UC DAVIS

Physics Newsletter

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Beam Time: UC Davis Scientist Dan Cebra Aims for the Big Bang

U.C. Davis physicist Dan Cebra was featured in the December 18 issue of the Sacramento News and Review. *Here are some (slightly edited) excerpts from that article:*

by Ralph Brave, contributing editor,* Sacramento News and Review, *as edited by Steve Carlip, associate professor

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Physicist Dan Cebra labors at UC Davis as a member of a billion-dollar international scientific collaboration that in 1999 will attempt to re-create the Big Bang by smashing atoms together at nearly the speed of light. The goal is to create a state of matter that existed for only a moment within the first millisecond after the Big Bang created the universe some 10 billion to 20 billion years ago.

While the results of the experiment are unknowable until it is actually conducted, the hope is that the effort will help us achieve a new understanding of the origin of the universe and why it came to be the way it is.

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A simplified briefing on the current scientific understanding of the universe will allow some grasp of what Dan Cebra and his colleagues are up to. The notion that the universe was created by a Big Bang—an explosion of energy at infinitely hot temperatures occurring everywhere all at once—is now accepted by all reputable scientists. What is not known is why there wasn't simply a continuous flat distribution of the energy from the Big Bang, similar to the spreading effect of spilled coffee on a rug. As Dr. Cebra expresses it, "Somewhere there were some primordial perturbations, fluctuations, that allowed matter to cluster."

Whatever those fluctuations were, without them you wouldn't be reading this now. Because those primordial disturbances permitted particles to form, and then to organize themselves into the forms of matter that now make up the universe. One of the most basic particles has come to be known as the quark (a word derived from James Joyce's *Finnegans Wake*). Protons and neutrons are composed of three quarks bound together. But at some point just after the Big Bang, physicists theorize, there must have been a state of the universe when there was nothing but free-floating quarks, held together by massless particles called gluons. The scientists' quest is known as "the search for the quark-gluon plasma," also the title of Cebra's graduate seminar at UC Davis.

The experiment to find the quark-gluon plasma will occur at the Brookhaven National Laboratory on Long Island, New York, in 1999. The atom-smasher being utilized is known as the Relativistic Heavy Ion Collider (RHIC). Two beams of gold atoms will be circulated around a 2.4-mile tunnel at nearly the speed of light. At six detector stations—one of which will be occupied by Cebra and his colleagues—the beams will cross, resulting in their collision and fracturing into their constituent particles. The collisions will model the Big Bang by occurring at the highest temperatures of any such experiment yet conducted.

Thinkers and Tinkerers

If another kind of big bang hadn't occurred, Dan Cebra himself might not be part of this quest. Shortly after World War I erupted, the Austro-Hungarian army combed the countryside for draftees. Coming upon the Cebra farm in Slovakia, they sought to enlist Cebra's grandfather, then 17 years old. Since the family had previously spent some years in the United States, they claimed American citizenship for him. He was given a week to get out, and he did.

Cebra's father excelled in school, graduating from the University of Pennsylvania in three years, earning a doctorate in biology and a teaching post at Johns Hopkins University. Dan Cebra grew up in Baltimore and followed his father's footsteps to Penn as a biology major. But biology for him was really "more of a hobby, in order to communicate with my father," finding the field's problems "more or less straightforward." He turned to physics, he says, "because I wasn't very good at it." He was intrigued with the possibilities of investigating

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Inside This Issue

Dan Cebra, assistant professor

Beam Time

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"microscopic things that are invisible—even conceptually invisible—yet which you can study and measure."

Cebra received his Ph.D. in physics from Michigan State University. If his choice of subject was in any part a rebellion against his father, he found the means to reconcile. He married a biologist. His wife, Karen, is a mammalogist and ornithologist who works at the California Academy of Science.

Postdoctoral work brought him to the Lawrence Berkeley Laboratory in 1991, where he volunteered to help devise the laser equipment required for the now-decommissioned Bevatron. Cebra found enjoyment in solving the puzzles involved in how to build a better device. Since arriving at UC Davis in 1993, he has continued specializing in the design and operation of laser calibration systems. And that is the role that he and his UC Davis team are playing in the upcoming experiment.

As Dan Cebra tells it, there are two types of physicist: the thinkers and the tinkerers. The thinkers are the theoretical physicists who, through acts of imagination and mathematics, discover and describe the fundamental laws governing the universe. To the extent that physicists have a public persona, it is that of the thinkers, such as Albert Einstein and Richard Feynman.

The tinkerers are the experimental physicists, such as Dan Cebra, who design the ways and means to test the predictions of the theorists. While the thinkers are renowned for their individualism and strong egos—necessary equipment in a field where there is always and only one right answer to a problem—the culture of the tinkerers is necessarily cooperative. Particularly with the larger and more expensive experiments now required in particle and nuclear physics, collaboration is the nature of the experimental game.

The Brookhaven experiment—led by Yale University physicist John Harris—involves 300 mostly American scientists who work in teams that are based either at universities or national laboratories. Dan Cebra's team at UC Davis is composed of 10 members—two other faculty, (Paul Brady and Jim Draper), one professional scientist, and six graduate students.

Their role in the experiment is to design the laser systems that will allow continuous verification that the equipment detecting and measuring the particles which emerge from the collisions is accurate. Without the correct implementation of their laser systems, the data results from the experiment would, at a minimum, be thrown into grave question.

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The laser systems, designed in prototype at UC Davis, will have their beams distributed into various parts of the particle detector while it records the collisions. The positioning of the laser beam allows the experimenters to know that the detectors are correctly calibrated. But if the lasers are looking after the detectors, what's looking after the lasers? Included in the laser design is a photo diode that allows a feedback system for automatic realignment.

Countdown to a Collision

Sometime in late 1998, Cebra will take a sabbatical from UC Davis and move to the Brookhaven lab in preparation for the experiment.

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In the early 1980s, Brookhaven built a tunnel for a collider called ISABEL as a means of locating rare, exotic particles. Illustrative of one of the dangers that the experimentalist faces, the system's prototype magnets worked, but it turned out to be a fluke. The real magnets did not work. Just as Brookhaven scientists were redesigning the magnets, an Italian scientist was accepting the Nobel Prize for having created the sought-after particles at a collider in Switzerland.

The failure further exacerbated deep competitive divisions between the American physics community and their European counterparts, a situation that Cebra deplores. He places part of the blame for the collapse of Congressional support for the proposed Superconducting Super Collider in the early 1990s to the American scientists' failure to invite European participation, with the consequence that U.S. taxpayers were being asked to foot the entire $2 billion required. It now appears that lessons have been learned, as just last week the U.S. announced an unprecedented half-billion dollar contribution to an atom smasher, the Large Hadron Collider, being built in Switzerland.

The $300 million tunnel for ISABEL was left vacant. So when the American community of nuclear physicists turned its attention to the search for the quark-gluon plasma, they had an existing available tunnel to use. Without it, some speculate, the costs might have been prohibitive for the experiment to proceed.

When Cebra and his colleagues gather at Brookhaven, nearly a decade of work and a billion dollars of equipment will reach culmination at "beam time"—when the beams of gold atoms begin circulating around the tunnel and colliding inside the detectors. The beam will run for about eight months a year for perhaps the next 10 years.

Repeated collisions are necessary so that the scientists can verify that what they are recording is a real property of the particles rather than a random event. But with the current sophistication of their detectors, they will also receive immediate results that will give them some early indication of whether they have achieved their goal.

According to Cebra, the weeks leading up to the initial beam time are incredibly stressful, with all the kinks in the equipment still being worked out. Despite the cooperative basis of the enterprise, or because of it, tempers can flare. At a previous similar experiment, a technician became so frustrated in his differences with other personnel that he tore a vacuum pump out of the wall. The tensions can even rise to the point that physicists are thrown off projects.

But whatever the problems, the experimenters have to be ready to "take beam" when beam is being given. Often, according to Cebra, the first few days are a period of panic because some problems with the detector system are only revealed when the experiment has actually begun.

The data recorded from this experiment may or may not show that the quark-gluon plasma has been achieved. Years of data analysis may be required, says Cebra, who adds that there is some evidence that a previous experiment found small droplets of the quark-gluon plasma. Perhaps it might just be a matter of adjusting the criteria for it, he suggests. On the other hand, he says there are scientists who are skeptical that such a state of matter ever existed or is attainable.

Since a quark is so minuscule that it cannot be seen directly with any existing technology, how will they know that they have attained the quark-gluon plasma? Cebra and his colleagues will be looking for a signature flow of protons emerging from the collisions that will be indicative of the desired state.

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The End of Physics?

There is a mounting perception in science that we may be nearing something like "the end of physics," when all of the basic laws of the universe are known. Certainly Dan Cebra foresees that "in 30 to 50 years, no one will be doing nuclear or particle physics any longer." The laws of the nucleus of the atom will have been conquered, just as the laws of electromagnetism were fully elaborated by the end of the 19th century.

The late California Institute of Technology

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Beam Time

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physicist Richard Feynman foresaw just this possibility. "This thing cannot keep going so that we are always going to discover new laws," he told an audience in 1964. "What can happen in the future is either that all the laws become known ... or it may happen that the experiments get harder and harder to make, more and more expensive, so you get 99.9 percent [of the laws] ... and it gets slower and slower and more and more uninteresting ... But I think it has to end in one way or another."

The colliders such as those at Brookhaven are examples of these increasingly expensive physical experiments for increasingly smaller additions to knowledge. One consequence of this development is that some physicists are bringing their expertise into other sciences, such as the study of the physics of biological molecules. Other physicists are finding a market for their mathematical expertise on Wall Street. Even the UC Davis physics department seems to be tacitly acknowledging the emerging shift in focus. Cebra says the next several hires of faculty will be cosmologists.

When the results are in, whatever they show, what will we have learned?

Cebra doesn't hesitate to assert the fundamental nature of the research involved, meaning that applications of the knowledge gained are not the standard by which its worth should be evaluated. When pressed on the issue of what came before or caused the Big Bang, Cebra admits the importance of the problem, but defers to the theologians for responses....

Late Friday afternoons are a time when members of Cebra's seminar and other UC Davis graduate physics students gather at the campus pub to share stories. The UC Davis students are quick to defend the current large experiments on the grounds that previous fundamental research resulted in technological spinoffs, from transistors to photovoltaic solar cells. But given time to consider an outsider's perspective, these same students take a more reflective approach. Physics graduate student Tom Gutierrez perceives the physicist's stance as, "We poke the universe, and the universe pokes back." But he concedes that "even if we understand the properties of all matter, that may not answer the big questions."

Grad student Jennifer Klay, who is a member of the UC Davis experiment team, sees value in understanding the phases of matter at the beginning of time, but doesn't believe it can answer "our theological questions." It does appear, however, that it can change the questions. For example, whatever the understanding of the Big Bang cannot do, it does cancel out a literal interpretation of the Bible. Or so it would seem, though Klay says that she has met one working physicist who is also a biblical literalist.

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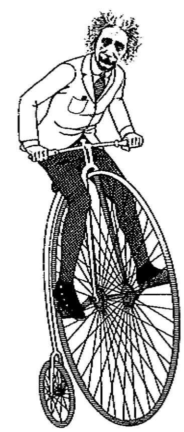
UC Davis graduate student Dan Lattimore states simply, "We don't know the consequences of not knowing the quark-gluon plasma." By implication, he's asking whether the human species can afford to take the risk of continuing not to know. Is this the blackmail of a future physicist defending his profession? Or is it the blackmail of the indifferent universe itself? Or perhaps it is simply an ineradicable expression of our favorite game.

Those interested in learning more about the upcoming experiment can find information at the Web site of the Brookhaven National Laboratory at ***http//www.bnl.gov/.*** ❖



Degrees Awarded

Ph.D. Degrees Awarded

December 1997

Gary Cao
"Optical studies of interfaces and bulk liquids: surface diffusion and nonlinear optics"
Senior process engineer at Intel Corporation

March 1998

Paul C. Bloom
"Investigation of trilinear vector boson couplings through W boson pair production in dilepton decay channels"
Research associate and postdoctoral fellow at McGill University, Montreal

Scott D. Ruebush
"The growth of thin epitaxial copper films on ruthenium (0001) and oxygen-precovered ruthenium (0001) as studied by x-ray photo-electron diffraction"
Senior advisory development engineer at Seagate Technology

Ronald L. Sobey
"Inferences from vector boson production on the electroweak sector"
Postdoctoral researcher at UC Davis

Sung-Po Wei
"Analysis of diffuse-photon-density waves in multiple-scattering media and the application in optical imaging"
Process development engineer at Integrated Silicon Solution, Inc.

Bachelor's Degrees Awarded

Fall 1997

Jeremy F. Thorsness, BS

Konstantine S. Tonas, AB

Karel E. Urbanek, BAS

Brian T. Zaugg, BS

Winter 1998

David W. Chan, AB

Asha Desai, BS

Simulations Help Teach Difficult Concepts

This article is based on a piece by Aviva Luria in Information Technology Times, *January 1998, and on notes by Rod Cole.*

For nearly fifteen years, Rod Cole has been a pioneer in the use of technology in the classroom. As a lecturer in physics, and particularly as an instructor for the Physics 9 series—the introductory course for physics, engineering, and other science majors—Cole finds himself faced with the task of presenting difficult physical concepts to large groups of beginning students. Creating animated tutorials has made this task easier.

In the early '80s Cole began creating digital films using a VAX machine, a VCR, and a graphics application. "Ten seconds of video tape would take all night to film if nothing went wrong," he says. Now, using QuickTime or Java, Cole might be found creating a tutorial for his students on the very morning of his class. "With simulations I can do a lot of things that I can't do with real materials," he says.

"The tutorials we have developed are a variety of exercises and visualizations using QuickTime computer animations, traditional programs, and JAVA simulations," explains Cole. "The original motivation in 1984 was to show how electromagnetic radiation is generated in a manner that was meaningful to introductory students. For alumni who remember their own introductory electricity and magnetism, it is a mathematically abstract subject, being described by Maxwell's equations, and it is difficult for students to learn. It is especially difficult for students to develop a 'gut feeling'. There is no way for students to smell, view, or play with the fields. And when point charges start to move, the fields from these charges must be evaluated using retarded times, which means even the simplest problems become too calculationally cumbersome to perform by hand.

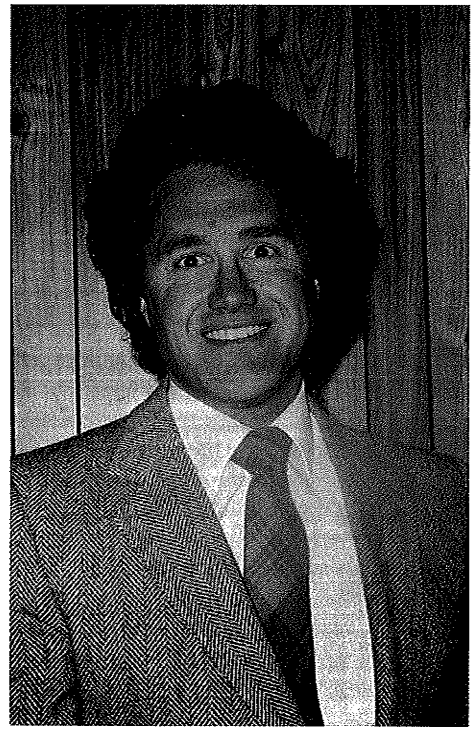
"From a simple beginning, we expanded the tutorials to cover the whole course. The goals are first, to aid in the visualization of the mathematical structure, such as gradient, divergence and curl. A good example is the 'Flux' tutorial. Second, students do not come into physics with a clean slate. They often have a pre-Newtonian view of the physical world. The tutorials help students replace incorrect models with physically realistic models, as in the 'DC Circuits' tutorials. Third, because computers can perform laborious and difficult calculations, they allow us to include topics such as radiation that we did not cover before. Thus, we find that computers are changing not only the way we teach, but also what we teach."

Cole has never been satisfied with students learning by rote; he aims for students to develop a "gut feeling" about physics, as well as intellectual comprehension. "I believe students do not have the 3-D visualization skills they used to have," he says. "Probably it comes from not playing in the same way. Students used to take things apart a lot more than they do now. The tutorials really help students with visualization problems."

Students in Cole's Physics 9 class work on exercises in the computer labs in groups of two or three. They can also work on the problems on their own time, whether in a lab or on a personal computer. Cole's Web site provides a link to the necessary plug-ins, so that students can run the tutorials using the Web browsers on their own machines.

Some of the programs now being used were developed at Davis. SilverHammer (a take-off from an old Beatles song, "Maxwell's Silver Hammer") runs on an Apple Macintosh and is available by anonymous ftp from maxwell.ucdavis.edu. It uses the Lienard-Wiechert potentials to solve for the fields from point charges that are moving and accelerating. SilverHammer is a 2-D program, however, and many of the fields must be visualized in three dimensions. Cole uses modeling programs such as Matlab and Infini-d to create 3-D simulations of the plots made by SilverHammer. To view the movies, you can log into http://maxwell.ucdavis.edu/~electro/ and open the magnetic fields folder. The movies require that the QuickTime plug-in is installed in the plug-in directory for your browser. The "ElectroCard" site requires Javascripting enabled on your browser. The course also uses other programs, such as Scott Johnson's award winning "Gas 3D" and some proprietary programs from Carnegie-Mellon.

"ElectroCard" is designed as an experimental effort to push the envelope of what computer-based technology can do in education. Streaming QuickTime and JAVA over the Internet requires a large bandwidth from the Internet, which heavily taxes machines. Unfortunately, most students do not have the equipment or the connections to use ElectroCard at home, but the computing world is rapidly changing, and Cole is looking toward the future when issues such as bandwidth are non-existent. For now, discussion sections use the computer labs in Olson and Hart, which have T1 lines.



Rod Cole

Research indicates that the tutorials are working. UC Davis graduate student Scott Tooker spent the last year working on a master's thesis project that compared students in the section that used the tutorials with students in sections that did not. He tested understanding of the basic concepts by giving pre- and post-tests. He concluded his study by noting that "students were on average, increasing their conceptual understanding by 52 percent of the material covered in [Physics] 9C. Students in other sections, on average, only increased their conceptual understanding by 33 percent of the material covered."

Since 1984, many alumni have contributed to the development of these tutorials, and any success can be attributed to the long hours and wonderful ideas they have given to the project. Many thanks go to (in chronological order): Bryan Galdrikian, David Krull, Monica Sweitzer, Steven Finch, Terry Palmer, Curtis Brune, Scott Tooker, Danny Banks, and Andrea Saunders. Students who are currently involved with the project are Erik Galindo, Mayra Padilla, Miguel Garcia, and Victor Wong. ❖

The Joint National Conference of Black Physics Students and Black Physicists

by Tynisha Johnson, undergraduate student, and Tracey Johnson, graduate student

After a long flight that included several layovers in various locations all across the country, we finally arrived in the Lexington area. Dropping below the cloud cover on approach to Bluegrass Airport, you quickly understand why Kentucky is named the "Bluegrass State." The surrounding countryside is made up of low rolling hills covered with horse farms and the famous bluegrass. An absolutely beautiful place it is. Unfortunately, for the next several days we would not see much of the outdoors, as we were here to take part in a joint conference comprising black physicists and black physics students. After a taxi cab ride from the airport (surprisingly, the driver was from California) we went through the registration process at the Hyatt Lexington. The activities of the first day consisted of a welcoming banquet and study room sessions. One of us (Tracey) decided to skip the study rooms and go exploring. As luck would have it, the Hyatt Hotel is located in the middle of a business district, and after walking around for about an hour Tracey decided that the streets were a little bit too empty, so he went back to the hotel to deal with jet lag.

It should be mentioned that we did not know what to expect from our visit to Lexington, as neither one of us had ever been there. Lexington is a college town in every sense of the phrase, but differs from Davis in several ways. Most notable among these differences were: 1) Where are the bikes? We saw four or five bicyclists over the course of our stay. Not a bike-friendly place. You should be considered an extreme biker if you are brave enough to ride those streets on any two-wheeler. 2) Where can we recycle? Not a recycling receptacle in the entire student center and apparently there were none anywhere in town. 3) These folks are just crazy about basketball! Everywhere there was a television set there were people gathered around watching their Wildcats! Sure the Aggie Pack is excitable, but Kentucky 'Cats fans are definitely fanatics! 4) Cigarette smoking and bad coffee were everywhere. Need we say more?

As mentioned before, this was a joint conference and so had many overlapping events. Some of these events included poster and recruiting sessions, demonstration "experiments" that clearly illustrated physical principles, banquets, a dance, and of course many scientific talks. The theme of the student conference was "Physics: life in motion," and coinciding with the celebration of the electron discovery centennial, the opening and closing presentations were geared to acknowledge the celebration. The opening presentation was given by Dr. S. James Gates, a high energy theorist from the University of Maryland. (Many people out there may know of Dr. Gates from appearances on several PBS specials.) In the talk entitled "Frontiers in Physics," he explained how our understanding of the electron has shaped the world as it is today. He went on to say that many people he comes into contact with tend to think the scientific community is in decline. However, this decline is just a myth if you consider all the projects that are in the planning and/or installation stages. Some of these include: the Laser Interferometric Gravity Observatory (LIGO), the Relativistic Heavy-Ion Collider (RHIC), the planet-seeker project, the National Ignition Facility (NIF) and the Human Genome Project.

We believe that the intent of Dr. Gates' presentation was to inspire beginning undergraduates to continue their education through graduate school. He also demonstrated financial incentives through a series of plots (with data taken from AIP publications) which clearly exhibited greater salary potential for holders of the Ph.D. when compared to holders of less advanced degrees. An interesting point was raised from observation of these graphs. They clearly demonstrated that MS holders had a higher income potential, on average, than Ph.D. holders during the first few years of employment. No specific reasons were given for this observation but it was noted that after those first few years, salaries for Ph.D. holders increased at a rate much higher than those of other degree holders.

Dr. Gates' attempt to inspire students to continue on to graduate school was echoed by almost every speaker who gave a presentation during the student sessions. These talks ran the gamut from speculations on African astronomy all the way to studies of x-ray emissions from elliptical galaxies. Most of these presentations were given by advanced graduate students, and those presentations given by physicists were clearly recruitment talks. The best talk of the student sessions was given by Dr. Peter Delfyett, who is a laser experimentalist from Central Florida University. He began by describing a method by which information can be transferred more rapidly than anything the Microsoft people have utilized. Once he had made his assertion, Dr. Delfyett exclaimed, "We can put Bill Gates out of business!" With that the audience roared its approval and Dr. Delfyett was off to the races! We believe that he compressed a 30-minute talk down to about 15 minutes. Fortunately, for most of us in the audience, it seemed that freshman physics was all that was required to understand a good deal

of the presentation. Dr. Delfyett concluded his talk saying that there is much work yet to be done and invited students to talk to him about that work.

The most valuable sessions for many undergraduates were the designated recruiting sessions. Representatives from various institutions were given five minutes to "boost" their home campuses. This may seem like a fairly short time, but each of the 10 recruiters also set up booths in the poster session. This is where the representatives really earned their pay. They had to deal with queries such as how to get into graduate school and how to deal with life once a student is in graduate school, and also had to explain what life is like "living" in a research laboratory. These sessions also provided tips on taking the GRE and dealing with the institute-specific written preliminary. We feel that this part of the conference was very useful even to those of us that have already been through those gauntlets. But with these tips came the universal feeling that diligence, industry and endurance are the most desirable traits that a graduate student in physics must possess in order to be successful.

As in most conferences with a teaching theme that we have been to, there was a session on demonstrations of physical principles. Called the "Physics Spectacular," many of the results reminded us of the old adage "If it wiggles, it must be biology. If it smells bad, it must be chemistry and if it does not work, it must be physics!" (That adage must have been coined by PHY5 students.) Unfortunately Friday the 13th came a week early for the three experiment demonstrators, who were having a slight lapse in

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National Conference

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good luck. The good thing here is that most people in the audience knew what to expect, and so we were all just having a good laugh.

The conference concluded with a banquet and a dance. The speaker during the closing banquet was Dr. Ronald Mickens from Clark Atlanta University. In keeping with the observation of the electron centennial celebration, Dr. Mickens presented an abridged history of the electron. The presentation was loaded with references to scientists both obscure and very well known. This talk was given in a very light-hearted mode, as Dr. Mickens peppered the presentation with barbs pointed at everybody in the audience. No group was considered sacred. Undergraduates, graduates and physicists were roasted many times. Exactly the last thing that we expected, but quite the good time!

The conference itself was an incredible experience as we learned many things about science and ourselves as well as many things about other Black physics students and Black physicists. At least one of us plans to return to the conference next year to present a paper and act as a recruiter for the UC Davis physics department. Our thanks go out to all of those people who made our trip possible. ❖

New Phi Beta Kappa Member

Congratulations to **Andrew Gordon Tenn** who was recently elected as a Member in Course of Phi Beta Kappa. The Society was founded in 1776 at the College of William and Mary in Williamsburg, Virginia; the UC Davis chapter, designated Kappa of California, was chartered in 1968. Kappa Charter recognizes by election as Members in Course juniors and seniors who have compiled outstanding academic records in a curriculum including the humanities, natural sciences, and social sciences.

From the Chair

Dear Friends of UC Davis Physics:

I am pleased to write you at a time that the rains seem to be subsiding, hopefully, and to tell you that we are not under water for now! I hope that you all are having a great year.

Unfortunately, we had to postpone our planned alumni reunion, previously scheduled for April 25th, due to the press of business here, including our current recruitment of four new faculty members. I hope that in my next column I will be able to tell you of the wonderful new faculty members who will have joined our department. The reunion will be rescheduled for some time next academic year.

The news here is very good. Besides our faculty recruitments, with thanks to the great support we have been getting from Dean Peter Rock and the rest of the UC Davis administration, a number of positive developments are worth mentioning. Our new introductory physics honors course for physical science and engineering majors, Physics 9H, is off and running with a great start: over 50 students enrolled and very enthusiastic responses to our changes in the curriculum (more early emphasis on modern physics) and the timing of the course (starting in the first quarter of the freshman year rather than the traditional third quarter start). Professors Dan Cox and Joseph Kiskis have done a great job teaching this new course, and several other faculty members have been involved in the curriculum and laboratory development.

Further good news is the success of our students and postdocs in finding good jobs in academia, industry and government laboratories in permanent or postdoctoral positions. The San Francisco Bay Area especially is a science "boomtown" right now, with the growth of large and small high tech companies providing excellent jobs for our students. There is an increasingly positive attitude among our graduate students that they can fulfill their dreams and partake in the joy of basic research in any area and still be well-prepared for a satisfying job. We recently did an internal survey regarding the placement of our students over the past five years. Our more than 50 Ph.D. graduates appear to be doing very well. It's always great for me to see a returning graduate, whom I remember being ensconced in jeans and a tee-shirt, coming back to visit with a suit and tie, and oftentimes in a fancy car!

A further note is the increasing involvement of many of our faculty members in "service to the community" activities. Several of our faculty members have assumed key committee positions on campus, and there is an increasing sense that we can give a part of ourselves to the overall campus and community in addition to our usual research and teaching activities. Professor Larry Coleman was the chair of the UC Davis Academic Senate last year and did an excellent job in leading the UC Davis faculty through a number of important issues. Also particularly noteworthy are Professor Richard Scalettar's efforts in mentoring and recruiting to campus students from under-represented groups, and leading efforts to prepare them for a science education and to mentor them when they are here. Richard was recently honored with a special award at the UC Davis Affirmative Action and Diversity Achievement Award ceremony for his highly successful efforts. Other faculty service activities will be highlighted in future issues of our newsletter.

I wish you all a great summer and look forward to seeing you next year.

Sincerely,

Barry M. Klein

Barry M. Klein

Alumni Dinner Postponed

The UC Davis physics department alumni event that had been planned for April 25, 1998, has been postponed until next spring. We hope that you will plan to join us then for a good time with your former professors, fellow students, and friends. We look forward to seeing you in spring 1999!

NSF CAREER Award

Assistant Professor Rena Zieve was awarded a prestigious Faculty Early Career Development (CAREER) award by the National Science Foundation for research on heavy fermion superconductors and for efforts to increase undergraduates' exposure to experiment.

by Rena Zieve, assistant professor

I recently received a "CAREER" award from the National Science Foundation. The grant is meant to help new faculty develop into well-rounded professors, with involvement in both research and education.

My research plans involve the heavy fermion superconductor (U,Th)Be_{13}. Conventional superconductivity—in materials from $Nb_{13}Ti$ (which is used for most superconducting magnet wire) to aluminum and other pure metals—is well understood. The key interaction is an attraction between electrons mediated by vibrations of atoms in a crystal. This leads to only one kind (i.e., one phase) of superconductivity. Its characteristics include extreme sensitivity to magnetic impurities and exponential dependence of many properties on temperature.

"Exotic" superconductors, such as heavy fermion materials and high-temperature superconductors, also have an attractive electron-electron interaction, but not from atomic vibrations. Finding the cause of the attraction motivates much of the research on these compounds. Whatever the mechanism, it allows exotic superconductors to incorporate magnetic ions and magnetic ordering without losing their superconducting properties, and replaces the usual exponential temperature dependences with power laws. Most surprisingly, thermodynamic measurements on (U,Th)Be_{13} show several superconducting phases.

Learning how the phases differ may lead to understanding the reason behind the superconductivity. My approach will be to study how defects affect the different phases. Columnar defects, in which the crystal structure is destroyed along lines, will be created through heavy-ion irradiation. Point defects will be made by both irradiation and substitution. Low-temperature thermodynamic and magnetic measurements on these samples will be used to identify the superconducting wave function(s) of the system.

As a low-temperature physicist, I am concerned with how to introduce students to research. The heavy fermion materials described above are superconducting only below 1 Kelvin, so experiments will be done on a dilution refrigerator which cools to less than 15 milliKelvin. The experiments generally take at least six months of full-time work to complete, and at some stages require daily maintenance of the refrigerator. This time frame makes it impossible for most undergraduates, or even graduate students still involved in coursework, to carry out an experiment from start to finish.

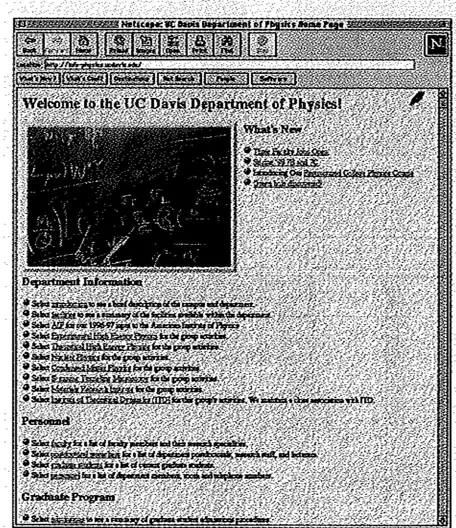
To give more students the satisfaction of completing a project, my CAREER program includes a second line of experiment more appropriate for undergraduates, on packings of solid objects. If a single layer of identical spheres is "annealed," which in practice means shaking the container, they form the densest possible arrangement, a triangular lattice. If instead the spheres are in a three-dimensional box, annealing also increases the density. However, the spheres do not form a regular lattice, and the density approaches 0.64, well below the highest known value of 0.74 for a hexagonal close-packed lattice.

Both physical experiments and computer simulations show that this behavior is not limited to spheres, nor to a particular way of shaking. In two dimensions, layers of pentagons and heptagons also form lattices which are believed to be the densest possible packings for those shapes. In three dimensions, the 0.64 density limit holds for spheres whether the force holding them together is directional (such as gravity) or uniform (such as hydrostatic pressure), and whether the shaking is done continuously or not.

I want to examine the difference between two and three dimensions using arrangements a few layers thick. The first version of the experiment is extremely simple, consisting of a computer-controlled shaker and a box of ball bearings. We can control the number of layers by changing the height of the box. Eventually, I hope that an understanding of why packing is more efficient in two dimensions will let us devise better annealing algorithms for three dimensional samples. This could have important practical consequences for composite materials, which frequently consist of sphere-like blobs of one compound embedded in a matrix of a second material. Achieving desired properties often depends on reaching a high density of the first component. A better packing algorithm would be a useful tool.

After more than a year of renovations and equipment orders, my laboratory is nearly ready for experiments. I have in hand my first samples of (U,Th)Be_{13} with columnar defects. My dilution refrigerator has arrived and should have its first successful cooldown in a few weeks. I'm expecting a productive few years with the NSF CAREER support. ❖

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>

Graduate Student Open House

by Joseph Kiskis, professor

On March 13 and 14, the department hosted its third open house for admitted graduate students. This event provides an opportunity for students who are considering UC Davis for their graduate study in physics to visit the department and receive an overview of its graduate program.

This year 43 students have been admitted for fall 1998. Of those, 12 accepted our invitation to visit during the open house. They came from all over the country, with Hawaii, Washington, California, Utah, Indiana, Maryland and New York represented.

On Friday evening a reception provided an opportunity for the students and faculty members to meet and have informal conversations. Saturday was primarily an introduction to the research programs in the department. After a general introduction by our department chair, Barry Klein, there were brief overviews of the main research groups by Professors Sudhindra Mani, Dan Cebra, Steve Carlip, Bob Becker, Gergely Zimanyi, Shirley Chiang, and Wendell Potter. Dr. Francisco Kole of KLA-Tencor Corporation also spoke about his very successful transition from thesis research in experimental high energy physics at UC Davis to employment at a company that produces testing equipment for the semiconductor industry. During the rest of the morning, students had time to wander from lab to lab to see equipment and discuss the research in more detail with faculty and current students. After lunch, there was a tour of the campus, followed by a poster session where some current graduate students presented their research. Then came opportunities for the prospective students to talk with current students and some of the faculty. The day closed with an enjoyable dinner at the Silo Pub.

By all accounts, the event was very successful. This was due to the efforts of many people. Professor Daniel Cox and Graduate Program Coordinator Lynn Rabena did a tremendous amount of work on organization. Many other graduate students and faculty also contributed their time and energy. Their efforts to improve the graduate program by helping to recruit the best students are greatly appreciated. ❖

Standing left to right: Eric Minassian, Don Futaba, Philip Rogers, Marlon Barbero, Christopher Hill, William Butler, Christie Devlin, Rebecca Newcomb, Ling-Lie Chau. Front row left to right: Yuko Nakazawa, Yu Sato, Simon Mun, Carina Kamaga, Matthew Enjalran, Douglas Pahel, Jennifer Klay.

Participants at poster session.

Discussion at the poster session.

Taking a break between presentations.

Happy Retirement, Rory!

by Wendell Potter, senior lecturer SOE

After 29 years of dedicated service to the physics department, Aurora Tafoya, known affectionately to all as Rory, has retired. According to her husband, Ed, Friday, March 27, was not just the last day she had to get up early, but was also the last day *he* had to make the bed! Rumor has it that she's planning to do a lot of traveling and quilting, but is definitely not making beds.

Rory began her career with the physics department when we were still located in Young Hall, typing manuscripts and providing other secretarial services to the theory group, led by Bill True. Two years later, when we moved into our spanking new building, she landed an office on the fourth floor (up high in the clouds with the theorists), occupying it for a couple of years.

In 1973, however, she came down to the second floor to find her true (not to be confused with Bill) calling, working with undergraduate major records, scheduling courses, and managing the seemingly infinite number of details that must be attended to in order to keep the growing instructional program of the department functioning.

It was about this time that the notion of having vice chairmen (sic) in departments was growing in popularity across the campus, and physics jumped on the bandwagon. Not only did Rory have to keep everything connected with the undergrad program running smoothly and get students enrolled into courses each quarter, she had to manage and endure a succession of three often out-of-control and definitely quirky vice chairs. Glen Erickson and Rory established many of the routines later inherited by Wendell Potter, Neal Peek, and then Wendell again. (At some point they became "vice chairpersons.")

Many old-timers will remember one of these "quarterly routines" that started very early in the morning on "In-Person-Enrollment" day. Rory—having put up many signs and having arranged the furniture in the three classrooms off the front porch of our building the night before—would oversee the many hundreds of student registrations carried out by sleepy and grumpy TAs. Somehow, by quickly adding or removing lab and discussion sections on the fly, Rory managed to get most of these desperate students into classes, while at the same time ensuring that we not end up with any nearly empty lab and discussion sections. In more recent years, this whole process has been computerized, of course. The overall goal is the same—to get students into courses they need—but the skills and energy required to pull it off seem to scale directly with the degree of computerization.

Both old-timers and more recent folks will fondly remember and miss Rory's candy jar, which for many years was a clear plastic apple (bought from some faculty member's kid selling junk to raise money for the band or something). This apple, sitting on the file cabinet as you approached Rory's desk, was symbolic of the reception everyone received, whether you were a worried freshman trying to get into a course or a harried faculty member concerned about the textbooks that hadn't arrived for your class. Somehow, Rory was always able to remain calm and pleasant and to treat everyone with respect and courtesy, regardless of the number of crises occurring simultaneously. It is this quality that we will remember and miss the most about Rory. ❖

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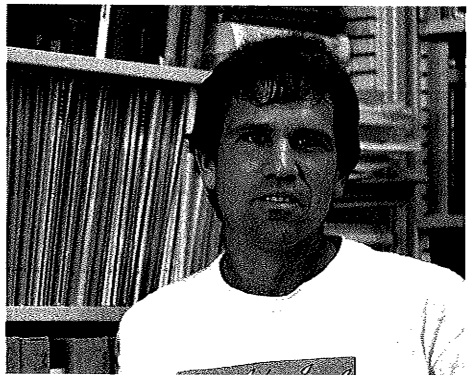
Faculty Honors



Richard Scalettar recently received a UC Davis Affirmative Action and Diversity Achievement Award for his contributions to these efforts. Professor Scalettar is a mentor of students in the Minority Undergraduate Research Participation in the Mathematical and Physical Sciences program, and serves as the physics department representative to the program's steering committee. He has used funding from the Office of Naval Research to work with four female students over the last three summers, and has also worked with a female undergraduate student for a year on research in flux line dynamics and parallel computation. Professor Scalettar participates in the UC Davis Educational Opportunity Program, meeting with students and their families to help in their introduction to the campus. His work with affirmative action and diversity has had very positive outcomes that have benefited many students. Congratulations, Richard!

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