UCDAVIS

Newsletter

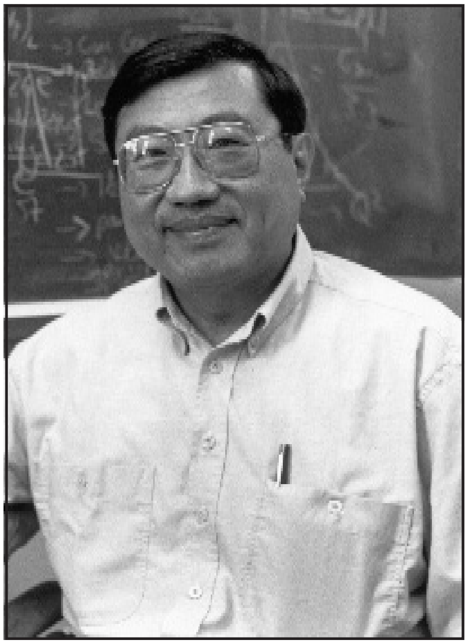
Number 7 A Newsletter for University of California, Davis, Physics Alumni Fall 1998

From the Chair

A warm greeting from the new chair of the physics department!

As a 28-year veteran of the UC Davis physics department (26 years on the faculty after two years as an assistant research physicist and lecturer), it is my great pleasure to take the helm of the department during what I consider to be its most exciting period of expansion of excellence. The physics department is one of five departments in the Division of Mathematical and Physical Sciences, which was established three years ago in the College of Letters and Science. The division and the dean are totally committed to an excellent physics department. The campus, rebuilding its faculty after the wave of early retirements in the early 1990's and expanding in anticipation of the enrollment increase of "tidal wave II," is embarking on a strategy of planned initiatives. Two of the inititives—"Computational Sciences" and "Nanophases in the Environment, Agriculture, and Technology"—fit very well with the goals of our department. We are now poised to expand into the next stage of excellence in research and teaching.

In the last 12 years, we have expanded the condensed matter area of the department. To this end, we specifically brought in Professor Robert Shelton, a condensed matter experimentalist, and Professor Barry Klein, a condensed matter theorist, as chairs of the department. In these 12 years, we have successfully recruited a remarkable 12 condensed matter physicists. With this mission accomplished, Professors Shelton and Klein have moved into higher administrative positions to serve the broader sector of the university. With the anticipated arrival of Professor Daniel Ferenc in July 1999, we have also completed rebuilding the nuclear area of the department. Our strategy has been to create a critical mass in the relativistic heavy-ion experimental program, the frontier of nuclear physics. This growth is timely for their involvement in the experiment at the upcoming Relativistic Heavy Ion Collider, a machine widely expected to have enough energy to melt the nucleus into a quark-gluon plasma.



Winston Ko

We are now in the midst of building our astrophysics/cosmology program. For many years Professor Robert Becker has been our lone astrophysicist—the university had restricted full fledged astronomy/astrophysics programs to only four campuses because of limited telescope capacity. Things have changed with the advent of the Keck telescope. At UC Davis, we have identified a niche to build the cosmology program with a bridge to the particle physics program. It is indeed exciting that the physics of the very early universe, when the energy density was extremely high, is tightly linked to the physics of the fundamental particles and force. Professor Andreas Albrecht (from Imperial College, England) has now filled the first of four new faculty positions in the department. He has written a feature article on cosmology in this issue. We have initiated recruitment for the second cosmology position, and we hope to have the position filled by July 1999.

The opportunities facing physics are exciting. I am enthusiastic that we can build an exciting department together!

Sincerely,

Winston Ko

W Ko

Inside This Issue

The Physics Department's Largest Laboratory: The Universe

by Andreas Albrecht, professor

Cosmology is the study of the origins and evolution of the universe. People have wondered about these issues since the beginning of time, but through most of history the subject seemed to be one for philosophers and theologians. In the last few centuries (and especially this one), more and more science started creeping in to the picture, but it is only in the last decade or two that cosmology could claim to be a major field of science. Now, a great deal is being claimed about the current successes and future promise of cosmology. The exciting prospects of cosmology are being recognized by physics departments and funding agencies around the world, as higher priorities and levels of resources are being assigned to the field. Happily, here at UC Davis we are at the forefront of this process. The new cosmology group here will expand to five members in the space of three years, at which point we expect to be one of the major world centers for cosmology.

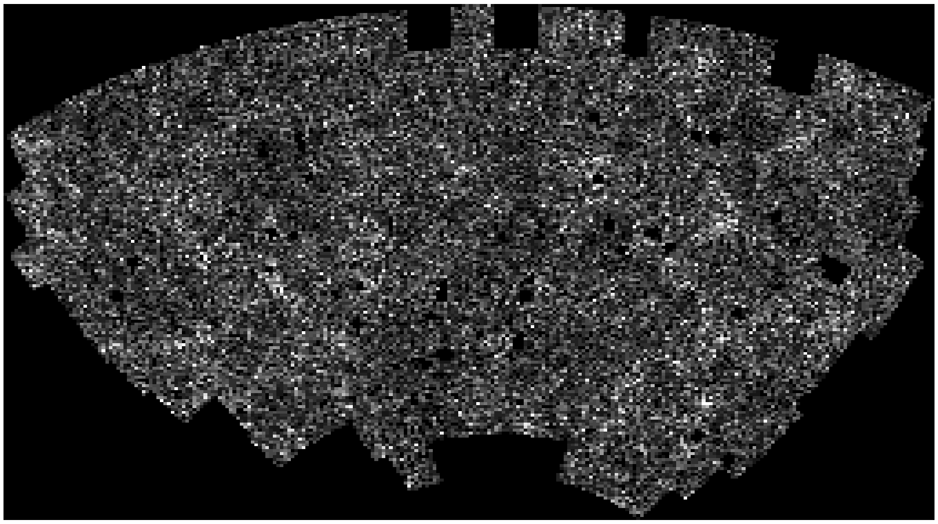
It is worth noting that the recent coming of age of cosmology has come at an important time in the evolving relationship between science and society. Citizens and politicians are questioning with increasing frequency the role of basic research and the extent to which they should support it. The old mix of elitism and cold war paranoia no longer can be counted on to provide the steady stream of funding it once did. I feel that cosmology has a special role to play in these discussions. First of all, the field generates a very natural interest—it does not take much work to persuade non-experts that the questions are interesting. Secondly, because the field is presently making such rapid scientific progress, it makes an ideal showcase of what science has to offer. People's natural curiosity about the universe can lead them, unwittingly in some cases, into a first rate introduction to the excitement and rewards of frontier research. I have always taken a strong interest in advancing this role for cosmology, and I expect my efforts in this direction to continue here at UC Davis.

This special role for cosmology takes on a more substantial form when it comes to university level teaching (both undergraduate and graduate). In this context, I have often seen that the passion for the fundamental questions of cosmology causes students to stretch and challenge themselves intellectually in ways that they might not otherwise have achieved. As often as not, once hooked on the thrill of conquering intellectual challenges, these students discover they can find equal (if not greater) personal satisfaction from taking on challenges in a wide variety of other areas, both in academia and industry. I believe this is probably one of the most important spin-offs from the field of cosmology.

But what are the new ingredients that are making cosmology such a success, and what are the tools we need to realize the great promise of the field? There is no doubt that a key element of current progress in cosmology is the new data. Modern technology is completely revolutionizing observational astrophysics. One of the crucial astronomical measurements is the redshift of an object. From the redshift we can determine an object's radial motion relative to us. For distant objects this radial motion is dominated by the cosmic Hubble expansion, and even the remaining motion can have deep cosmological significance. Not long ago redshifts had to be measured one at a time. Now an automated spectrometer exists which can measure 200 redshifts at once. In a few years the Sloan Digital Sky Survey will have measured the redshifts of well over a million galaxies, using a spectrometer now under construction that can measure 640 objects at once. These advances are being repeated across the board, with rapid progress at all wavelengths, and covering a wide range of astronomical objects.

A particularly important example is the mapping of the sky at microwave frequencies. We expect to extract from such a map information about light that has interacted very little over the last 10 billion years, giving us an image of the edge of the observable universe. (The early universe was so hot and dense that it was opaque, so there is only so far back we can look before hitting this opaqueness, the so-called "last scattering surface.") This Cosmic Microwave Background (CMB) has been observed since the '60's, and one of its most striking features is its tremendous isotropy. The isotropy of the CMB provides crucial evidence supporting the standard Big Bang model of the universe. But almost all models also predict tiny deviations from perfect isotropy, and in most cases the details of these tiny deviations (or fluctuations) are relics of earlier events that provide direct links with the high energy physics that describes the earliest stages of the Big Bang.

When I was a graduate student in the early '80's, fluctuations in the CMB had not been measured, although steadily decreasing upper bounds on their amplitude were being determined. Today, thanks to the COBE satellite, we have a map of these fluctuations over the entire sky, down to a resolution of seven



This is a representation of the "APM" survey (APM stands for Automatic Plate Machine). There are well over one million galaxies in this survey - many more than there are pixels in this image. The gray scale is used to indicate the number of galaxies per pixel. Much has been learned about galaxy correlations from this survey, despite the fact that it is only two dimensional (redshifts were not taken). A few years from now, the Sloan Digital Sky Survey will have taken redshift measurements of about a million galaxies. (Maddox et al., Oxford University Astrophysics Dept.)

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The Physics Department's Largest Laboratory

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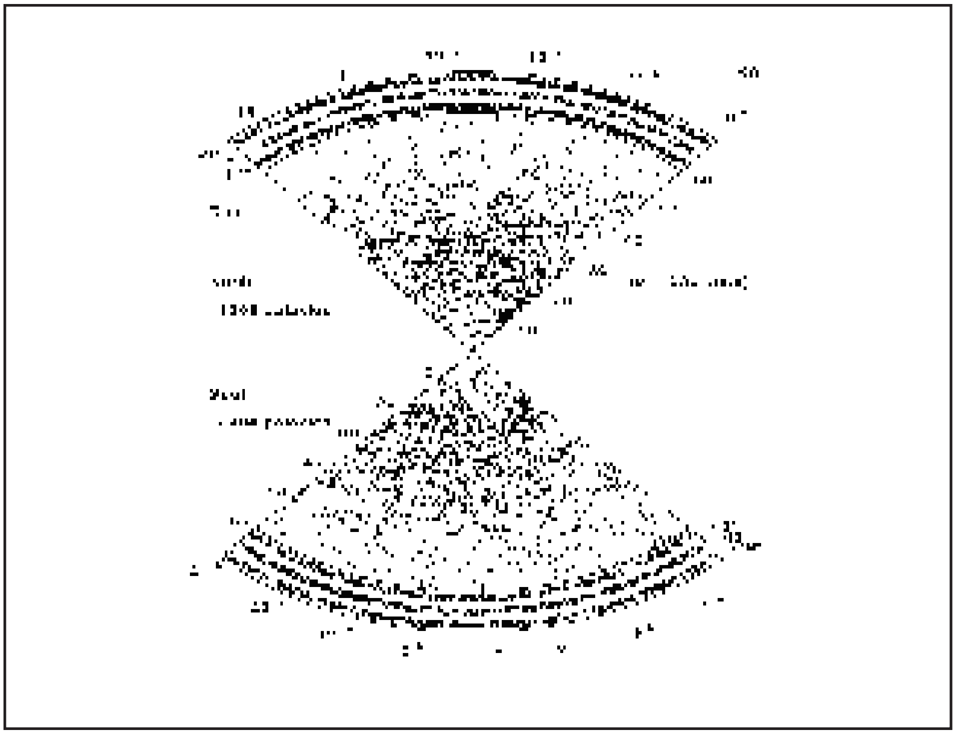

This is a representation of the "Las Campanas" redshift survey, which has measured the redshifts of more than 26,000 galaxies. It is hard to represent this 3D information on the page (we are positioned at the center, and the outer stripes are meant to represent different slices). For more information and a "movie" tour through the data, see <http://manaslu.astro.utoronto.ca/~lin/lcrs.html>.

degrees. Furthermore, numerous smaller patches of the sky have been measured to much higher resolutions. Satellites now being built (NASA's MAP and the European Space Agency's PLANCK, of which I am a member of the Science Team) will measure the microwave sky at a large number of frequencies with a resolution of fractions of a degree. The advent of the COBE data was already revolutionary. There is no question that the new CMB data will completely transform our understanding of the universe.

The example of the CMB and redshift data are but two items on a long and impressive list of new information about the universe which is flowing in at a tremendous rate. Much of the current theoretical work reflects the theorists' natural interest in getting as close as possible to the new data. For example, some of my recent work includes developing new statistics that can be used to extract crucial pieces of information from the new data, as well as studies of how our uncertainties about the last scattering surface will affect our interpretation of the CMB data. There has also been a lot of work identifying the observable signals that will have the most impact on our understanding of the early universe. Recent work of mine has emphasized the significance of certain features in the angular power spectrum of CMB anisotropies. This kind of phenomenological work is the bread and butter of modern cosmology. There is a lot to be done, and it is certain that this kind of work will be rewarded by steady progress as the data continues to flow in.

But ultimately, what will all this concrete, steady progress tell us? Behind fairly straightforward questions like "what was the spectrum of primordial perturbations" lurk more difficult questions, like "how could we possibly claim to have a theory of initial conditions for the universe, which could explain these primordial perturbations?" Perhaps surprisingly, we are not at an utter loss on such questions either. A big part of the reason cosmologists can be so ambitious traces back to the isotropy of the CMB that I mentioned earlier. Because we do not believe we are at some special central location in the universe, the isotropy we observe in the CMB (the temperature looks the same in all directions) is interpreted as homogeneity (the universe was the same temperature at all locations at the time of last scattering). Of course, the homogeneity is not perfect due to the perturbations, which give small spatially varying corrections to the temperature (at the 0.001 percent level). Still, the inferred homogeneity allows us to construct a remarkably simple model of the universe, the standard Big Bang model, in which the universe is an expanding body in nearly perfect local thermal equilibrium for most periods of its history.

Against the backdrop of this simple model, the field of particle cosmology has developed. In an expanding and cooling homogeneous quasi-thermal state (starting with the ultra-hot singularity of the Big Bang) one can use models of the fundamental constituents of matter to generate a detailed description of the matter as it expanded and cooled. The standard analysis of nucleosynthesis gives a good illustration of what is possible: Known laboratory measurements teach us enough about nuclear reactions to know that the nuclei were in chemical equilibrium at sufficiently early stages. As the universe expanded and cooled, one can trace (using computer models of the relevant equations) the ultimate freezing out of particular nuclear species, thus providing a prediction of their primordial abundance. These predictions are broadly confirmed by observations, leading to one of the great successes of cosmology.

But physicists have gone further. At high enough temperatures no experiments have probed the nature of matter directly, but there is a great deal of speculation by high energy physicists as to what the laws of nature could be like in these regimes. Thus, at sufficiently early times, the universe becomes a laboratory in which one can test ideas in high energy physics. One can work out the observable consequences of a given model and check if it is consistent with the observations. One of the great recurring ideas in high energy physics is spontaneous symmetry breaking. It is the only known way of giving fundamental particles a non-zero mass. Almost every instance of spontaneous symmetry breaking in particle physics will result in a cosmological phase transition, as the universe cools from a high temperature symmetric phase to the symmetry-broken phase. Cosmic phase transitions are a source of a wide range of interesting observable consequences. In fact this sub-field made its debut in the form of the famous monopole problem. It was shown that the phase transitions associated with essentially all known grand unified theories produced magnetic monopoles in such quantities that they would be the dominant form of matter today. Since not a single magnetic monopole has been observed to date, all those models were ruled out.

So against the background of a homogeneous expanding universe, the field of parti-

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The Physics Department's Largest Laboratory

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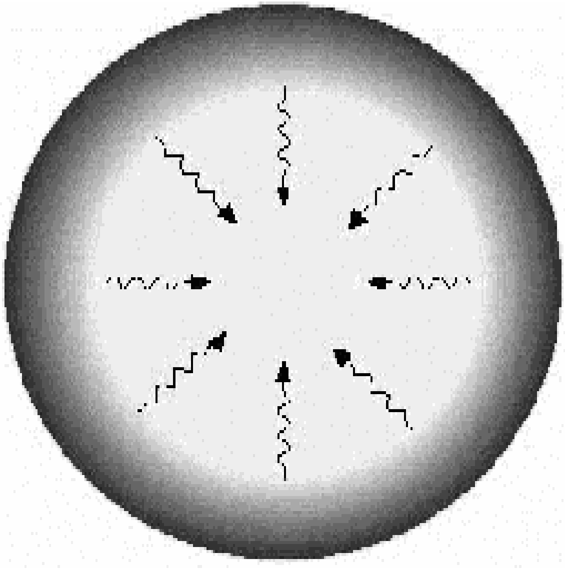
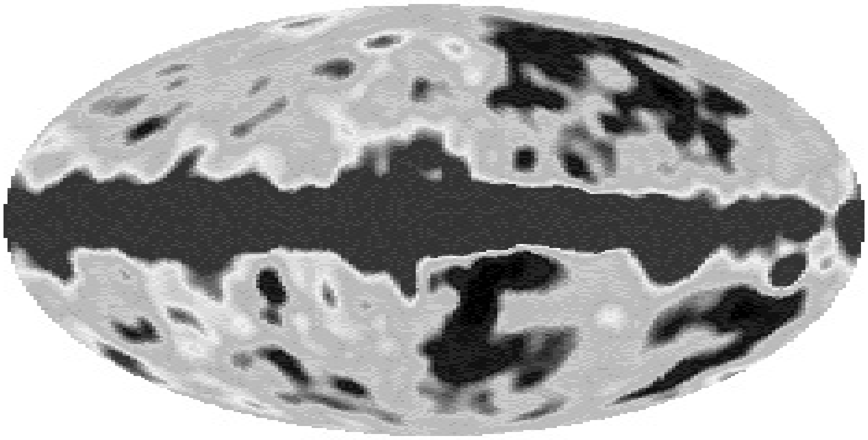
cle cosmology has flourished. It is interesting to note that Newton used his cosmos (the motions of the planets) as a laboratory where sufficiently simple conditions prevailed to test his big ideas. To us the cosmos encompasses much more. But even so it offers us an excellent laboratory in which to test our big ideas. The special relationship with astrophysics is an interesting one: Astrophysics is not particle physics, but it is a necessary tool to do cutting edge particle physics, much like one must understand the physics of particle detectors if one is to interpret a laboratory experiment. One of the links with astrophysics that deserves special mention is the question of the dark matter. It is clear from astrophysical observation that most of the matter in the universe is dark and is thus sufficiently hidden not to be clearly identified. The most popular explanation of the dark matter says that it is weakly interacting frozen out fundamental particles, whose abundances can be calculated in specific models using methods similar to the nucleosynthesis calculations. This provides a particularly profound link between particle physics and astrophysics, since the entire picture of galaxy formation hinges crucially on the nature of the dark matter.

So thanks to the field of particle cosmology, numerous links can be made between current observations and events in the very early universe. Thus, the new cosmological data will teach us not only about astrophysics, but about high energy physics as well. But do these links really help us understand the most fundamental questions? Even if we do think of galaxies as being seeded by topological defects formed in a cosmic phase transition, and having halos of dark matter composed of specific fundamental particles, the nature of the galaxies is also affected by the initial conditions given to the universe before the phase transition. It might seem natural to assume perfect homogeneity, but that is only one possible initial state out of an infinity of possibilities. (It turns out, in fact, that given gravity's natural tendency to clump things, a homogeneous initial state looks like an extremely unreasonable starting point.) Surely our universe simply had one set of initial conditions and there is nothing more one can say about it.

But modern day cosmologists still do not give up! We believe we can even explain the initial conditions of the universe. The basic idea on which we pin our hopes was already present in the discussion of nucleosynthesis. Why did we think we could predict the abundances of the elements, without reference to the initial conditions? The key was the local chemical equilibrium that existed at the



This image illustrates the "last scattering surface." Photons reaching us (shown at the center) today have traveled freely since the universe was opaque, under the hot, high-density conditions of an earlier epoch. (Picture by J. Weller)



Here is the COBE image of the microwave sky (NASA).

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The Physics Department's Largest Laboratory

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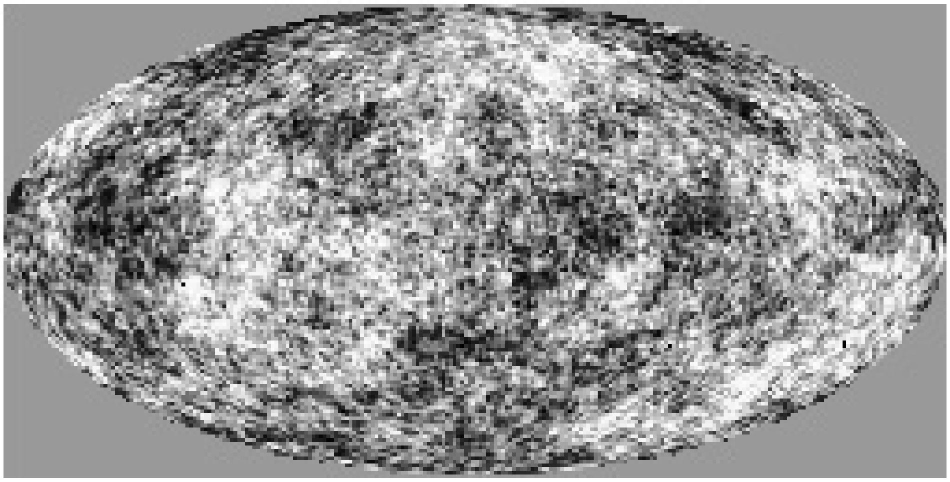
beginning. The process of equilibration wiped out information about any chemical initial conditions from an earlier epoch, and gave a clean predictable starting point for the process of nucleosynthesis. In this picture, the impact of different pre-equilibrium initial conditions is hidden in subtle details of the microscopic motions—things which mean nothing to us.

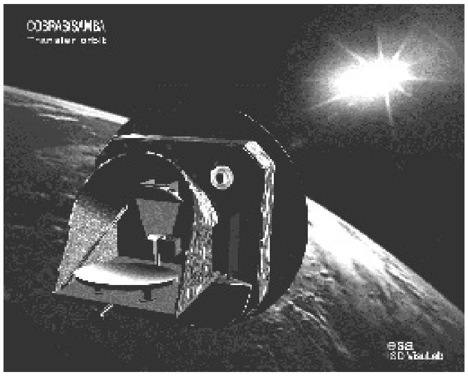
The theory of cosmic inflation implements the same idea to explain the homogeneity of the universe. It can be shown that under the right conditions, a special potential dominated state of matter can be achieved, for which gravity is repulsive. In this state, cosmic expansion would be ultra-rapid, and many different initial conditions would be drawn toward an attractor which is the homogeneous expanding universe of the standard Big Bang. In fact, it turns out that variations on the inflationary theme predict small perturbations, and inflation is actually the account of the origin of these fluctuations favored by most cosmologists. I should mention that the idea of a potential dominated state of matter is also a product of the fundamental role of spontaneous symmetry breaking in particle physics. Not only does modern cosmology help us test models of particle physics, it draws some of its key ideas from particle physics as well.

Inflation is a relatively new arrival, and I certainly feel there are many loose ends to be resolved. For what sorts of pre-inflation initial conditions is the convergence really effective? Can one work out a model in which the probability in the space of all possibilities is really peaked around the universe in which we live? These questions still have not been given satisfactory answers. In fact, in the face of so much promise of concrete progress on other questions at the phenomenological end of the field, these deeper questions look like just so much navel gazing. However, once we have processed all our new data, and hopefully made sense of it, these deeper questions will still demand attention.

I hope I have conveyed some of the scope and excitement of the field of cosmology. I am really looking forward, with Bob Becker and other members of the department, to building an impressive cosmology group here. We will keep you posted of new developments, as our group and the field continues to grow. ❖

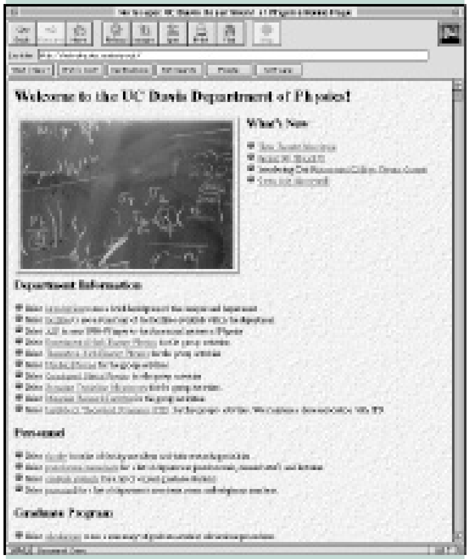


This is a simulation of the microwave sky as it would be seen by PLANCK, given a particular model for the primordial fluctuations. The foreground (e.g., galactic) microwave sources have not been included in this early simulation, but understanding them will be a crucial factor in the ultimate success of the experiment. (Image from the PLANCK Phase A study)



This painting anticipates a view of the PLANCK satellite (yet to be launched) on its way to its final data-taking position, four times farther from the earth than the moon. (PLANCK was formerly called COBRAS/SAMBA)

Physics Home Page



Welcome to the UC Davis Department of Physics!

What's New

Department Information

Personnel

Graduate Program

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

Degrees

Ph.D. Degrees Awarded

June 1998

Paul E. Anderson
"The effects of cobalt and nickel doping on the spin-peierls transition in $CuGeO_3$"
Senior advisory development engineer at Seagate Technology, Bloomington, MN

Lynn Wood
"Transverse flow in 158 AGeV/c Pb+Pb at the CERN SPS"
Postdoctoral researcher at Iowa State University

September 1998

David Feldman
"Computational mechanics of classical spin systems"
Permanent faculty position at the College of the Atlantic, Bar Harbor, ME

Carey Huscroft
"Quantum Monte Carlo simulations of disordered fermi systems"
Postdoctoral researcher at the University of Cincinnati, OH

David Reisman
"Numerical simulation of fiber and wire array z-pinches with Trac-II"
Physicist at Lawrence Livermore National Laboratory, CA

Michael Skolones
"Advances in polarization double modulation far infrared spectroscopy and study of poly (ethylene oxide): sodium iodide complex films"
Software engineer at Schilling Robotics, Davis

Ramon Ynzunza
"Time- and state-resolved spectroscopy, diffraction, and circular dichroism in core photoelectron emission from clean and oxygen covered W(110)"
Postdoctoral researcher at Intel Corporation, Santa Clara, CA

Bachelor's Degrees Awarded

June 1998

Anthony F. De La Cerda	BS
Lisa M. Gerhardt	BS
Jeremy J. Gray	BS
Brian T. Greensmith	BS
Mayra L. Padilla	AB
Trevor R. Price	BS
Hao-Wei Shi (Degree in Applied Physics)	BS
Scott W. Spicer	BS
David D. Stark	BS
Hong D. Trinh (Degree in Applied Physics)	BS
Elizabeth J. Wesely (Degree in Applied Physics) Departmental Citation Saxon-Patten Prize in Physics	BS
Lisa K. Weston	BS

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Student Awards

Ryan Couch Memorial Award

The Ryan Couch Memorial Award, established in memory of the late Ryan Edward Couch (a former physics graduate student at UC Davis), provides support to graduate students in physics selected by physics faculty members through a competitive process.

Recipients are:
Carey Huscroft - awarded to present his paper, "Disorder-Driven Evolution of the Density of States Gap in the Attractive Hubbard Model," at the March 1998 American Physical Society meeting in Los Angeles.

David Feldman - awarded to present his paper, "Statistical Mechanical, Information Theoretic, and Computational Approaches to Pattern," at the March 1998 American Physical Society meeting in Los Angeles.

Thomas Gutierrez - awarded to present his paper, "Leading Charm Hadrons in _____ Interactions," at the April 1998 American Physical Society meeting in Columbus, Ohio.

The following awards were presented at the annual physics department spring picnic, which is held to honor outstanding undergraduate students in physics.

Departmental Citation
Kassandra J. Kisler
Janelle M. Leger
William E. Mickelson
Elizabeth J. Wesely

The Departmental Citation is awarded for excellence in the major program and outstanding GPA in courses given by the department major program.

Saxon-Patten Prize in Physics

William E. Mickelsen
Elizabeth J. Wesely

William and Elizabeth were awarded the Saxon-Patten Prize by vote of the physics faculty. They were selected for their outstanding GPA in the major program and their continued interest in the study of physics. ❖

Introducing...

Andreas J. Albrecht

Professor

Ph.D. - University of Pennsylvania,
Philadelphia, 1983

Research Area: Cosmology

Professor Andreas Albrecht joined the faculty of the UC Davis Department of Physics in July 1998.

How did the universe come into existence? How was the matter we observe around us created, and why does it exist in the state we observe? Has it existed like this forever, or was there some dramatic creation event? These are questions that have excited and perplexed ordinary people and professional philosophers alike ever since records began, and no doubt long before that. But can science possibly have anything to say about these questions, or are they so out of reach that they are destined to be the subjects of endless unresolved debate? It was a keen skepticism about this point that made me very uncomfortable with the field of cosmology when I started graduate school in 1979. Despite my skepticism, I wound up writing my Ph.D. thesis on cosmology, fully expecting that my transgression would be remedied by subsequent work in "pure" particle physics.

Since that time, the field of cosmology has undergone an amazing transformation, and I have come around to the view that to do cosmology in this age is to participate in one of the great scientific events of all time. What has caused this transformation? One of the key driving forces is new technology, which is opening up many new possibilities for gathering data. Today we know the positions of a couple of million galaxies (already many times more than when I started my Ph.D.). In a few years that number will increase by a factor of more than 100. Dedicated satellites are being built that will probe the universe to greater depths than ever before, and thus reveal detailed facts about the universe in areas about which we can only speculate today.

But the new data is only half the story. In the last couple of decades we have also seen dramatic developments on the theoretical side. In particular, a host of specific models have emerged that describe how the universe evolved in the first stages of the Big Bang, and how the galaxies and other structures began to form. It is already clear that these models have numerous characteristic observable signatures that will allow them to be tested by the new data. In fact, a large range of models has already been ruled out. One of the great challenges currently facing the theorists is to make predictions to the level of precision commanded by the observations. This task involves digging deep into the astrophysical issues that affect the observations as well as understanding the high energy physics which is needed to describe the ultra-hot early stages of the Big Bang. There are even links with condensed matter physics, due to the key role that phase transitions are expected to have had in the early universe. Modern technology is contributing crucially to the theoretical side of the effort as well, by providing ultra-fast computers of ever-increasing speed.

Andreas Albrecht, professor

The fundamental challenge for cosmologists of our time is to make the most of the tremendous opportunities that we are faced with. This is an epoch where our understanding of the universe can deepen very rapidly. Are we up to the challenge? Will people look back on this era as one in which we used our precious new data to sow confusion or to reveal great truths about the universe? My personal research goal is to do as much justice as possible to the opportunities that lie before us.

At any given time, my main research focus might be on a very astrophysical problem, aimed at carefully establishing the link between the complex astrophysical objects we observe today (such as galaxies) and the early universe. Or it could be on some fundamental problem in early universe theory, which typically involves deep connections with high energy physics. The diversity of physics that is relevant to modern cosmology certainly adds to the challenge, but ultimately also adds to the sense of adventure as one explores one of the great frontiers of human knowledge.

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Richard Scalettar is the physics department's new vice-chair, graduate program. He replaces Joseph Kiskis in that capacity. We are indebted to Professor Kiskis for his dedicated service to the department for the past 2 1/2 years.

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Congratulations, Barry Klein!

We are pleased to announce that Professor Barry Klein has accepted an appointment to serve as Vice Provost—Academic Personnel for the UC Davis campus. His appointment was effective July 1, 1998. In his new role, Barry is responsible for academic personnel policy and process, grievance procedures, affirmative action, faculty development, and management training for academic leaders and supervisors. He plays a key role in the recruiting and retaining of faculty campuswide. We are honored to have our colleague in this academic leadership position.

Barry is a highly accomplished faculty member, and served with distinction as chair of the Department of Physics at UC Davis since 1992. During his tenure as chair he led a number of exceptionally successful faculty recruitments. That experience, combined with his strong and demonstrated commitment to diversity, will serve UC Davis extremely well during the next several years as the campus recruits for the more than 500 faculty positions to be filled between now and 2005-06.

Barry will remain a faculty member of the physics department. Please join us in wishing him the best in his new campus position.

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Welcome, Graduate Students

The Department of Physics is proud to welcome the following new students to our

Hollie Cooper - UC Davis
Rebecca Duke - California State University, Stanislaus
Dustin Froula - California Polytechnic University, San Luis Obispo
Jeremy Gray - UC Davis
Gerald Hyatt - University of the Pacific
Kyung-hyuk Kim - Seoul National University
Kay Kunes - California State University, Sacramento
Mark O'Toole - California Polytechnic University, San Luis Obispo
Steven Oliver - University of Nevada, Las Vegas
Trevor Price - UC Davis
Carrie J. Prisbrey - Brigham Young University
Hauss Reinbold - Walla Walla College, College Place, WA
Masashi Sato - Education Abroad Program Exchange Student, International Christian University, Tokyo, Japan
Yu Sato - International Christian University, Tokyo, Japan
Constantinos Skordis - Imperial College, London, England
Petros Thomas - Addis Ababa University, Ethiopia and ICTP, Trieste, Italy
Duhong Trinh - UC Davis
Trevor Willey - Utah State University, Logan
Limin Zhao - University of Science and Technology, Academia Sinica, Beijing, China

Physics Club Officers
1998/99

President - Joe Rakow
Vice President -Richard Lozano
Secretary - Ingrid Stoltmann
Treasurer - Daisy Raymondson
Social Director - Amy Tan
Social Director - December Martin

Astronomy Club Officers
1998/99

President - Jason Cosman
Events Coordinator - Roger Littge
Publicity Rep - Daisy Raymondson
ASUCD Rep - Gabe Prochter
Web Master - Ryan Poling

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Newsletter

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

Department Chair: Winston Ko; Department Vice Chair, Undergraduate Program and Administration: Wendell H. Potter; Department Vice Chair, Graduate Program: Richard Scalettar

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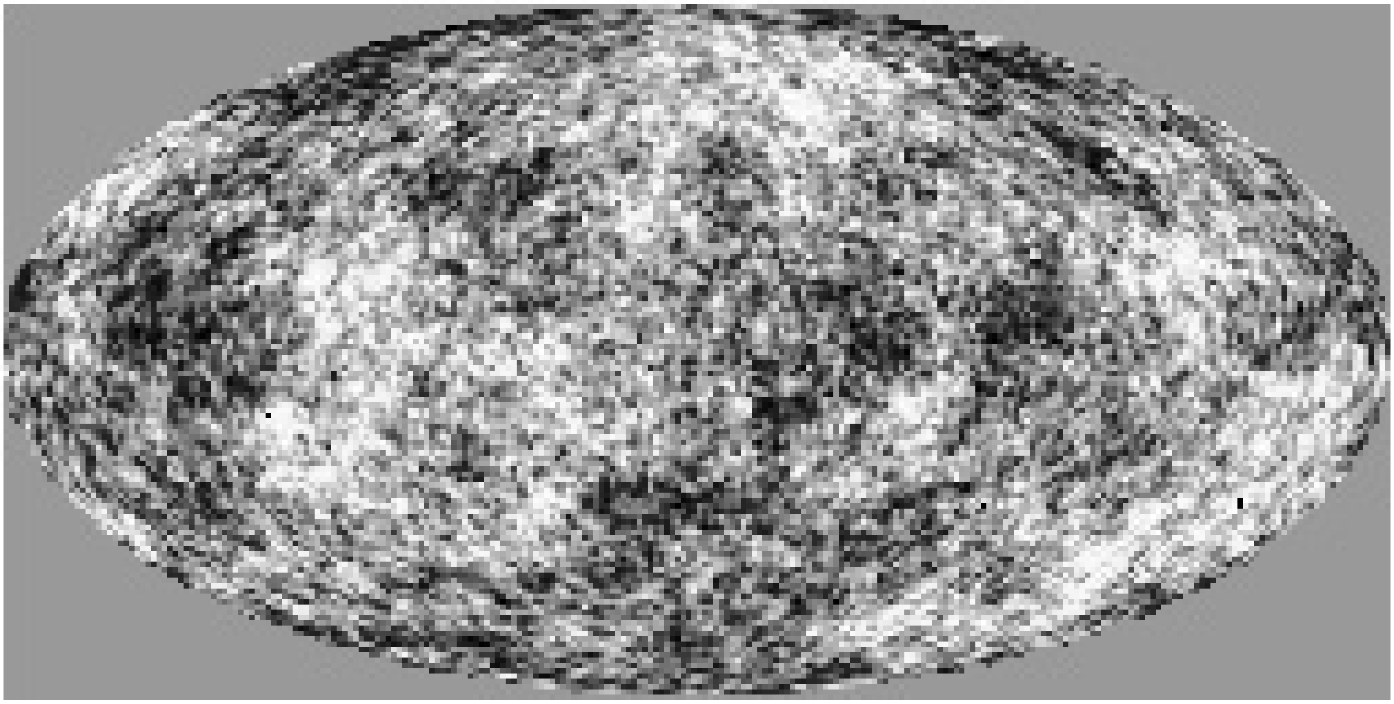
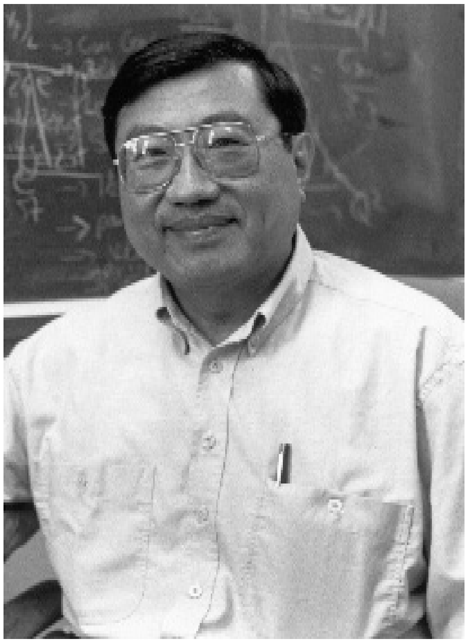
University California, Davis
Davis, CA 95616





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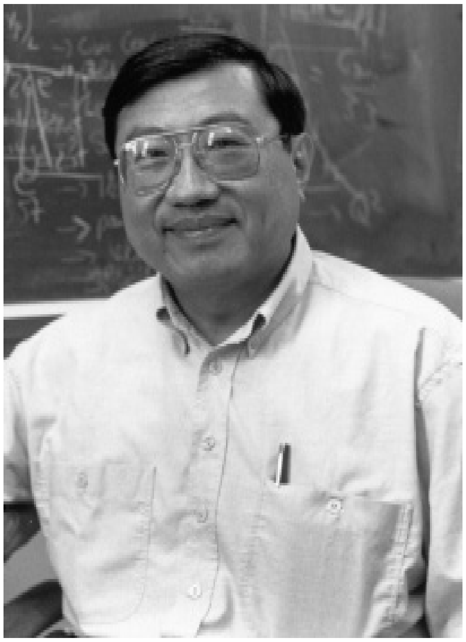

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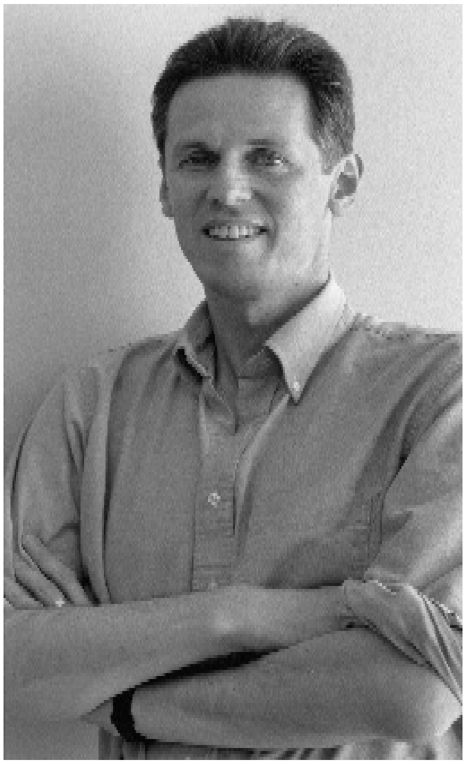

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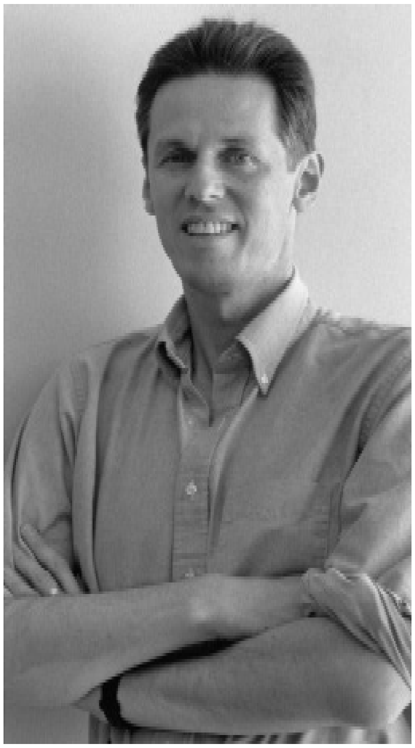

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