

Physics at Brown

News for Alumni and Friends

2006 Issue

Welcome to another issue of the Brown Physics Newsletter. Much has happened during the past year. Under the leadership of President Ruth Simmons and Provost Robert Zimmer, Brown has entered a new phase in the implementation of its *Plan for Academic Enrichment* (<http://www.brown.edu/web/pae/>), with an official kick-off last November of a capital campaign. Physics is participating actively in the Plan for Academic Enrichment by working with Chemistry and Engineering on an expansion into the area of NanoScience and Soft Matter.

2005 was designated as *the Year of Physics* in celebration of the centennial of *Einstein's Miraculous year of 1905*. Like most other physics institutions, we engaged in a yearlong sequence of public lectures. Our own Nobel Laureate Professor Leon Cooper delivered the first lecture. President Simmons and Provost Zimmer inaugurated this wonderful series of public lectures.



Chung-I Tan

In this issue we highlight our growing biophysics program. In particular, we focus on the accomplishments of Professor Jay Tang, who came to Brown in 2002, having previously served as an Assistant Professor at Indiana University. Jay is our first biophysicist, who has developed new interdisciplinary courses on biological physics for advanced undergraduates, as well as for graduate students.

We continue to highlight the research of our recent Galkin Foundation Fellow, Sootaek Lee, who did his thesis work with Professor Brad Marston. The Physics Department has also been supporting the effort of the Dean of the College in offering freshman seminar courses. One such course, “Beautiful Theories of Physics”, taught by Professor Jevicki, was highlighted in the last issue. We have followed up this year with two new seminar courses, one by Professor Cutts, “Inner space/outer space—exploring the frontiers of physics”. The other is taught by Professor Leon Cooper, “Images from Science, Images for Science”. The course is co-taught with Professor Richard Fishman of the Visual Art Department.

Even in this my second year as the Physics Chair, what I wrote a year ago seems just as apropos: “Much has been accomplished in recent years, but much remains to be done. With a dedicated staff, committed faculty, enthusiastic students, supportive administration, and engaged alumni and friends, the future looks bright.” In this issue we highlight some of the events that have taken place during 2005.

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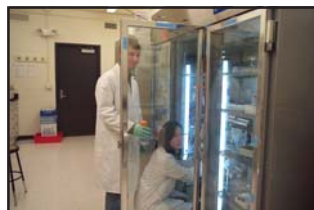
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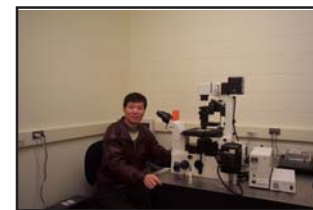
BROWN

Biological Physics Blossoms at Brown

The physics of biological self assembly, DNA sequencing, protein folding, and cell motility are just a few of the new topics now routinely addressed in Barus and Holley. Their prevalence reflects the strength of a growing major research area in the department. Arguably, the nucleation of biological physics coincided with the arrival of biophysicist, Professor Jay Tang less than five years ago. His research on biological self assembly, microorganism motility and biomolecular motors immediately attracted students. It also complemented Professor Jim Valles' ongoing investigation of dividing and swimming cell systems using magnetic fields.



Jorge Viamontes and Hyeran Kang

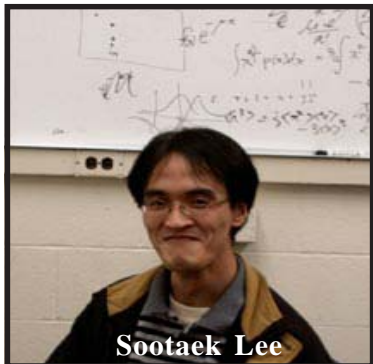


Jay Tang

The new cadre included Professor Sean Ling who entered into the single molecule biophysics arena after a very successful sabbatical that led to development of new nanopore devices for biomolecules. Starting with the Tang

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Galkin Fellow - Sootaek Lee



Sootaek Lee, a 2004 – 2005 Galkin Foundation Fellow, carried out his Ph.D. dissertation research on fundamental questions in the theory of strongly correlated electrons. One of the most amazing phenomena in the natural world is the ability of electrons to move through certain materials without any resistance. This superconductivity was first noticed almost a century ago by Heike Kammerlingh Onnes in 1911. Certain metals, such as lead, when cooled down to temperatures close to absolute zero become perfect conductors. In 1957, John Bardeen, Leon Cooper and Robert Schrieffer discovered a very successful microscopic model that explains superconductivity, a model now widely known as BCS theory. According to the BCS theory, superconductivity occurs due to the instability of the Fermion liquid of electrons to attractive interactions mediated between electrons by phonons. Electrons join up in pairs known as “Cooper” pairs. The quantitative success of the BCS theory in describing low temperature superconductors made it one of the most successful theories ever proposed.

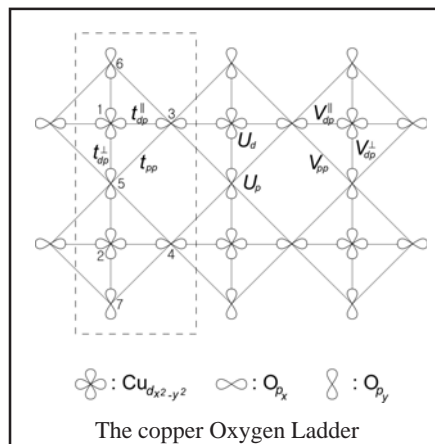
In 1986, however, Georg Bednorz and Alex Mueller discovered a new class of superconducting materials: Layered ceramic copper oxide compounds that have a much higher transition temperature to superconductivity – so much so that these materials are called “high temperature superconductors.” This Nobel-prize winning discovery sparked enormous experimental and theoretical research effort. The discovery is technologically significant because now much cheaper liquid nitrogen can be used instead of liquid helium as the coolant. Two decades since the discovery, the transition temperature reached about 160 degrees above absolute zero in mercury-based copper oxide compounds.

However high temperature superconductivity came as a great surprise to theorists since according to conventional BCS theory the transition temperature cannot exceed about 30 degrees above absolute zero. The superconductivity was even more mysterious as typically ceramic compounds are insulators. Even at temperatures above the superconducting critical temperature, in the so-called “normal state,” the

materials exhibit strange characteristics. In particular the “pseudogap” and “strange metal” phases cannot be described by conventional Landau Fermi liquid theory that works so well for ordinary metals. During the past decade much effort has been devoted to finding an explanation for mechanism of high temperature superconductivity and the mysterious pseudogap phenomenon.

A “quantum phase transition” between competing forms of order is a possible explanation for the pseudogap physics. Several different orders that might compete with superconductivity have been proposed.

Sootaek Lee’s thesis focuses in part on a study of a simplified model of the ceramic cuprates, one in which the full two-dimensional lattice of copper and oxygen atoms is replaced by a “ladder” consisting of two chains of alternating copper and oxygen atoms. Such a simplified model is able to support superconductivity and other forms of order, yet at the same time is amenable to solution by powerful theoretical techniques that only work for systems that extend in one spatial dimension, such as a ladder. With assistance from Dr. John Fjærestad and his advisor, Prof. Brad Marston, Sootaek showed that a circulating-current phase proposed previously by other theorists does not arise, at least when interactions between the electrons are weak. Instead the part of the phase diagram relevant for cuprate high-temperature superconductivity is dominated by d-wave superconducting tendencies or a dimerized phase. This work, the first of its kind, was published last year in *Physical Review*.



The Galkin Foundation Fellowships are funded through a generous donation by Mr. Warren Galkin, Class of 1951. Each year the Fellowship recognizes exceptional promise and achievement in physics by a senior graduate student.

Professor Kyungsik Kang

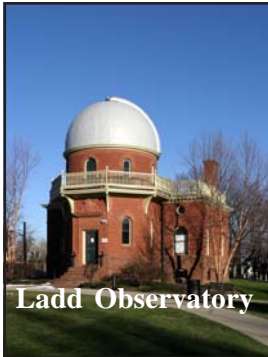
Prof. Kyungsik Kang, who first joined our Department in September of 1964, has chosen to take his retirement as of 1 July 2005. In his Brown career of 41 years of teaching and research (in High Energy Particle Theory), Prof. Kang wrote scores of well-received research papers, while supervising the doctoral theses of a large number of graduate students. He is a Fellow of American Physical Society, Division of Particles and Fields. During his career at Brown, he performed numerous academic duties, including several stints as Administrator of the High-Energy Theory Group. His ongoing efforts in arranging scientific interchanges between colleagues at Brown and in Seoul, as well as joint US-Korean Conferences, and in arranging to bring selected Korean students to Brown for their doctoral studies, have been strikingly successful.

Prof. Kang now enters the delightful period of Emeritus research, free from the ordinary pressures of teaching and administrative duties. His ex-graduate students, and colleagues from Brown and elsewhere, are now in the process of arranging a celebratory Workshop on "Perspectives of Particle Physics", to be held on July 6-7, 2006, at Brown in his honor.



Kyungsik Kang

The Physics Department is currently engaged in a faculty search in High Energy Theory, in conjunction with Prof. Kang's retirement and the departure of Prof. R. Brandenberger. The search Committee is chaired by Prof. A. Jevicki with G. Guralnik, G. Landsberg, D. Lowe, C-I Tan and G. Xiao as members.



Ladd Observatory

Ladd Observatory

The skies over Ladd Observatory were clear and cold, but our visitors- more than 100 of them- were able to stay warm inside. They viewed the moon on a monitor, with a feed from a CCD connected to a telescope on the roof. We pointed the telescope using remote control software, also on the computer downstairs. At the same time we heard from a member of Carle Pieter's planetary science research group, Noah Petro, about the origin of the craters we had just seen. Before, during, and after the talk people lined the stairway to the observing room, where they could directly glimpse the Moon's thousands of craters at high resolution, through Ladd's historic 12" refractor, completing their informal lesson in lunar science.

This was just one of many exciting evenings at the Observatory. We have renewed our speaker program, attended to a variety of physical plant problems, and created a centerpiece of science education for the community. The variety of visitors on any given night is extraordinary- school children, kids from the neighborhood, Brown faculty, students, and staff, and people from all walks of life and from all over Southeast New England. Every month you'll see a fire truck or two parked outside of Ladd- and a crew of firefighters and local police officers lined up to view the rings of Saturn, the Moon, or a binary star.

We kicked off our speaker program in the Fall, with Hendrik Gerritsen, a former Director of Ladd, talking to us about the history of constellations. Recently Bob Horton gave an impromptu lecture during which he showed some of the extraordinary astronomical photographs that he took from dark sky sites out in the Mojave Desert. People crowd the entry-way to the library to catch every word of the lectures, and the excitement and curiosity are infectious. For their part, guest speakers enjoy the wide variety of questions, many of them surprisingly different (and often more challenging) than the questions they get back on campus.

Mike Umbricht, formerly the Director of the Roger Williams Park Planetarium, is hard at work researching and preserving old scientific instruments. Dave Huestis and Craig Cortis, two experienced amateur astronomers, help us by pointing our telescopes at the variety of interesting objects visible on any given clear night, and by explaining the nature of these objects to visitors.

Last but not least, Francine Jackson writes a very enjoyable and interesting column for our Listserv every week. <http://listserv.brown.edu/archives/laddobservatory.html> Francine has served as staff astronomer at a number of observatories and planetaria, including New York's Hayden Planetarium.

Ladd's renewal activities can be credited to the hard work of the members of the Physics Department, using funds provided to us by the Office of the President and by an anonymous donor.

2005 PhD Recipients

CAGRI AYDIN

“Silicon Based Tunneling Devices Combined with Silicon-on-insulator for Ultra-large-scale Integration”

GHAZAL GESHNIZJANI

“Back Reaction of Long Wavelength Perturbations During Inflation”

AMBARISH GHOSH

“Experiments with Electron Bubbles in Liquid Helium”

KEVIN GOLDSTEIN

“De Sitter space, interacting quantum field theory and alpha vacua”

STILIANOS KESISOGLOU

“Search for Gauge Mediated Supersymmetry Breaking in the $\tilde{a}\tilde{E}_T$ Channel”



DENIS KONSTANTINOV

“Experiments with Bubbles Containing Electrons in Excited States in Liquid Helium”

ZHENYI LONG

“Studies of Two Dimensional Superconductor-Normal Metal Hybrid Thin Films”

DMITRI PETROV

“Novel Approaches to Numerical Solutions of Quantum Field Theories”

HAIQING XIANYU

“Variable Wavelength Selection Devices: Physics and Applications”

LUK CHONG YEUNG

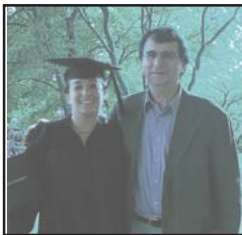
“A Mechanics Model of Calcium-dependent Synaptic Plasticity”

QIANG ZHANG

“Ultrafast Spin Dynamics in Half-metallic Ferromagnetic Thin Films”



2005 Senior Honors Recipients



MATTHEW CARRIUOLO, “The Lorenz Attractor, Chaos, and Fluid Flow” Advisor: Prof. Marston

ALEXIS CROW, “Near-Surface Diffusion of SNA Molecules” Advisor: Prof. Breuer

SUSANNA FINN, “Analyzing Simulations for the Balloon-borne Large Aperture Sub-millimeter Telescope” Advisor: Prof. Tucker

DEMETRIOS HARRINGTON, “Construction and Calibration of Laser Tweezers Apparatus Using a Fast Camera” Advisor Prof. Tang



ROHIT HEGDE, “A Tully-Fisher relation for the Great Wall of Galaxies” Advisor: Prof. Dell’Antonio

YONG WOOK KIM, “Large Deviations and Importance Sampling in Rare Events Monte Carlo Theory” Advisor: Prof. Dupuis

CHRISTOPHER MENDILLO, “Seeing Correction and Deblending in the Deep Lens Survey” Advisor: Prof. Dell’Antonio

ROBERT E. MORRIS, “Cosmic Strings as Remnants of Symmetry Breaking” Advisor: Prof. Guralnik

NIRAVUN PAVENAYOTIN, “Thin Metal Films on Nanopore Arrays” Advisor: Prof. Valles



WILLIAM RICE, “High frequency sound propagation in water” Advisor: Prof. Maris

NICHOLAS BENJAMIN SCHADE, “Glavanotaxis vs. Magnetotaxis in Paramecium” Advisor: Prof. Valles

DANIEL SILVERMAN, “Study of Liquid Xenon Detector for WIMP Dark Matter” Advisor: Prof. Gaitskell

SUSAN TOLWINSKI, “Quantum Gravity via Matrix Models and Bubbling AdS Spaces” Advisor: Prof. Jevicki



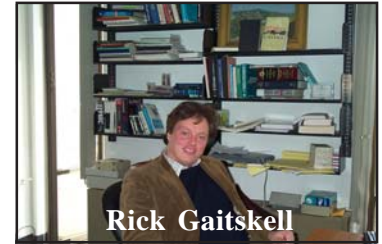
Robert P. Sanchez ‘58, Trustee Emeritus, Awarded Diplomas

Richard Gaitskell Promoted to Associate Professor of Physics Effective July 2005

Richard received his B.A. in Physics from Oxford University in 1985 and his Ph.D., also from Oxford University, in 1993. Prior to coming to Brown in September of 2001, he was a Fellow of the UC-Berkeley Center of Particle/Astrophysics and was also a Senior Lecturer at the Univ. of London. His current research is in an emerging field of experimental astro/particle physics. The basic goal is to understand the origin and evolution of the universe, with current emphasis on searching for the invisible “missing dark energy/mass”. He is a national/international leader in the search for the Cold Dark Matter, and has written a highly cited review on

“Direct Detection of Dark matter”, *Ann. Rev. Nucl. and Part. Sci.* 54 (2004). He is currently engaged in a new effort of using liquid xenon technique for dark matter detection.

During the past several years, Professor Gaitskell has also taught a highly successful course on “Special Relativity and Quantum mechanics” to our first-year students.



Visitors

Jeff Murugan

Originally from Durban on the east coast of South Africa, Jeff moved to Cape Town where he completed his undergraduate studies at the University of Cape Town. He completed a Masters degree and moved to the Mathematical Institute of Oxford University to undertake a PhD jointly with Professors Philip Candelas at Oxford and George Ellis at the University of Cape Town. His Phd, completed in 2004, was an eclectic collection of results in string theory and cosmology.

Jeff is working on issues of the gauge theory/gravity correspondence with Professors Antal Jevicki and David Lowe.

Jeff says “Even though I am set to leave Brown at the end of this year, I am certain that the ties that hold me to this fantastic place will hold for years to come.”

Robert de Mello Koch

Robert de Mello Koch is a member of the Center for Theoretical Physics, at the University of the Witwatersand in Johannesburg South Africa. He is currently visiting the High Energy Theory Group, during his sabbatical year. His research interests include string theory, QCD and matrix models. He is also a lecturer at the African Institute for Mathematical Sciences (AIMS) and a member of the Stellenbosch Institute for Advanced Studies (STIAS).

Wayne Ford

In 2004 Wayne returned to Brown after having left with his Ph.D. in 1980. Frank Levin and Stavros Fallieros were his friends and mentors; today, Humphrey Maris and his team in the picosecond ultrasonics lab serve that role. His passion today is the physics of nanostructures. Between 1980 and today, he studied the electronic and atomic structure of material surfaces for 10 years at the Xerox Webster Research Labs, the University of Pennsylvania, and Montana State University in Bozeman, Montana as a physics professor. Wayne then spent 13 years at the Intel Logic Technology Development labs in Hillsboro, Oregon where he served in various leadership roles. Those labs solved the important material, metrology, and processing problems and introduced key fab and analytical lab instrumentation that ultimately led to breaking the 90 nm ULSI technology node. Wayne says of Brown “Now, due to the generosity of my host, I’ve been able to ‘re-charge’ and see many of the fascinating new things developing in Brown’s research community and ‘re-learn’ many of the things I’ve forgotten along the way. And, equally engaging and satisfying, I’ve been able to connect to the Brown undergraduate community by team teaching the introductory physics courses.”

Physics at Brown

Physics Dept. Chair*Chung-I Tan***Contributors:***Dave Cutts**Jim Valles**Brad Marston**Dave Targan***Co-editors:***Dave Cutts**Chung-I Tan***Layout Editor:***Beverly Travers**Jane Martin*

Address: Physics at Brown, Box 1843, Physics Department
Brown University, Providence RI, 02912

Phone: (401) 863-2644 **Fax:** (401) 863-2024

email: newsletter@physics.brown.edu

We welcome your comments and contributions!

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lab's work on biological materials, which are considered "soft" these research efforts position the physics department well to contribute to a recent, major university initiative to create a Center for NanoScience and Soft Materials. The CNSSM will facilitate interdepartmental collaboration development and idea exchange to fuel research in these inherently cross-disciplinary fields.

Two new biological physics courses bring our students up to speed in biological physics. Professor Jay Tang started *Biological Physics (PH0161)*, a course that has provided about 15 advanced undergraduates and graduate students with the background training necessary to address biophysics problems each of the last three years. The second offering, *Selected Topics in Molecular Biophysics*, was collaboratively developed by physicists and biologists. Professors Jay Tang and Jim Valles, Jr. of Physics, Dale Mierke of Molecular Pharmacology,

Physiology & Biotechnology, and Joanne Yeh of Molecular and Cellular Biology created a course in which students learn the theory and applications of selected molecular biophysics techniques from the faculty that use them. Its first year was extremely successful, attracting about 30 students.

Faculty and students alike learn about the very latest developments in the literature through biophysics seminars in the series, *Frontiers in the Interaction Between Physics and Biology* co-organized by Professors Cooper, Ling, Tang, Valles and Powers (engineering) and the weekly biophysics journal club. Students, faculty and postdocs present recent articles at the forefront of biophysics. Altogether, these activities cultivate the blossoming of biological physics in the physics and engineering building which was planted with Jay Tang's arrival.

CNSSM Initiative

The Departments of Chemistry and Physics and the Division of Engineering have proposed the formation of a cross-disciplinary **Center for Nano-Science and Soft-Matter (CNSSM)**. The goal is to promote frontier research on nanoscience, particularly in the area of "soft materials" and their properties at the nano-meter scale. The electronic devices that pervade our lives are the products of the concerted efforts of chemists, engineers, and physicists working in the area of materials science. The next major advances in materials science that will have the greatest impact are likely to come in the area of soft materials or soft matter when probed and constructed at the nanometer scale. The study of these materials, which include biological matter, offers new opportunities for fundamental science and promises to lead to new applications and devices important to medicine and electronics. The CNSSM will foster the development of the collaborations and intellectual exchanges between the faculty in chemistry, engineering, physics, and biology which are essential for making rapid and prominent progress.

A proposal for creating a CNSSM was submitted on November 22, 2004, to the Academic Priority Committee (APC) from the Department of Chemistry, the Department of Physics and the Division of Engineering. We received APC endorsement in Sept. 2005. The proposal envisages completing the establishment of the center in two phases: In Phase I, the main goal is the creation of a cadre of research groups performing cross-disciplinary collaboration in soft materials research. The core of center faculty will be established through strategic hires. In Phase II possible additional complementary faculty hires in each of the participating departments will be made. A new facility to provide the necessary research and office space, as well as a central location for the interdisciplinary efforts in this area, will also be established.

Brown has a distinguished history in materials research that includes several academic units. The establishment of a CNSSM will solidify Brown's position in this emerging frontier of science. The Physics Department is currently engaged in a faculty search in conjunction with this CNSSM Initiative. The search committee is headed by Prof. H. Maris, with S. Ling, B. Pelcovits, J. Tang, J. Valles, and G. Xiao as members from Physics. Prof. J. Xu of Engineering and Prof. S. Sun of Chemistry also serve on this search committee.



President's and Provost's Remarks at the Opening of the Brown Physics Department Einstein Lecture series to celebrate the 100th anniversary of Albert Einstein's Miraculous year of 1905.

President Simmons's opened her remarks with "Martha Mitchell's one-volume *Encyclopedia Brunonia* makes the point that physics has been part of the Brown curriculum since the University's earliest days. Known as 'natural philosophy' in the 18th century." She was pleased for a number of reasons to be able to introduce Leon Cooper, Professor Laureate of Physics at Brown University. Foremost was his gift of exciting people about physics. She stated that "physics in general is not without its connections to popular culture and public understanding. Yet an increasing fraction of current concepts from physics – whether the interactions of subatomic particles or the behavior of galaxies – is beyond the reach of the general public." She continued by saying, "The World Year of Physics Web site prominently and rather bluntly says, 'The general public's awareness of physics and its importance in our daily life is decreasing. The number of physics students has declined dramatically.' That is both ironic and tragic. It is ironic because physics has no peer among disciplines when it comes to facilitating and explaining the technologies that are now commonplace in life and culture in the twenty-first century. Worse yet, the loss of the public's connection to physics could mean less inspiration and incentive for the next generations of Solomon Drownes, Albert Einstein's and Madame Curies."

President Simmons stressed "that is why these lectures – three this spring and three next fall – are such an important initiative in reacquainting us with the crucial role physics has played and must continue to play both in meeting global

challenges to health and environment and in continuing humankind's essential quest for new knowledge and understanding." "Dr. Leon Cooper certainly helps to bring that point home. His is one of the most impressive resumes in the long history of the Brown faculty and all of you are familiar with its many features."

Her final remarks set the tone of the day. "We are so fortunate to pay tribute to Albert Einstein and kick off our World Year of Physics celebration today with our own resident genius. Colleagues and students, I am pleased to present the 1972 Nobel laureate in Physics, the Thomas J. Watson Sr. Professor of Science and our own rock star, Dr. Leon Cooper."

Provost Robert J. Zimmer stated that "The world-wide attention to physics in this 100th anniversary of a remarkable year in the life one physicist is certainly cause for reflection. One marvels at the staggering nature of Einstein's individual achievements, but likewise at the amazing development of physics as a whole over the last 100 years. Our understanding of the physical world has changed dramatically in the past 100 years due to the work of so many Physicists, and the impact of that work has been transforming not only on fundamental understanding but on the society in which we live. It is work and impact of which physicists are justifiably proud, and which we all would do well to remember." "Let me conclude by saying how pleased I am to be here at this inaugural event of what I know will be an exciting programmatic year for physics at Brown, and for the physics community more generally."



The Brown University Department of Physics presented an Einstein Lecture series to celebrate the 100th anniversary of Albert Einstein's Miraculous year of 1905.

All events were supported in part by "The Charles K. Colver Lectureship and Publication Fund" and a generous contribution from Wini B. Galkin '52

Brown Professor, Leon Cooper, March 7
 Harvard Professor Howard Berg, March 14
 Broadcast of Prof. Leon Cooper's 3/7 talk, Mar. 21
 Stanford Professor Leonard Susskind, April 18
 MIT Professor Rainer Weiss, September 26
 CCNY Prof. Michio Kaku, October 17
 UCLA Prof. Nina Byers, November 14
 Jack Liebeck, Violinist, November 14
 MIT Prof. Alan Lightman, November 16

Physics at Brown

Physics at Brown Newsletter
Department of Physics
Box 1843
Brown University
Providence, RI 02912

ALUMNI, WE'D LIKE TO HEAR FROM YOU!

News? Comments?

Please write to the above address or e-mail us at newsletter@physics.brown.edu

Physics at Brown

Novel Approaches To Climate Workshop At the Aspen Center for Physics, June 2005

It is now widely acknowledged that human activities such as the release of greenhouse gases to the atmosphere are causing the Earth's climate to change rapidly. There is a pressing need to understand more clearly what the future will bring. Prof. Brad Marston was the lead organizer of a workshop entitled *Novel Approaches To Climate* held over a three-week period this past summer at the Aspen Center for Physics in Colorado that looked at how modern physics might contribute to a better understanding of climate. Profs. John Harte (Berkeley), Daniel Cox (UC Davis) and Grisha Falkovich (Weizmann Institute) joined Prof. Marston in running the workshop.



Brad Marston

The need for accurate, detailed, climate predictions is great, but even the most sophisticated models running on the world's fastest computers are far from directly capturing crucial physics such as cloud formation and deep convection. First-principles models of ecosystem dynamics are even further out of reach, yet ecosystems respond to and affect climate in a wide variety of ways. The premise of the Aspen workshop was the idea that the science of climate can be advanced by an infusion of ideas from modern physics. As a central goal we sought to identify outstanding questions that would benefit from physics input, and to determine the most intelligent ways to go about answering these questions. In addition connections were made between experts in different fields, enabling the solution of outstanding open problems, such as how changes in the atmosphere, oceans, and terrestrial ecosystems influence each other.

The workshop was supported by funding from the National Science Foundation, BP, and the Institute for Complex Adaptive Matter. More information, including slides from most of the talks, can be found on the web at URL <http://homepage.mac.com/bradmarston/aspen.htm>

Prof. Marston has been invited to follow-up on the Aspen workshop by running a three month long program on the physics of climate change at the Kavli Institute for Theoretical Physics at the University of California in Santa Barbara during Spring 2008.