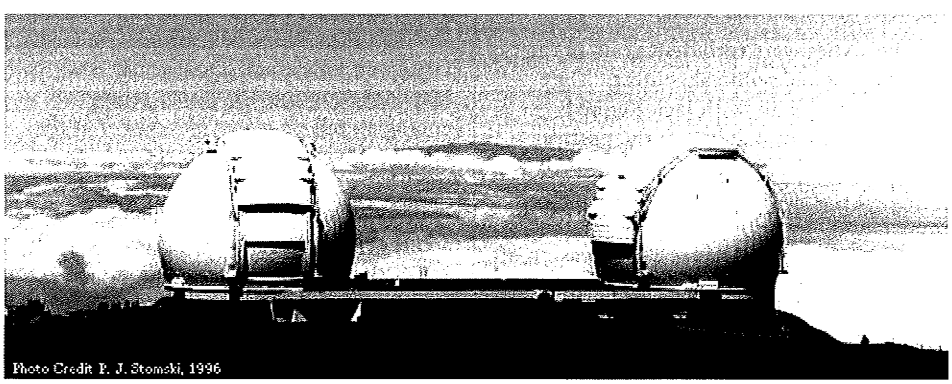
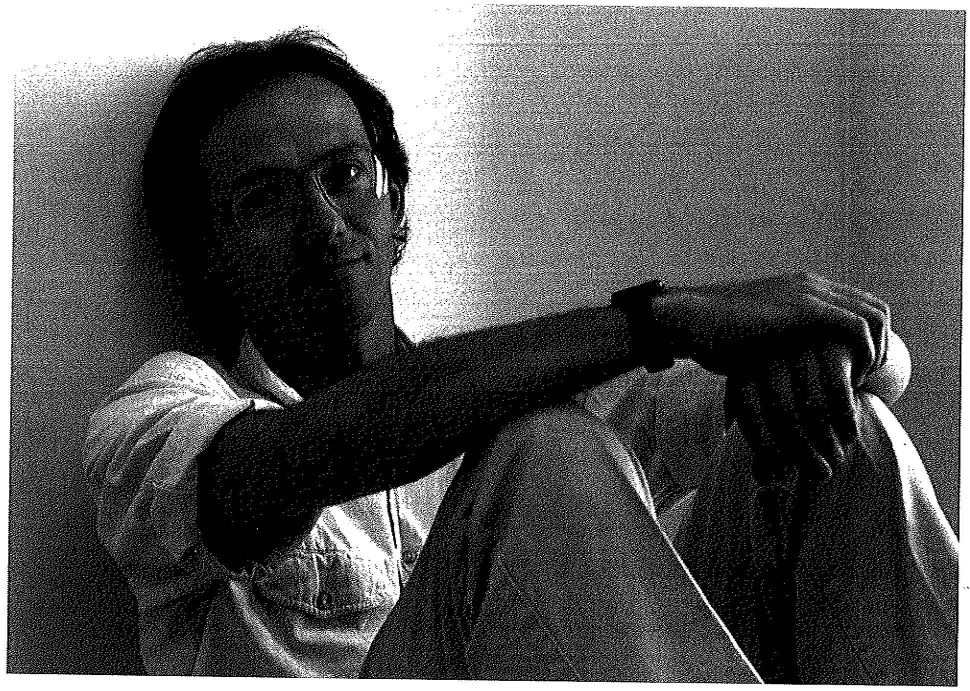


Photo Credit F. J. Stomski, 1996

Keck Observatory

High Temperature Update

by Gergely Zimanyi, associate professor



The discovery of high temperature superconductivity was one of the most exciting events in the last decade of science. Early in 1987, I had the good fortune to attend the American Physical Society meeting in New York City, where the discovery was announced. The organizers opened all three ballrooms of the Hyatt Regency to accommodate the 4,500 conference guests, and even then the fire marshal would not allow the session to start until the packed aisles could be cleared. Each speaker — including the Nobel laureates — was given five minutes to talk. The no-break session finally ended at 5 a.m. The next day the *New York Times* called the meeting the "Woodstock of Physics."

Why all this excitement? To answer this, let us remember that superconductors are capable of carrying currents with no loss due to electrical resistance. In contrast, about 20 percent of the electrical energy in the U.S. is lost between power plants and households due to the resistance of the cables in between, amounting to billions of dollars wasted. Eliminating this loss could have a major impact. So why don't we use superconductors for power cables? Conventional superconductors operate only at very low temperatures, below -400 degrees Fahrenheit. This number was slashed in half by the new class of superconductors. The excitement in the air was that it might be possible to find related compounds that could operate at room temperature, requiring no cooling.

Ten years have passed since "Woodstock." We may be asked to take stock: how much of the promise has materialized? Even today, unfortunately, we don't have superconductivity at room temperature. However, we do understand to a large degree why high temperature superconductors superconduct, and this knowledge may guide us toward an eventual solution to the puzzle.

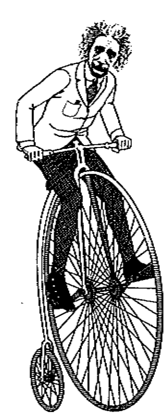
The basic physical picture is that high temperature superconductors have a special magnetic pattern, called antiferromagnetism. This means that the spins of the electrons point up and down in an alternating pattern. If an electron passes through this spin pattern, it flips many of the spins, costing a lot of energy and slowing down the electron. But if a second electron comes after the first, it flips all the spins back to where they like to be in the first place, eliminating the energy cost. Hence the two electrons together can propagate with no loss of energy. Named after their discoverer, this phenomenon is called "Cooper pairing." In the previous low temperature superconductors, it was the vibrations of the atomic lattice that bound the Cooper pairs together; in the high temperature superconductors, it is the fluctuations of the magnetic spin pattern.

We have also learned the spatial shape of these Cooper pairs: Their wave function is of the d-wave form. They take this anistropic shape in order to minimize the Coulomb repulsion between the electrons.

On the front of applications, the Pirelli Power Cable Company last year announced plans to install high temperature superconductor-based cables in New York City, where there is a realistic possibility of cooling electric lines in utility tunnels. People have also succeeded in building SQUIDS — superconducting quantum interference devices — out of these materials. A SQUID is extremely sensitive to variations of the magnetic field: the precision is $\sim 10^{-12}$, an amazing number. These apparatuses will undoubtedly find applications in geology; e.g., to locate oil deposits underground, and also in medicine, where they can map out minuscule variations of the magnetic activity of our brains. Some early tests are already being conducted in both fields.

Finally, there is a concerted effort to build even faster computers using high temperature superconductors. Some early examples have already been produced using the so-called Josephson effect. These operate around 100 times faster than the theoretical limit on silicon-based semiconductor transistors. The last remaining hurdle is to put a lot of these Josephson junctions on a single chip. The present world record is about 2,000 transistor-equivalent, so inventors have some way to go before posing a threat to present technologies.

I hope I have conveyed some of the physics as well as the excitement of the field, which has now clearly reached maturity. The early promises have given way to steady growth. We feel confident that the broad physical mechanism has been identified correctly, even if the fight is just as fierce concerning the details. And the reports from the front of applications make many of us optimistic that another decade need not pass before high temperature-based electronic equipment will be a regular part of the industrial landscape. ❖



'88

Robin Zagone (B.S.) went on to receive her Ph.D. in non-linear optical physics from Oregon State University in 1995. She is currently studying medicine at Oregon Health Sciences University, Portland, Ore.

'90

Nancy L. Larson (B.S.) is employed as a research assistant with Ron Roberts & Associates, Inc, in Williston, Fla. Her previous function was as principal investigator for two Department of Defense contracts.

Vittorio Paolone (Ph.D.), currently a researcher in high energy experimental physics, has accepted a faculty position at the University of Pittsburgh. He also received an Outstanding Junior Investigator award from the Department of Energy.

'91

Brian L. Pickering (M.S.) has taken a tenure track position teaching physics, geology, earth science and astronomy at North Central Michigan College, Petoskey, Mich.

Dennis DeWitt (B.S.), applied physics graduate, is currently a captain in the Air Force. His most recently duties include piloting C-130s in Saudi Arabia and flying support into Bosnia and Hungary.

'94

Christopher Ray (Ph.D.) recently accepted a regular faculty position at St. Mary's College of California in Moraga.

What are you doing now?

If you are interested in sharing your current activities in future issues of *The Physics Newsletter*, please complete and return the information form on page 9. You may also send your information via e-mail to: simoes@physics.ucdavis.edu. Please include the word "Newsletter" in the "Subject/Regarding" line of your message.

What Got You Interested in Physics?

by Doug Green, alumnus

Ninety-five hundred! Ninety-six hundred! Ninety-seven hundred! the announcer yells out at the bridge building competition. Ninety-eight hundred! Crraackk! My 29 gram balsawood bridge took first place in the local science Olympiad competition. I never knew what physics was until that year, my senior year in high school. I had no intention of going to a university and had no idea of what I wanted to do with my life up until that senior year. Luckily, my physics teacher changed all that and made physics fun, active and challenging. I absolutely loved it! After winning the bridge competition (which he entered me in), I decided to go to college and pursue a degree in engineering or the sciences.

But what sold me on a physics major was a college physics instructor who used to launch 18 smoke rings over 20 meters, showed us how to make pyrex disappear and taught us how to make holograms. Wow! I was hooked. Then in my junior year, I signed up for Professor Wendell Potter's physics education course (directed study), in which I had the chance to help build a 10-foot geyser, a diffusion cloud chamber, and to perform various demonstrations during Picnic Day. During my senior year I began to realize that I did not want to become a nuclear physicist, but a physics teacher instead.

What got you interested in physics? For me it was my high school and college physics instructors. I am sure this is the case for many of us physics fanatics. So after receiving my B.S. in physics, I returned to Davis and got a secondary science teaching credential, and before I knew it I was getting multiple job offers to teach physics. Now it's my turn, and I am pulling out all the stops. Last year my physics students did everything from rocketry experiments to holography to criminalistics. I am having a blast, and so are the students.

I can't say it's always easy, though. I think I have learned more about the field of physics (and science in general) this past year than I ever learned at UC Davis. Don't get me wrong: at UC Davis I learned how to solve very complicated problems and derived some astounding equations in many areas of physics. But to teach some of these concepts to teenagers with little or no math background requires one to have a solid understanding of physics. So I often find myself rethinking my explanations, correcting my own misconceptions (I never knew I had so many) and developing a variety of teaching techniques just to ensure that all students can learn all the fields of physics (not just Newton's Laws). An interesting tool I encountered this summer was a way of teaching circuits (i.e., Kirchoff's Laws) using coloring diagrams, in which different colors represent electric pressure (CASTLE, M. Steinberg). This is just one of many techniques that can bring the physics experience to all high school students while maintaining a high level of conceptual understanding.

For many of my physics students, this will be the first time they get to formally study the non-general science topics of gravitation, relativity, rotational mechanics, thermodynamics, sound and light, electricity, magnetism and nuclear science. I get so excited to be the first teacher to bring these amazing topics to their education. Prior to teaching my first lesson, I ask students what they think they are going to study in this physics class. A huge majority of them just think they are going to learn mechanics stuff. That's sad!

I had the privilege of working at Lawrence Berkeley National Laboratory this past summer, interacting with other teachers from all over the United States. Many of them confirmed that this mechanics view is typical at many high schools. Why is this? Here are a couple of possible explanations. Since physics is taught with trigonometry or calculus, many (although not all) high schools offer only one or two physics classes. Therefore, the rest of the school has very little knowledge of what is going on in those classes. Another reason may be that teachers from other areas of expertise are often called upon to teach the one or two physics classes that are offered. I have heard about biology teachers, chemistry teachers, math teachers and even a music teacher being asked to teach physics. This seems to me to be an outrage! But what is a school principal to do? There are hardly any science teachers out there with a physics background. So if you love showing the wonders of physics to people, you may want to look into a physics teaching career. There is such an incredible need for you. I have found it to be a very rewarding and incredibly fun career.

Doug Green graduated from UC Davis in 1993 with a B.S. in physics. He is currently teaching physics at Vanden High School in Fairfield, Calif.

Introducing...

Daniel Cox

Professor

Ph.D., Cornell University, 1985

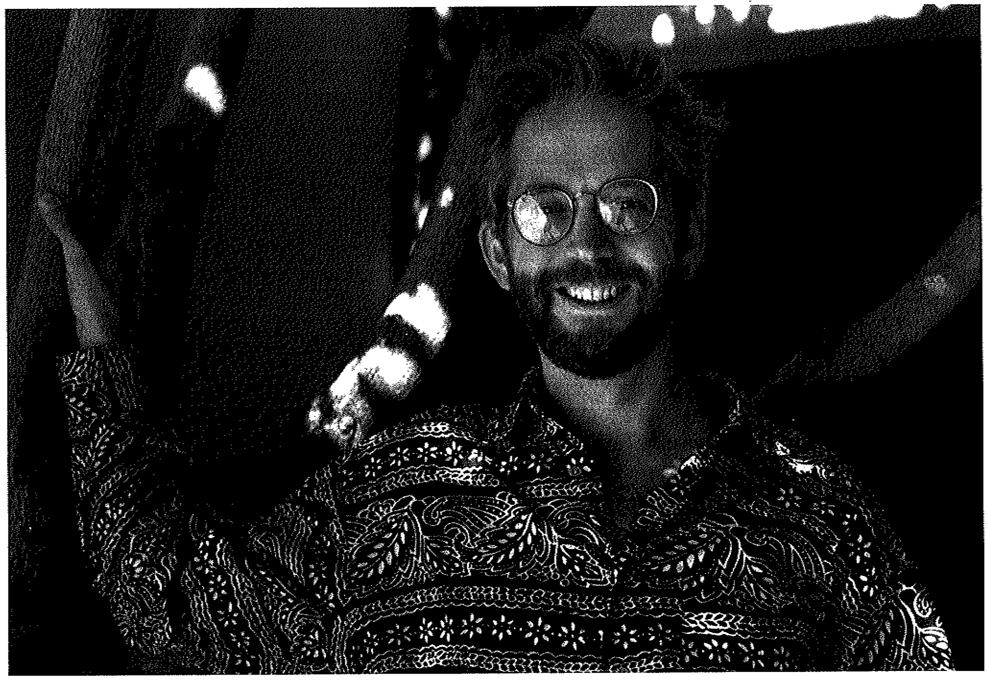
Research Area: Theoretical Condensed Matter Physics

Professor Daniel Cox joined the faculty of the UC Davis Department of Physics in July 1996.

The celebrated "Standard Model" of particle physics has been phenomenally successful in describing the forces of nature and the details of processes at sub-nuclear length scales. This model is described in terms of a few experimentally determined parameters such as the electron charge and the masses of elementary particles. It may be regarded as an "effective theory" valid for the particular energy and length scales so far studied in particle accelerators (or for certain time frames in the early universe).

In a similar way, Landau's Fermi Liquid Theory represents a kind of "Standard Model" for interacting electrons in metals. Like the standard model of particle physics, this theory has been phenomenally successful. Also like that other standard model, the Landau theory is an "effective theory," in this case valid at long distances and low energies. The Landau theory supposes that interacting electrons at sufficiently low temperatures have energies which are in a 1:1 correspondence to the non-interacting case. The interactions are said to "dress" the electrons into "quasiparticles" which behave as ordinary electrons apart from a renormalized mass and magnetic moment which readjust measurable properties relative to the free electron limit. This picture underlies most of our successful understanding of metallic physics—for example, the Bardeen-Cooper-Schrieffer (BCS) theory of superconductivity assumes that Landau quasiparticles pair and the resulting condensation of these pairs produces the superconductivity. The trouble with the standard model of particle physics and the standard model of metal physics is their very strength: the astonishing descriptive and predictive power they have successfully displayed exerts an overwhelming intellectual tyranny over the field! Physicists in both areas have been hopeful of finding some glimmer of new science that may indicate the breakdown of these theories and generate new work.

Fortunately in the case of metal physics, this has begun to occur. The high temperature superconductors, for one, display over a wide



range of material parameters a clear breakdown of the Landau theory. Experiment shows that the quasiparticles are not characterized by sharp quantum mechanical levels and thus cannot represent the fundamental "particles" of these materials. It turns out that another class of materials, the heavy fermion materials (in which interactions drive the electron mass up by a factor of a thousand!), also show this unusual behavior. These materials are also superconducting, and there is strong evidence that the superconductivity is the most unusual yet found (based, for example, upon highly complex phase diagrams).

These heavy fermion materials contain rare earth atoms (like cerium) or actinide atoms (like uranium) together with "light electron" atoms (like copper). These atoms have open f-electron shells and so can have magnetic and electric moments. It is the interactions between the atomic magnetic and electric moments on the rare earth or actinide atoms which provide the exotic low temperature physics.

Much of my recent research has focused on producing a theory of these unusual materials. I am studying a particular model (the "two-channel Kondo model") in both the extremely dilute limit (one uranium or cerium atom in a metal) and the fully concentrated limit (one uranium or cerium atom in every repeat unit cell of the crystal). These models have low energy states which completely defy a description by Landau theory, and have properties which display a good (if incomplete) correspondence to real materials.

A wonderful theoretical result has been the finding of exotic superconductivity that is fundamentally linked to the breakdown of the Landau theory, and the discovery that this superconductivity is indeed the weirdest so far found—the pairs avoid each other in time, and seem to have a net momentum to their center of mass. This steps way outside the BCS paradigm.

The techniques used in my research group and collaborations range from analytic phenomenology to large scale computation involving Feynman diagram methods or Quantum Monte Carlo techniques. These approaches are sometimes best realized in odd limits (such as infinite spatial dimensionality or infinite number of quantum mechanical components to the magnetic moment) which are a lot of fun to explore and understand. Despite these extreme theoretical wanderings, I always keep an eye on the experimental backdrop (to make sure I stay on this side of the looking glass!).

I am also cultivating interests in environmental physics and within a year or two may be looking for students to work with in this area. I am interested in certain problems arising in the study of global warming and biodiversity. ❖

From the Chair *(continued from page 1)*

can read about Professor Cox in this issue, as you did about Professor Zieve in the last newsletter issue.

Over the past several years our faculty have created a departmental "Strategic Plan," which has guided us in requesting and successfully acquiring new faculty "lines" as we have grown back from our VERIP losses. Feeling that the condensed matter program is stable and appropriate, we have looked for areas where we were missing the intellectual emphasis to nurture our research programs, or where we were missing the faculty needed to engage our students in key emerging areas of physics. Our latest approved expansion is in the area of cosmology, the study of the universe and its past and future evolution. This is an area that has gotten a great deal of press lately—physics is an experiment-driven discipline, and there has recently been tremendous growth in experimental cosmological data, much of it from new breakthrough observing instruments such as the UC Keck telescope in Hawaii and the Hubble Space Telescope. We have had one very lonely astrophysicist, Professor Robert Becker, in our department for more than a decade; he is a highly successful and acclaimed astronomer, but one faculty member on his own was simply not enough to deliver the appropriate course offerings or to develop a graduate research program in this highly timely area. This has now been rectified: we now have four new positions in cosmology, the first of which is being recruited at this writing and is likely to be filled (I hope!) by the time you get this newsletter in the mail. The other three cosmology positions will be filled within the next two years. This is a great opportunity for our department, and it has us all excited. In this endeavor, we greatly appreciate the support of the UC Davis administration, with special thanks to our dean of mathematical and physical sciences, Peter Rock.

Where are we going in the future? Our department strategic plan also calls for an addition of one or more people to our nuclear physics program, which was particularly hard hit by the retirements. Currently, Professors Brady and Cebra, along with the highly active Emeritus Professor Draper, make up the core of that program. Its current emphasis is on research in relativistic heavy ion physics, geared to a new relativistic heavy ion collider (RHIC) that will be operational at the Brookhaven National Laboratory in a few years. At RHIC, which forms the cornerstone of near-term nuclear physics research, the basic structure of nucleons (their quark building blocks) will be probed by studying the "quark-gluon plasma" expected to form in heavy ion collisions. As you might surmise, there is strong overlap between research in our high energy, nuclear and impending cosmology groups. There is even expected to be an increasing interaction with the condensed matter people!

Finally, a few special congratulations. Professor Shirley Chiang gave birth to a baby girl in January, and Professor Sudhindra Mani and his wife added a baby boy to our physics community. All are doing well. I would also like to congratulate Professor Robert Shelton, who has assumed the position of UC Vice Provost for Research in the Office of the President. Professor Shelton had been our campus's vice chancellor for research, in addition to running a robust research group in experimental condensed matter physics. We are fortunate that Professor Shelton will remain in our department and continue his research—he is maintaining his home in Davis and his faculty position in our department.

Sincerely,

Barry M. Klein

klein@bethe.ucdavis.edu

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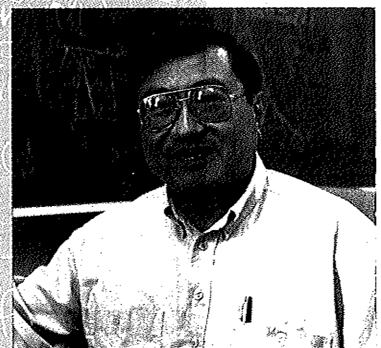
Faculty Highlights

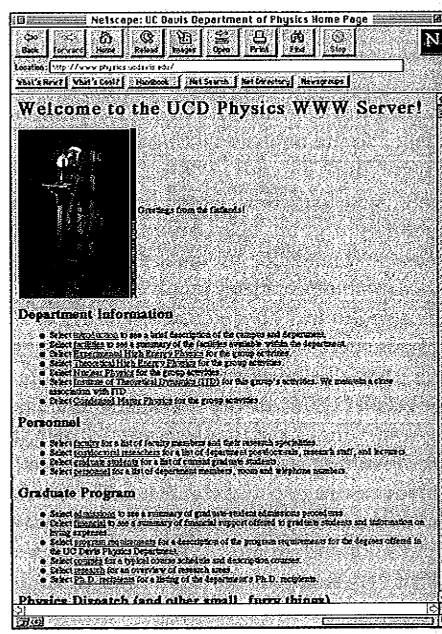
Professor Winston Ko has been selected to receive a Faculty Development Award from the UC Davis Office of the Provost. The purpose of this award is to support development of research by providing recipients time for concentrated research efforts.



Winston Ko

Professor Robert N. Shelton has been appointed Vice Provost for Research at the Office of the President. In his new position, Dr. Shelton will coordinate the development of systemwide research policies among the Office of the President, the nine UC campuses, and three DOE laboratories managed by UC. Dr. Shelton joined the UC Davis faculty as a professor of physics and chair of the physics department in 1987. In 1990, he was named vice chancellor for research for the Davis campus. He will continue to maintain his faculty appointment at UC Davis along with his very active research program.

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>

Ph.D. Degrees Awarded

December 1996

Russell B. Cosgrove
"Time and Observables in Quantum Gravity via the Evolving Constants Method."
Project engineer, Radian Technology, Santa Clara

Steven M. Glenn
"A Search for Self Interactions of Neutral Electroweak Gauge Bosons."
Instructor, University of Rochester, New York

Soong-Hyuck Lee
"Interlayer Magnetic Coupling in Pd/Pd (1.2 at. % Fe) Multilayers."

Fengcheng (Taylor) Lin
"Detection of B^o_d in a Hadron Collider."
Senior design engineer, Philips Semiconductors, Sunnyvale

Jeffrey B. Rowe
"Muon Measurement in High Field Solenoid Detectors."
Postgraduate research, High Energy Group, UC Davis

March 1997

Bennett Corrado
"Optical Transmission and Reflection at Interfaces and in Waveguides: Surface Electromagentic Radiation, Selective Mode Launching, and Microreversibility in Optical Scattering."

Patrick M. Len
"Atomic Holography with Electrons and X-rays."
Lecturer, UC Davis

June 1997

Jerry Chance
"Nuclear Matter Flow in Ni Induced Relativistic Heavy Ion Collisions from 0.4 to 2 A GeV."

Isaac Huang
"Global and Collective Phenomena in Pb + Pb Collisions at Projectile Energy of 158 GeV/ Nucleon."

Chance Hoellwarth
"Magnetic and Heat Capacity Measurements of the Superconducting $Y(Ni_{2-x}Co_x)B_2C$ System."

George F. Pope
"Elastic Photoproduction of J/ψ at the H1 Experiment at HERA."
Post-doctoral research associate, University of Pittsburgh

Eric D. Tober
"The Interfacial and Surface Properties of Thin Fe and Gd Films Grown on W(110) as Studied by Scanning Tunneling Microscopy, Site-Resolved Photoelectron Diffraction, and Spin Polarized Photoelectron Diffraction."
Post-doctoral researcher, IBM Almaden Research Center

Zaixin (Jack) Wang
"Short-range Magnetic Order From Spin-Polarized Photoelectron Diffraction and Holography: Experiment and Theory for MnO(001)."
Senior development engineer with ProLinx Labs, San Jose

Bachelor's Degrees Awarded

March 1997

Stephen R. Hauskins, AB

Tonas S. Konstantine, AB ❖

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 mail your information to: University of California, Davis, Physics Department, Davis, CA, 95616, Attention: Joey Simoes. You may also e-mail your information to: simoes@physics.ucdavis.edu . We would especially like to receive alumni e-mail addresses, so please be sure to include yours!

Name: ______________________

UC Degree: ______________________

Class of: ______________________

Current Employment

Title: ______________________

Company/School: ______________________

Address: ______________________

Other News

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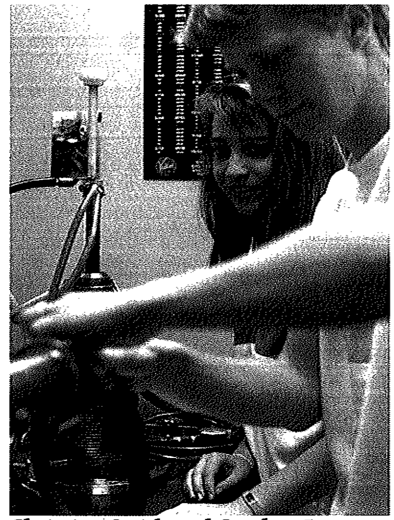
Department News

Ji-Zhe Liu, research physicist, retired from UC Davis on January 1, 1997. Dr. Liu specialized in conceiving, growing, and characterizing crystals of new, exotic materials, an area in which he had a great deal of success. Dr. Liu received his diploma from Nanjing University in the People's Republic of China in 1962 and advanced to associate professor at Nanjing University in 1986. He was a visiting scientist at Argonne National Laboratory from 1985 through 1989 before coming to UC Davis in July of 1989. During his career, Dr. Liu received two Outstanding Scientific Awards from the Jiangsu Province Government, People's Republic of China. One award (1980) was for achievement in the growth of quality YIG crystal and the design of microwave delay line. The second award (1982) was for achievement in basic research and improvement of Hexagonal Ferrite.

Congratulations to **Nilda Muniz** (left), office manager, for her recent promotion to executive assistant to Dean Barbara Metcalf (Division of Social Sciences, College of Letters and Science). Nilda worked for the physics department for over 18 years. We all wish her our best in her new position!



Christine Smith and Stephen Irons work at the DC Plasma Soot Generator creating soot from which they will extract a bucky ball.

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