stanford university
PHYSICS Newsletter
DEPARTMENT
FEBRUARY 2005

Stanley Wojcicki

February, 2005

A Letter from the Chair

Dear Physics alumni and friends,

Greetings! We anticipate many changes in the coming year, with construction underway for our new Physics and Astrophysics building, and more growth in the Kavli Institute for Particle Astrophysics and Cosmology. We currently have three physics faculty searches underway, in AMO physics and in both theoretical and experimental astrophysics; the latter two positions are joint with SLAC.

Two new faculty have been hired this past year, and both have joint appointments in Physics and SLAC. Tom Abel, a theoretical astrophysicist whose previous position was at Penn State University, began his Stanford appointment as an Associate Professor (untenured) last fall. Tom is one of the leaders in the field of the early structure

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Andrei Linde Receives Cosmology Prize

Andrei Linde was named co-recipient (with Alan Guth of MIT) of the 2004 Cosmology Prize by the Peter Gruber Foundation. This prestigious award was given in recognition of the important contributions of Linde and Guth in developing and refining the theory of cosmic inflation. Both physicists were presented with a gold medal and a $200,000 cash prize at a ceremony held last June at the Smithsonian Institution in Washington, D.C. The Peter Gruber Foundation stated that Linde and Guth were chosen "for their development of fundamental ideas of cosmic inflation, which has been one of the dominant themes of cosmology for more than two decades. The original concept of inflation and its many variations, including chaotic inflation, proposed and developed by Guth and Linde, have led to a revolution in our approach in studying cosmology and to understanding the history of the universe."

Alan Guth and Andrei Linde

Robert Hofstadter Memorial Lectures Planned for May 23 – 24, 2005

Peter L. Galison

We are very excited to announce that the annual Robert Hofstadter Memorial Lectures will be given this year by Peter L. Galison, Mallinckrodt Professor of the History of Science and Physics at Harvard University. Professor Galison was named a MacArthur Foundation Fellow in 1997, and he was the recipient of the Max Planck Prize in 1999. Professor Galison has a wide range of interests, including the intersection of philosophical and historical questions, and the complex interaction between experimentation, instrumentation, and theory. He is an award

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formation in the universe. Steven Allen, an experimental astrophysicist from the University of Cambridge, began his appointment as an Assistant Professor in January, 2005. He has had a major impact on observational cosmology, and his focus is on x-ray astronomy. All of us in Physics and SLAC are very excited about having these two young faculty join our departments, and we look forward to collaborating with them in the years to come.

There have been other exciting changes and opportunities for our faculty this past year. Former Physics Department Chairman and Nobel laureate Steven Chu was named Director of Lawrence Berkeley National Laboratory last summer. All of us in the departments of Physics and Applied Physics were sorry to see him move on, but were also very pleased for him, since he is an outstanding choice for this prestigious position. Chu is on a two year leave from Stanford, where he has been on the Physics and Applied Physics faculty since 1987. He has called his years at Stanford, "among the happiest and most productive of my life."

Another unique opportunity was presented to Physics and Applied Physics Professor Robert Laughlin, who is also on a two year leave, having accepted a temporary position as President of the Korea Advanced Institute of Science and Technology (KAIST) in South Korea last summer. We look forward to hearing about Laughlin's experiences in his leadership position.

Tom Abel

Steven Allen

Within this newsletter you will find articles about the current research by Professor Sarah Church, whose work has taken her and her research group to the South Pole, as well as the research being done by the Kavli group, and an update on the new Physics and Astrophysics building.

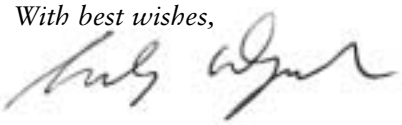
I am very pleased to report some recent prestigious awards received by our Physics faculty. This past year Prof. David Goldhaber-Gordon received a David Packard Fellowship, Stephen Shenker received the Richard Herschel Weiland Professorship, Andrei Linde received the Gruber Foundation Cosmology Prize, and Patricia Burchat was appointed a University fellow in Undergraduate Education.

We look forward to this year's Robert Hofstadter Memorial lectures, which will be given by Peter Galison, Professor of History of Science and of Physics at Harvard University. Prof. Galison's work explores the complex interaction between the three principal subcultures of twentieth century physics — experimentation, instrumentation, and theory. Prof. Galison was named a MacArthur Foundation Fellow in 1997 and received the Max Planck Prize in 1999. He is also the author of several books, the most recent of which is entitled, "Einstein's Clocks, Poincaré's Maps." The Hofstadter lectures will be held at Stanford University on May 23 and 24 in the Hewlett Teaching Center (TCSEQ), Room 201.

An unusually large group of thirty-six students entered our Ph.D. program in 2004. The incoming graduate students include seven women and eighteen foreign students. One of these students has a Stanford Graduate Fellowship. We are happy to welcome these new students to our department.

I want to thank all of you who have made donations to the Physics Department this past year. Your contributions have created many opportunities and events for our students and for the entire physics community. On behalf of everyone in the department, I thank you very much for your continued support and interest.

With best wishes,



Stanley Wojcicki
Chair and Professor of Physics

Looking for the Signature of Inflation in the Cosmic Microwave Background Radiation

A US-UK consortium, led in the U.S. by Sarah Church, has recently deployed a millimeter wavelength telescope (QUaD) to the South Pole to look for the polarization of the Cosmic Microwave Background radiation – the relic radiation from the Big Bang. Recent detailed measurements of spatial variations in the temperature of the Cosmic Microwave Background radiation (CMB) by the WMAP satellite and other experiments have provided strong evidence that the inflationary model, in which the universe underwent very rapid expansion in the first 10^{-32}s of its existence, does indeed correctly describe the earliest moments of the universe. A sufficiently detailed measurement of the polarization of the CMB can be used to distinguish between different inflationary models and to probe our understanding of particle physics at energies that greatly exceed anything that we will ever be able to achieve in ground-based accelerators.

The CMB is a window to the cosmos almost 400,000 years after the Big Bang, representing the epoch at which the universe first became transparent to electromagnetic radiation. At earlier times photons were being continually scattered by the electrons in the ionized plasma, and through this scattering process they became partially polarized. A map of the polarization pattern of the CMB on the sky can be decomposed into components that either have curl or are curl-free, which, by analogy with electric and magnetic fields, are often called *B* and *E*-modes respectively. The *B*-mode component is of particular interest because it can be generated by the primordial gravitational waves that are predicted to be produced by many inflationary models. Moreover, the amplitude of the gravitational wave signature can be used to constrain model parameters. The catch is that the *B*-mode signal is expected to be very weak — at least 20 times smaller than the temperature anisotropies themselves.

The QUaD experiment is designed to measure the extremely tiny signal from *B*-mode polarization. The QUaD focal plane, shown in the photos, comprises a 31-pixel array, operating at 100 and 150 GHz that uses polarization-sensitive detectors made by collaborators at JPL. The QUaD detectors are bolometers which work by measuring the temperature change caused by the absorption of CMB photons in a

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Below: *The 2.6m QUaD telescope installed at the South Pole. The secondary mirror is supported by a foam cone to prevent scattering from metallic feed legs from introducing spurious polarized signals.*

Right: *Graduate student James Hinderks testing the QUaD focal plane in its cryostat at Stanford, prior to its shipment to the Pole in October 2004.*

Top left: *The QUaD focal plane was designed, built and tested at Stanford. The three stages operate at different temperatures and are thermally isolated from one another. The feed horns and detectors operate at 0.25 Kelvin while the lowest stage operates at 4K. Thirty of the thirty one feed horns that collect the radiation from the sky can be seen.*

New Center Probes Nanoscale Material

A new Center for Probing the Nanoscale (CPN) has been established, with $7.5 million in funding from the National Science Foundation. Kathryn Moler, Associate Professor of Applied Physics and Physics, and David Goldhaber-Gordon, Assistant Professor of Physics, are the Co-Directors of the Center. The Center was developed to support science and engineering research at the scale of the nanometer, and will create opportunities for researchers to develop new ways to measure, image and control nanoscale phenomena. The CPN will have offices and a teaching lab in the Geballe Laboratory for Advanced Materials, and will include researchers at Stanford, IBM and other companies. Participants from the Stanford Physics community include Professors Mac Beasley, Aharon Kapitulnik and Hari Manoharan. The research conducted at CPN will aim to develop new tools to enhance nanoscale research. Along with this exciting research, the center will provide a summer institute to train middle-school teachers, with a goal of passing on knowledge, inspiring students and sparking their interest in science.

Goldhaber-Gordon

Kathryn Moler

This image shows the electronic signature of a phantom atom (right peak, top) projected from a real atom (left peak, top) inside a nanostructure (elliptical ring) assembled atom by atom. Stanford Prof. Hari Manoharan reported on this "quantum mirage" in the journal Nature *while he was working at IBM in 2000.*

Progress on the New Physics and Astrophysics Building

We are just now beginning the construction of the new Physics and Astrophysics Building next to our Varian Physics Building. As you can see from the sketch, it is a mirror image of the Moore Laboratory for Advanced Materials, except that it has two full basements, making the total floor space similar to that of Varian Physics. Two thirds of the new floor space will be occupied by relocated programs from north HEPL, and the other one third will house the campus portion of our new Kavli Institute for Particle Astrophysics and Cosmology (KIPAC), our exciting new collaborative venture with SLAC. We have now completed four of nine new joint faculty appointments with SLAC for KIPAC. The University is continuing to solicit a naming donation in the $15M range for the new building, but has approved moving forward with construction since the clearing of the north HEPL site by late 2007 is needed to make room for the new Science Engineering and Medical Center (SEMC). We expect completion of construction for the new building by mid 2006 with occupancy starting in late 2006, and demolition of north HEPL in late 2007.

Stephen Shenker receives the Richard Herschel Weiland Professorship

Richard (Ric) W. Weiland established the Richard Herschel Weiland Professorship in 2002, in recognition of his upcoming thirtieth undergraduate reunion in 2006, and in honor of his late father, for whom the professorship is named. Ric's father, Dick Weiland, worked for Boeing as an aeronautical engineer for forty-six years and was intrigued by fundamental physics.

Ric Weiland obtained his B.S. in electrical engineering from Stanford in 1976. During his senior year, he helped his friends, Paul Allen and Bill Gates, get their new company off the ground. In April 1976, Allen and Gates officially hired him to manage Microsoft's software development and expansion. While at Microsoft, Ric developed the Microsoft Basic Interpreter for Atari and Apple personal computers and managed the completion of the Microsoft COBOL compiler for the IBM PC. In his last two years with the company, Ric was responsible for writing and designing Microsoft Works, which is still widely used.

Steve Shenker

Ric retired from Microsoft in 1988 and is now a private investor. He has supported a wide range of programs at Stanford. In 1999, he endowed the Martha Meier Weiland Professorship in the School of Medicine, in memory of his mother. He has also established a Stanford Graduate Fellowship and is a donor to the Hoover House Circle and The Stanford Fund. Some of his other gifts include unrestricted support for the School of Engineering, the Symbolic Systems Program, the School of Humanities and Sciences for research related to sexual orientation and identity, the Feminist Studies Program, the Medical School for research related to HIV/AIDS, and the Lesbian, Gay, Bi-Sexual, and Transgender (LGBT) Community Resource Center.

Professor Steve Shenker's research centers on string theory, the leading candidate for a unified theory of quantum mechanics, gravity and all other fundamental forces. Among other work, Shenker and his collaborators have given the first precise formulations of this theory in certain simple situations. Currently, he is pursuing the cosmological implications of string theory, focusing on the mysteries of the Big Bang and the singular centers of black holes.

On receiving this Chair, Steve Shenker wrote, "A striking aspect of our discipline is its highly interactive nature. The vast majority of work in the field is done collaboratively… building such a research group requires assembling a critical concentration of people. It is a bit like building a fire — one must pile enough logs together to sustain a flame. In many ways, my work with these groups over the years has been to light and feed these fires. This leads me to my strongest and most lasting impression about the Chair that Ric Weiland has endowed at Stanford in memory of his father. This gift enables the University to help sustain this flame. There is no more valuable gift."

CMB – *from page 3*

substrate cooled to 0.25K. The detectors are made polarization-sensitive by using a metalized silicon-nitride substrate that is etched to look like a wire-grid polarizer. Two detectors mounted orthogonally in a single feed horn allow the polarization state of the incoming radiation to be measured. The QUaD receiver is mounted on a 2.6m Cassegrain telescope that is located in the South Pole. We chose this remote (and cold) location because the atmospheric water vapor content is very low and water is highly absorbing at millimeter wavelengths. Also the 6-month long Polar night makes for extremely stable observing conditions!

The focal plane, shown in the figure, was designed and built in the Stanford Physics department. In May 2004 we received the QUaD cryostat from our UK collaborators and spent the summer installing and testing the focal plane. The testing was successful, allowing the completed receiver to be shipped to the South Pole in late October. Church-lab graduate student James Hinderks and postdoc Ben Rusholme were recently at the Pole testing the receiver and integrating it with the QUaD telescope. We expect to begin science operations soon.

For more information and latest news about QUaD, and information about other CMB experiments that the Church group is involved in, visit our website at **ww.stanford.edu/~schurch**

KIPAC Moves Forward

By Roger Blandford, KIPAC Director

The Kavli Institute for Particle Astrophysics and Cosmology (KIPAC) has made great strides since it the Institute's inauguration in March 2003. Recently, two additions were made to the faculty *(see Letter from the Chair)*. The first is Tom Abel, a computational astrophysicist from Bavaria by way of the Penn State University, who joins KIPAC as a new Associate Professor. The second appointment is Steven Allen, an X-ray astronomer from Cambridge University, who joined us in January as an Assistant Professor.

Andy Rasmussen has joined the Research Staff, and four new postdocs have entered KIPAC: Melanie Bowden from Cardiff, Marusa Bradac from Bonn, Jonathan Granot from Princeton and Weiqun Zhang from UCSC. Martha Siegel joined the administrative staff in September. The integration with the pre-existing campus astrophysics effort has gone extremely well, and Stanford is already over critical mass for a leading astrophysics and cosmology group.

The campus component of KIPAC has premises in the splendidly refurbished third floor of the Varian building, which KIPAC shares with the Stanford Institute for Theoretical Physics (ITP). There was an official ground-breaking for the Fred Kavli Building at SLAC in late June and construction is underway. Projected occupancy for the new building is November 2005. Progress can be reviewed at **http://www-group.slac.stanford.edu/kipac/kicam.jpg**. Meanwhile, plans are going forward for a new Physics building, located next door to Varian *(see article on page 4)*, which KIPAC will share with HEPL.

Over the past year, KIPAC has hosted or co-hosted several important meetings and workshops, including Space Part 03 in Washington DC, an X-ray polarimetry workshop held at SLAC in February, and a conference devoted to NASA's "Beyond Einstein" program hosted at SLAC in May. The 22nd Texas Symposiumn on Relativistic Astrophysics was also held on Stanford's campus this past December *(see adjacent article)*.

Highlights of Kavli research over the past year have included several research papers directed at understanding dark matter and dark energy and measuring the size and shape of the universe. Gravitational lenses and clusters of galaxies are favorite tools for carrying out these studies. In the world of high energy astrophysics, local interests have included the newly discovered double pulsar, which promises to aid work in general relativity, nuclear physics, relativistic plasma physics, and accreting neutron stars and gamma ray bursts. Experimentally, a large effort has been made to design a camera for the Large Synoptic Survey Telescope (LSST). KIPAC is also participating — in collaboration with our colleagues at the Lawrence Berkeley Laboratory — in the proposed SuperNova Acceleration Probe (SNAP).

Please feel free to stop by, either at SLAC or on campus, or to join us for Friday morning coffee (10:30 am, SLAC) or Tuesday afternoon teas (4:00 pm, campus). We look forward to meeting you.

The 22nd Texas Symposium on Relativistic Astrophysics

The 22nd Texas Symposium on Relativistic Astrophysics was held at Stanford University on December 13-17, 2004. The symposium was jointly organized by the Kavli Institute for Particle Astrophysics and Cosmology (KIPAC), the Stanford Linear Accelerator Center (SLAC), and the Physics Department. Over 400 distinguished scientists attended this event, featuring talks emphasizing recent developments in Cosmology, High Energy Astrophysics, and the frontiers between these and Gravitation and Particle Physics. The symposium also featured poster sessions, as well as a special evening lecture by Stanford Physics Professor Andrei Linde entitled, "The Origin and Fate of the Universe".

Honors Program in Physics

Each year, about a dozen physics majors (roughly half the graduating class) complete an Honors Thesis. Their research topics range from experimental questions, such as the development of state-of-the-art instrumentation for the detection of "gravity waves" or the cosmic microwave background radiation, to more theoretical questions, such as signatures of violation of fundamental symmetries of nature like Lorentz invariance.

Many of these students began the work that is the basis of their Honors Thesis while participating in Stanford's Summer Research College (SRC). The time spent with a research group during SRC allows students to learn the experimental or theoretical techniques critical to a particular discipline. For example, the detection of gravity waves is based on the interference of laser beams to measure distances as small as a millionth of a millionth of a meter! The detection of cosmic microwave background radiation is based on very sensitive detectors of infrared radiation, called "bolometers." Honors projects may require skills in laser physics, cryogenic techniques, computer programming or electronics. Summer Research College provides the concentrated time needed to learn the skills to contribute in these areas that are in the forefront of physics.

Students doing Honors Theses in physics usually join a research group, where they often discover that mentoring is provided by not only the Faculty member leading the group, but also by the graduate students and post-doctoral research associates (postdocs). The grad students and postdocs not only provide daily mentoring and advice, they also serve as valuable role models who can help undergraduates decide whether graduate school may be appropriate for them.

Although much of the Honors research in physics is done on campus in the Varian Physics Building or nearby Applied Physics and Engineering buildings, Honors research can take students off-site to nearby locations, including the Stanford Linear Accelerator Center just a few miles away, or to sites further afield, such as the telescopes in Hawaii! Students also work with faculty in other departments, such as Biological Sciences, or with physicists at other institutions, such as NASA-Ames.

In addition to the experimental techniques and physics concepts students learn through their Honors thesis, they also learn time management and scientific writing skills. Unlike normal coursework, which is structured around assignments like readings, papers, and problem sets, Honors research requires students to be self-motivated and to do a significant amount of planning, with the guidance of their research advisor. The Honors Thesis normally represents the largest writing project a student will tackle as an undergraduate.

An Honors thesis in Physics is a journey that starts with identifying and joining a research team and finding a specific project. Over the course of the project, intellectual relationships (and often friendships) are established with the members of the team. The end result is a professional research document describing a significant personal achievement.

Adam Sciambi with the apparatus he built to demonstrate the quantization of conductance, shown in the trace on the oscilloscope. Adam is doing honors research in Professor Hari Manoharan's Nanoscale Physics Laboratory.

Tess Williams working on the SuZIE (Sunyaev Zel'dovich Infrared Experiment) receiver, which will be used at a telescope in Mauna Kea to detect cosmic microwave photons and study the effects of the scattering of these photons in galaxy clusters. Tess works with Professor Sarah Church.

Katherine Luna with an apparatus that uses superconducting cavities to test for tiny anisotropies in space-time. For her honors thesis, Katherine is working on calculations related to these tests, with Professor John Lipa.

Memorial lectures – from page 1

winning author whose most recent book is entitled "Einstein's Clocks, Poincaré's Maps." The Hofstadter lectures have been scheduled for Monday, May 23, 2005 (an evening public lecture at 8:00 pm) and Tuesday, May 24 (an afternoon colloquium at 4:15 pm). Both lectures will be held at Stanford University, and we hope that you will save these dates on your calendars.

Both lectures will be held on campus in the William Hewlett Teaching Facility on Serra Street (TCSEQ, Room 201). If you have questions, please contact us by telephone: (650) 723-4347, fax: (650) 723-1821 or email: tice@stanford.edu. We hope you'll plan to join us for these exciting talks.

EVENING PUBLIC LECTURE

8:00 pm – Monday, May 23, 2005

THE ASSASSIN OF RELATIVITY

In his younger years — from the time they were students together at the Zurich Polytechnic — Albert Einstein was good friends with Friedrich Adler. Adler, son of the cultured leader of the Socialist Party in Vienna, was, like Einstein, a physicist very much engaged with both epistemology and politics. They shared a fascination for Ernst Mach — they even lived in the same building where their young children played together. Adler wrote his father that he and Einstein had "parallel lives." Then, in the midst of World War I, on 21 October 1916, Adler assassinated the Prime Minister of the Austro-Hungarian Empire. Einstein rallied to his defense and, between death row and Berlin, Adler and Einstein began an extraordinary correspondence about the meaning and validity of relativity. This paper is an exploration of the heady mix of psychoanalysis, politics, physics and philosophy that followed — as the world stumbled ever deeper into war.

AFTERNOON COLLOQUIUM

4:15 pm – Tuesday, May 24, 2005

PHYSICS: HISTORY OF THE PRESENT

This talk will focus on the historical motion that I see that is moving physics towards the boundaries with other fields through joint work with computation (simulations), mathematics (around string theory), and engineering/chemistry/biology (around nano-sciences).

2004 STUDENT AWARDS

A number of student awards were announced at our Physics/Applied Physics Commencement ceremony last June. **Robert McConnell** received the **David Levine Award,** presented to the outstanding Junior physics major. **Evan Kirby** received the **Jeffrey Willick Memorial Award,** given to the outstanding physics student in the field of astronomy. The **Paul Kirkpatrick Award,** given to outstanding physics teaching assistants, was given to **Jason Hogan** and **Ben Freivogel.**

Alex Saltman, Dylan Zwick and **Steve Healey** were Centennial Teaching Award recipients. The **Firestone Award** for excellence in Undergraduate Research was presented to **Matthew McQuinn.**

Finally, Physics senior **Erik J. Lessac-Chenen** received the **Urmy-Hardy Poetry Prize,** awarded annually by the Creative Writing Program for the best work of poetry written by an undergraduate. Erik participated in a campus-wide competition and was recognized for his poem "Incantation," illustrating once again that art and science are not mutually exclusive.

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