

Physics at Brown

2009 Issue

Greetings from the Chair

Welcome to the 2009 issue of the Physics Department newsletter. As you will see in the following pages, we have had a busy and eventful year.

We were proud to learn that Professor Gerald Guralnik was one of six recipients of the 2010 J.J. Sakurai Prize, a well-deserved and long overdue recognition for his work on the properties of spontaneous symmetry breaking.

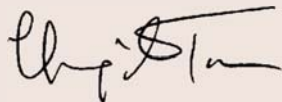
We welcomed Professor Ulrich Heintz, a particle physicist, to our Department in September. I am also pleased to report that the Kang family bestowed a generous gift on the Department to endow a lecture in honor of the late Professor Kyungsik Kang.

Over the past year, our graduate students have developed and refined the mentoring program they launched in 2008. In addition, they instituted a weekly coffee hour and a regular series of faculty presentations. Our undergraduates have been active in their efforts to organize talks for the Physics Women in Science and Engineering (WiSE) group and energize the Department Undergraduate Group.

The Department's inaugural Brown Degree Day (BDD) program last spring was a great success. Nearly 40 alumni returned to campus to talk about their career paths with our undergraduates and graduate students. Our students responded very positively to the opportunity to learn from such a diverse group of alumni, and we are looking forward to welcoming more alumni back to campus for the next BDD on Saturday, April 10. Following the event, the Department launched an online site for alumni to connect with one another, and I encourage you to visit www.physics.brown.edu/alumni/ to peruse the site and enter your information.

We continue to reach out to develop collaborative relationships with other colleges and universities, including Tougaloo College in Jackson, Mississippi, Vietnam's Hanoi University of Science, and three of the top research institutions in South Africa. In spite of the difficult economic climate, the Department continues to flourish and actively pursue avenues of opportunity and excellence wherever possible. I hope you enjoy reading about the exciting research, achievements and activities of our faculty and students.

With best wishes,



Chung-I Tan



Ladd

Ladd Observatory enjoyed an extremely productive year of science outreach activities. Our regular Tuesday evening public program continues to be well-attended, the impact of our outreach program has expanded, and collaborations between Ladd staff, Physics Department faculty, and various Brown and community programs have expanded considerably.

Clear nights afforded the public fantastic views of Saturn, its rings and many moons, as well as Jupiter and its finely detailed atmospheric bands and four Galilean moons. The major local network television stations continue to feature stories at Ladd, highlighting science events in the news and celestial phenomena such as meteor showers.

Teacher workshops sponsored by the NSF GK-12 grant and the RI NASA Space Grant were conducted by Mike Umbricht and Ian Dell'Antonio, assisted by grad students John Macaluso and Paul Huwe. In addition to regular workshops, we brought our solar telescope (with a narrow-band H-alpha filter) as well as white light "sunspotter" telescopes, on visits to local schools, including Hope High and Vartan Gregorian Elementary Schools. We loaned instruments to schools, and other school groups, such as Martin Luther King, visited Ladd for more extensive observation sessions.

The Department of Physics is collaborating with the Roger Williams Park Museum to create an exhibit about astrophysics. Ladd will loan some of its historic instruments such as a 19th century spectrograph, which is similar to the type of instrument that enabled astronomers to begin to apply principles of physics to understand the nature of remote celestial phenomena.



2009 Galkin Fellow - Kewang Jin

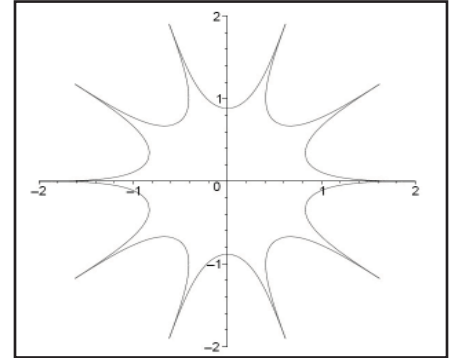


Kewang Jin, the 2009-2010 Galkin Foundation Fellow in the Physics Department, has developed techniques for generating classical solutions of strings in Anti-de-Sitter (AdS) space and for studying their classical dynamics. These solutions are very important in understanding the AdS/CFT correspondence, which relates the $N=4$ supersymmetric Yang-Mills theory in four dimensions to the maximally supersymmetric string theory on $AdS_5 \times S^5$.

The method employed for constructing AdS string solutions is based on a reduction of associated nonlinear sigma models to simple multi-component field theories. The reduction involving invariant fields provides a bridge to integrable equations of sinh-Gordon or more generally Toda type. These equations have soliton type solutions from which the spiky string solutions are constructed. One-to-one correspondence is seen between solitons and spikes of strings in AdS.

With his advisor, Professor Antal Jevicki, Kewang Jin has succeeded in constructing a large (most general) class of string solutions with N spikes in AdS_3 where the sinh-Gordon model provides the general N -soliton solutions. These general spiky strings are characterized by two arbitrary holomorphic functions and a discrete set of moduli representing the soliton singularities. After fixing the conformal frame, only the soliton moduli remain, giving a specification of the string moduli.

The most important application of the AdS string is for the calculation of the scattering amplitudes of Yang-Mills quanta at strong coupling. According to a formulation introduced by Alday and Maldacena, the amplitudes are given in terms of the expectation values of Wilson loops with polygonal boundary conditions specified by the momenta. The AdS/CFT correspondence then offers the potential for evaluating the strong coupling values of these amplitudes which are given by minimal surface areas in AdS spacetime. The evaluation requires finite area solutions with Euclidean string worldsheets. The inverse scattering method Kewang developed for the AdS problem turned out to be very useful for construction of minimal surfaces relevant to the Alday-Maldacena construction.



The Galkin Foundation Fellowships are funded through a generous donation by Warren Galkin '51. Each year, the Fellowship recognizes exceptional promise and achievement in physics by a senior graduate student.

Faculty Research

Ian Dell'Antonio is working on a variety of problems involving the use of gravitational lensing to measure quantities of cosmological and astrophysical interest. In conjunction with a group at the Smithsonian Astrophysical observatory, he is testing the use of weak gravitational lensing to detect and characterize lower-mass clusters of galaxies and the filaments of dark matter that connect them. He is also working with research groups at Yale and the WIYN Observatory on the development of a next-generation imaging camera, and on a major observational survey project to be carried out with it in 2011.

Dima Feldman is working on many-body systems with strong interactions in low dimensions. One of his interests is new approaches to electronics based on quantum wires with strong interelectron forces. Another direction of his research concerns novel states of matter and phase transitions in cold atom systems such as liquid-gas

transitions at zero temperature. He also works on the quantum Hall effect trying to understand charge transport and transitions between fractional states in which electrons decay into quasiparticles with smaller charges. Nonabelian quasiparticles in quantum Hall systems would open an excellent route to quantum computation. Prof. Feldman collaborates with experimentalists from Weizmann Institute in an attempt to detect such nonabelian anyons. His research is supported by NSF and BSF.

During the past year, **Herb Fried** and his ex-grad student Ming Sheu, along with two French colleagues (Y. Gabellini and T. Grandou) published a new, gauge-invariant formulation of QCD, whose exact sum over all exchanged gluons can be expressed by a simple set of local integrals for any process. In addition, Fried and Gabellini can now display an intuitive and physical argument showing that charge renormalization in QED is finite, and can understand - for

the first time in the long history of Physics - why the fine-structure constant is close to $1/137$.

The group led by **Richard Gaitskell** has been funded by the DOE and NSF for a new dark matter search experiment, called the LUX (Large Underground Xenon experiment). It is being built at the new deep underground Sanford Lab in the Homestake (Gold) Mine, South Dakota. The experiment will have a target mass of $1/3$ tonne of liquid xenon, and is projected to be the most sensitive dark matter direct detection experiment in the world when it is turned on in late 2010. The group's last experiment XENON10 (2007) had a target mass of only 15 kg, and its final result is currently still one of the most sensitive in the world. The new LUX experiment is set to improve particle dark matter sensitivity by a factor 100 over XENON10. Prof. Gaitskell is a PI, and one of the spokespersons (leaders) of this experiment.

Faculty in the News



Prof. Rick Gaitskell's search for dark matter is cited in a June 25 online news blog of *Scientific American*.



Prof. Gerald Guralnik received the J. J. Sakurai Prize for Theoretical Particle Physics. Read more on page 7.



Prof. Ulrich Heintz was elected as a Fellow of the American Physical Society.



Prof. Greg Landsberg was elected as a Fellow of the American Physical Society.



Prof. Sean Ling and former graduate student, Hongbo Peng, developed a breakthrough procedure in mapping a person's genome as reported in the May 6 issue of *Nanotechnology*.



Prof. Humphrey Maris received the Philip J. Bray Award for Excellence in Undergraduate Teaching in the Physical Sciences for 2009-2011.



Prof. Brad Marston presented a talk, "Quantum Mechanics of Global Warming," to a large public audience at the Aspen Institute. He is a co-author of the paper "Fire in the Earth System," published in the April 24 issue of *Science*.



Prof. Meenakshi Narain and graduate student, Monica Pangilinan, are the leaders of the prime analyses that resulted in the discovery of a new production process for the top quark; article published in *Physical Review Letters* on August 24.



The research of Dr. Wei Guo, graduate student, Da-fei Jin, **Prof. George Seidel** and **Prof. Humphrey Maris** was featured in "Viewpoint," an American Physical Society online report that highlights exceptional research.



Prof. Derek Stein was the recipient of an NSF CAREER award



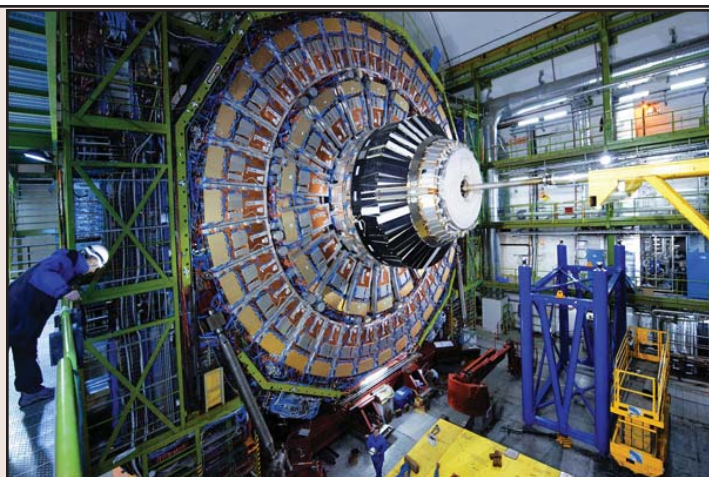
The BLAST experiment, led at Brown by **Prof. Greg Tucker**, plays a key role in the discovery of new galaxies as cited in an article which appeared in the April 9 issue of *Nature*.



Prof. Anastasia Volovich was the recipient of a 2009 Career Development Award.

US CMS Meeting at Brown

On May 6-8, 2010, the US members of the Compact Muon Solenoid (CMS) Collaboration, which operates one of the large detectors at the Large Hadron Collider located in Geneva, Switzerland, will gather at Brown University for their annual meeting. The Brown experimental particle physics group, consisting of Profs. Cutts, Heintz, Landsberg and Narain, are members of the CMS collaboration. First results from data collected during LHC collisions in December 2009 have already been accepted for publication. The CMS collaboration is looking forward to recording collisions from LHC operations at a center of mass energy of 7 TeV during Spring 2010. This meeting will provide an exciting opportunity to discuss analysis of and results from these first data collected by the LHC at the new energy frontier.



The CMS Cavern in February 2009 (Courtesy of CERN)

2009 PhD Recipients



Michael C. Abbott “Semi-Classical Approaches to Quantum Gravity and String Theory Solitons”

Ines V. Aniceto “Aspects of AdS/CFT Correspondence: Symmetries, Integrability and Solitons”

Tolga Atay “Nanoscale Optics by Localized Surface Plasmon Polaritons”

Hiroshi Eguchi “Study of Vapor-Deposited Au: Er Films and Development of Metallic Magnetic Calorimeter for Future X-ray Astronomy Missions”

Daniel D. Ferrante “Symmetry Breaking: A New Paradigm for Non-Perturbative QFT and Topological Transitions”

Wei Guo “Optical Absorption Properties of Electron Bubbles and Experiments on Monitoring Individual Electron Bubbles in Liquid Helium”

Jun He “Microrheology and Dynamics of F-actin Network”

Crysostomos Kalousios “Classical String Solutions in AdS/CFT”



Kam Tuen Law “Probing Abelian and Non-Abelian Statistics in Fractional Quantum Hall States”

Yanqiu Li “Ultrafast Phenomena on the Nanoscale in Solids: From Magnetic to Acoustic Phenomena”

Yifeng Liu “MT Striped Birefringence Pattern Formation and Application of Laser Tweezers in Microrheology, Bacterial Motility and Adhesion”



Seungwook Ma “Non-Perturbative Approaches to Problems in Strongly-Correlated Many-Body Physics”

Cuong Kieu Nguyen “Ultrasound Vibration Potential Imaging: Theory and Experiment”

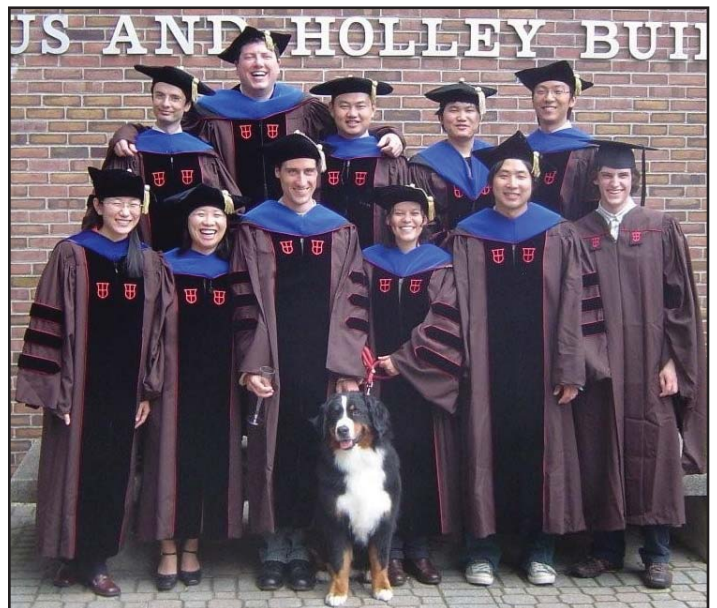
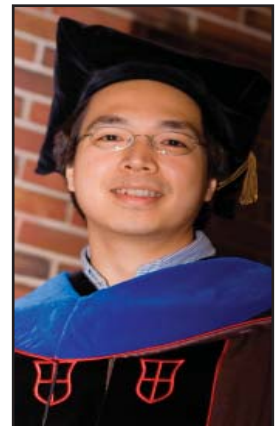
Patrick W. Oakes “The Liquid Crystalline Transition of F-actin and Neutrophil Mechanosensing”

Marc-Andre Vachon “Nuclear Magnetic Resonance Study of the Magnetism in the 2D Frustrated Quantum Heisenberg Antiferromagnet Cs_2CuCl_4 ”

Liang Wu “Analysis of Brain Signals with Machine Learning and Information-Theoretic Models”

Shanshan Wu “Fabrication of Nanopore System and Its Application on DNA Manipulation”

Yunhe Xie “A Search for Charged Massive Long-Lived Particles Using DO Detector”



Graduate Awards 2008-2009

Galkin Foundation Fellowship Award

Xiaojing Zou

Anthony Houghton Award (Excellence in Theoretical Physics)

Chrysostomos D. Kalousios
Seungwook Ma

Beyer Award (Excellence in Scholarship and Service)

Daniel D. Ferrante

Forrest Award (Excellent Work Related to Experimental Apparatus)

Jeffrey M. Shainline

Dissertation Fellowship Award

Ines V. Aniceto
Jun He
Chrysostomos D. Kalousios

Master of Science Recipients

Michael P. Antosh
Saptaparna Bhattacharya
Andrew S. Blaeser
Richard I. Cook
Sungwook Ma
John Macaluso

David C. Malling
Mirna Mihovilovic
Yongqiang Ren
Florian C. Sabou
Wanchun Wei

Undergraduate Degree Recipients



Matthew J. Ball, ScB, Physics with honors

Brian A. Bayes, ScB, Chemical Physics with honors, Magna Cum Laude

Simon S. Buttrick, ScB, Biophysics

Alexander W. Cerjan, ScB, Physics, with honors

Christie A. Ciarlo, ScB, Biophysics

Dylan V. Cofer-Shabica, ScB, Physics

John W. Cucco, BA, Physics

Alexander A. DeChaumont Quitry, ScB, Engineering-Physics, with honors

Jackson T. Del Bonis-O'Donnell, ScB, Mathematics-Physics

Ding Ding, ScB, Engineering-Physics, with honors

William J. Doyle, BA, Physics, BA, Economics

Stuart B. Elston, ScB, Physics

Anne M. Fabricant, ScB, Physics



Amandeep Gill, ScB, Physics

Anuj Girdhar, ScB, Physics, with honors

Michael R. Glassman, ScB, Biophysics

Nicholas R. Kennedy, BA, Physics

Robert J. Kim, ScB, Biophysics

Miriam R. Klein, ScB, Physics

Eric S. Leonard, BA, Physics

Nikolas C. Logan, ScB, Physics, with honors

Amy E. Lowitz, ScB, Physics, with honors

Sean E. McGeary, ScB, Biophysics

Teodor M. Moldovan, ScB, Computer Science, ScB, Mathematics, ScB, Physics, with honors

Samuel A. Ocko, ScB, Mathematics-Physics, with honors

Christine G. Pappas, ScB, Physics, with honors



Samuel N. Pucci, BA, Physics

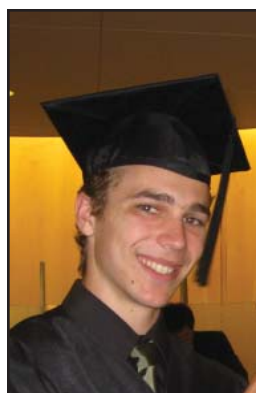
Reshma Ramachandran, ScB, Physics, with honors

Stefan B. Schaffer, ScB, Biophysics

Benjamin M. Skerritt, BA, Mathematics-Physics

Ruslan S. Skomorohov, ScB-BA, Physics-Economics

Aaron J. Weinstein, ScB, Physics, with honors



Undergraduate Awards 2008-2009

R. Bruce Lindsay Prizes (Excellence in Physics)

Anuj Girdhar
Samuel A. Ocko

Smiley Prize (Excellent Contribution to the Astronomy Program)

David Eichhorn

Mildred Widgoff Prizes (Excellence in Thesis Preparation)

Jackson T. Del Bonis-O'Donnell
Stuart B. Elston
Nikolas C. Logan

UTRA's 2008-2009

The UTRA program provides opportunities for collaboration between students and faculty and allows students to gain insights into the structure of academic work in a particular field.



Ryan Kaplan - Mitrovic Lab

Adam Coogan

"LUX and the Quest to Illuminate Dark Matter"

Katherine Dagon "Formation of Jets in Planetary Atmospheres"

Anand Desai "LUX: The Search for Dark Matter"

Nicholas Hagerty "Imaging of DNA Translocation Through Solid-state Nanopores"

James Hinton "Starfish Conformations in Nanopit Arrays"

Ryan Kaplan "Tuning and Noise Reduction of NMR-Probe Coils"

Matthew Kretschmer "Electrokinetic Energy Harvesting in Nanochannels"

Jared Lafer "Optimization of the Trigger for the CMS Detector at the Large Hadron Collider"

Laura Mocanu "Dark Matter Substructure in the Milky Way and its Effects on the Dark Matter Annihilation Signal"

Laurentiu Rodini "Research in String Theory"

Barbara Stekas "Optical Tweezers for Micromechanical Measurements of Colloids and DNAs"

Michael Wagman "Paramecium Motion and Effects of Viscous Drag Forces"

Katrina Wilson "Kinetics and Methods of Adhesive Secretion by *Caulobacter Crescentus*"



Michael Wagman-Valles Lab

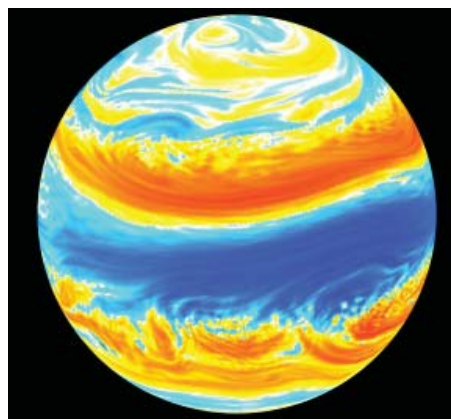
Physics Undergraduate Discusses Sustainability in Copenhagen

Katie Dagon was one of three students representing Brown University at a conference in Copenhagen on how universities worldwide can limit greenhouse-gas emissions and encourage sustainable practices. The gathering, held during the COP15 climate change summit in December, was organized by the University of Copenhagen and Yale University. Teams from participating institutions shared information and discussed various campus initiatives.



The Brown group focused on President Ruth J. Simmons's call in January 2008 for the University to reduce its greenhouse gas emissions by 42 percent below 2007 levels by the year 2020. In a report released this fall, the University announced it has reduced its carbon footprint by nearly 19 percent, well above the target 8 percent. That achievement, combined with other environmentally friendly efforts on campus, helped Brown score an A- in this year's College Sustainability Report Card, an independent evaluation carried out by the Sustainable Endowments Institute. The Brown team also explained efforts by student groups such as EmPOWER to promote sustainability on campus, as well as the work of individual departments, such as Facilities Management.

Katie, who works with Prof. Brad Marston on climate modeling, said she was honored to represent Brown at the sustainability meeting. "One of the best parts of the experience was meeting students from different universities around the world who were passionate about encouraging sustainability on campus. Talking with these students was incredibly rewarding and I learned a lot from them. I felt that the conference was a great success just for bringing together these students and helping to form relationships between universities. The ideas and insight of the younger generation are crucial to solving the global climate crisis."



Even a highly simplified model of the Earth's atmosphere shows great complexity in jet streams and macroturbulence. Mathematical approaches that focus on average statistics rather than detailed patterns can deepen our understanding of climate and climate change - Prof. Brad Marston

Professor Guralnik Awarded 2010 J. J. Sakurai Prize

Physics Professor **Gerald Guralnik** is one of six recipients around the world of the 2010 J.J. Sakurai Prize, awarded by the American Physical Society (APS) for outstanding achievement in particle theory. The citation from APS praises the six researchers for “elucidation of the properties of spontaneous symmetry breaking in four-dimensional relativistic gauge theory and of the mechanism for the consistent generation of vector boson masses.” Endowed in 1984, the J. J. Sakurai Prize is considered one of the most prestigious prizes in physics.

The six co-recipients of the prize produced three independently formulated papers, published in *Physical Review Letters* in 1964, which examined the theoretical mechanism from three discrete perspectives. Each paper made a unique contribution. Collectively, they laid the foundation for the 1979 Nobel Prize in physics given for the unified electroweak theory. These papers also led to the prediction of the “God Particle” or “Higgs boson,” a particle which is the focus of research for many high energy physicists.

Guralnik's current research is focused on quantum field theory, general relativity, and related computational methods. In addition,

he applies his expertise in large-scale computations to Brown's Ersatz Brain Project, which has the ultimate goal of designing a computer that simulates various processes of the brain.

A member of Brown's physics faculty since 1967, Guralnik came to Brown from the University of Rochester, where he worked as a postdoctoral research associate. Prior to his stint at the University of Rochester, he was a postdoctoral research associate at Imperial College, London, where he conducted his prize-winning research under a National Science Foundation Postdoctoral Fellowship. Guralnik received his Ph.D. in physics from Harvard. He is a fellow of the American Physical Society and was an Alfred P. Sloan Research Foundation Fellow.

The Sakurai Prize is accompanied by a monetary award of \$20,000 which was divided among Guralnik, Carl Hagen of the University of Rochester, Tom Kibble of Imperial College, Peter Higgs of the University of Edinburgh, and Robert Brout and Francois Englert, both of the Université Libre de Bruxelles.



New Faculty

Physics welcomed **Ulrich Heintz** to the Department as full professor on September 1, 2009. Heintz, a particle physicist, came to Brown from Boston University. He has worked for years with the other members of the Brown High Energy group, Meenakshi Narain, David Cutts, and Greg Landsberg, on high-energy particle collisions at the Fermi National Accelerator Laboratory.

Prior to his arrival at Brown, the native of Stuttgart, Germany was associate professor of physics at Boston University. He earned his master's and Ph.D. in physics at the State University of New York–Stony Brook. He is married to Meenakshi Narain and they have two sons.

At Brown, Heintz will concentrate on high-energy physics experiments taking place at Fermilab and at the Large Hadron Collider at CERN in Switzerland that may offer scientists a peek into the conditions that occurred less than a millionth of a second after the universe's creation 13.7 billion years ago. The collision of proton beams at the underground complex in Switzerland could reveal a host of particles that physicists have theorized to exist but have yet to see in nature.

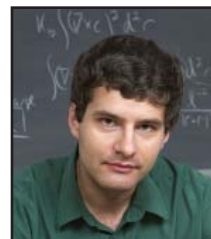
One of those “missing” particles is the Higgs boson, an object of great interest to Heintz. The Higgs particle is important because it could help explain the origin of the masses of elementary particles. Heintz has been studying subatomic particles at Cornell University and at Fermilab since the mid-1980s. His accomplishments include measurements of the masses and other properties of the W boson and the top quark. Recently, he contributed to the observation of single production of top quarks.



Promotions



Rick Gaitskill, promoted to full professor with tenure, leads a team searching for direct evidence of particle dark matter. The research team is working on an experiment that has a detector located in the underground laboratories of the Homestake Mine in South Dakota. Called the LUX experiment, the detector will begin running in 2010, and is expected to be the world's most sensitive dark matter detector to date. Rick joined the Brown faculty in 2001, and leads the Particle Astrophysics Group at Brown. Prior to Brown, Rick was a faculty senior lecturer at University College London, UK, and he held positions in California as a fellow at the Center for Particle Astrophysics at UC-Berkeley and a visiting scholar at Stanford University. He was a prize fellow at Magdalen College of Oxford University, UK, where he completed his undergraduate studies. He also earned a Ph.D. from Oxford for his thesis on dark matter detection.



Dima Feldman, promoted to associate professor with tenure, focuses his research efforts on theoretical condensed matter physics with emphasis on strongly correlated electrons in low-dimensional systems, and quenched disorder in hard and soft condensed matter. A graduate of the Moscow Institute of Physics and Technology, he received his Ph. D. from the Landau Institute for Theoretical Physics in 1998. He conducted postdoctoral research at the Weizmann Institute of Science and Argonne National Laboratory, and he joined the Brown Physics Department in 2003. He was a recipient of the Koshland Scholar Award from the Weizmann Institute of Science, a Salomon Research Award, and a CAREER Award from the National Science Foundation.

Brown Degree Day

The inaugural Brown Degree Day program, held on April 4, 2009, brought nearly 40 physics alumni back to campus. The event, which attracted more than 70 students, was an opportunity for concentrators to meet graduates of the physics programs and learn about a diversity of paths leading away from Brown after graduation. The day included presentations, a panel and roundtable discussions that provided students with the chance to hear from and interact with a wide range of alumni. The response from the participating alumni and students was overwhelmingly positive. One alumnus wrote “After five minutes, I felt as though I had walked into a big club where I knew everyone, even though I didn’t. It was very enjoyable to reconnect with the Department.” Another commented “The event was well-organized, it suited me perfectly in terms of Saturday, and [it was] well-attended and crisply executed. The dinner event at the Faculty Club was excellent, as were the speakers chosen.”

The department will host the second Brown Degree Day on April 10, 2010, and plans to make the program an annual event. Following up on the success of the event, the department created an interactive alumni website <http://www.physics.brown.edu/alumni/index.asp> which allows physics alumni to connect with one another and provide insight to current students regarding career options. You are encouraged to check it out!



Alliance with South African Institutions

The Physics Department is actively pursuing working relationships with the University of Witwatersrand (Johannesburg), the University of Cape Town and STIAS (Stellenbosch Institute for Advanced Studies). The goal is to develop robust research and teaching collaborations with faculty in theoretical physics at these three top South African institutions. In addition to research collaborations, a series of lectures, seminars and participation in summer schools and programs directed toward undergraduate and graduate students will contribute to the development of fundamental sciences in South Africa. Professors Antal Jevicki and Chung-I Tan are spearheading the effort to build upon an already strong foundation, and their endeavor will solidify Brown’s role in the programs and schools planned by the South African Institute of Physics. Three of the leading string theorists in South Africa were educated at Brown, and Prof. Jevicki has been an active participant in several schools and meetings organized by South African universities.



Brown-Tougaloo Collaboration

The Brown University – Tougaloo College Partnership (BTP) is designed to enrich both campuses through student and faculty academic and cultural exchanges, collaborative research ventures, and administrative-level engagements. The Physics Department’s relationship with the college, located in Jackson, Mississippi, began in 1964 when the late Prof. Robert Beyer went to Tougaloo to teach and learn. Over the past year and a half, Prof. Chung-I Tan and Prof. Jay Tang have been engaged in developing an active collaboration with Tougaloo’s Physics Department which is comprised of only two faculty members.

At the invitation of Prof. Tan, the two professors, Dr. Biswas and Dr. Banerjee, visited Brown near the end of 2008. Dr. Biswas presented a seminar, and he and Dr. Banerjee met with assorted faculty members in the Physics Department. In November 2009, Prof. Tang traveled to Mississippi where he participated in the annual BTP Advisory Council meeting and gave a talk to science undergrads and faculty. Prof. Banerjee will teach a course at Brown this summer. Profs. Tan and Tang continue to seek ways to provide research opportunities to Tougaloo undergraduates.



Santanu Banerjee, Professor of Physics; Larry Ray, Director of International Programs; and Professor Jay Tang



SURE Program

2009 marked the second year of the Department’s cooperation with the Chinese University of Hong Kong (CUHK) to provide research opportunities for their undergraduates. To date, four CUHK students have conducted summer research projects at Brown, and a fifth student, Liu Binyang, will arrive in June to work with Prof. Greg Tucker. Mr. Liu will work on programming a motor servo system, and using measurements from that to contribute to the understanding of the instrumental optical response of the Millimeter-wave Bolometric Interferometer. CUHK has been pleased by the multiple opportunities offered by Brown’s Physics Department to expose students to cutting-edge research projects. The Summer Research Undergraduate Experience (SURE) program is supported by funds from CUHK and Brown University.

GK-12 Outreach Program

The Physics Department plays an active role in Brown's GK-12 program, which is supported by the National Science Foundation. The primary goal of the GK-12 program is to have graduate student teaching fellows bring their research experience into the classroom. The program provides summer research experiences for K-12 teachers and high school students, pedagogical training for K-12 teachers and graduate fellows, design and implementation of hands-on science teaching modules, and professional development for K-12 teachers and graduate fellows.



During the spring of 2009, graduate student Paul Huwe was a GK-12 fellow, working with teachers at Hope High School. The



work has continued during the fall by John Macaluso who says that being part of GK-12 has been a rewarding experience. "As someone who has an interest in promoting science education, GK-12 provided an excellent opportunity to engage with local Providence schools and teach science to interested students. Also, as a graduate

student, GK-12 supplied me with an excellent source of research support. I highly recommend the GK-12 Fellowship to any graduate student who is willing to commit some of their time to improv-

Student Activities

Department Undergraduate Group

The Physics Department Undergraduate Group (DUG) organizes events for undergraduates concentrating in physics. Although inactive for the past few semesters, the DUG has started holding talks again so that undergraduates can find out more about the work that physicists are doing at Brown. Plans are in the works to expand the Physics DUG's activities in the coming semesters to provide some of the services that the old DUG had for undergraduates, such as help sessions for first-year physics courses.

Graduate Student Mentoring

As part of the Physics Department's focus on teaching quality and support for graduate students, all incoming graduate students are assigned two mentors: a community mentor and a teaching assistant mentor from a list of graduate student volunteers. The community mentors provide support, advice and a social networking opportunity for new graduates. The teaching assistant mentors are assigned to provide support specific to the teaching assignments given to new students. The mentors provide encouragement and guidance to prepare graduate students for teaching and to improve the overall quality of teaching in the department.



Andrew Blaeser and mentee Andrew Favaloro

ing science education and inspiring the next generation of scientists."

Graduate student Shawna Hollen has been a GK-12 fellow at Vartan Gregorian Elementary School. Shawna considers the program both challenging and rewarding. It is, she says, "challenging to balance a significant amount of teaching with research, and rewarding in a way that research never is - every day you work, you feel that you've accomplished something important. I've also learned a great deal from the kids' teachers. It is their job to teach these kids, and there is a lot of effort spent in giving every child the best possible opportunity to learn the material. I have learned a lot about how people learn and how to best communicate information...as long as you know your audience, these lessons can apply to elementary school students or to research colleagues."



Over the summer, Prof. Ian Dell'Antonio hosted a GK-12 high school student in his lab, and a middle school teacher worked in Prof. Jim Valles' lab. More recently, a new GK-12 program was launched at Ladd Observatory where teachers obtain and analyze variable star data.

The units are designed so that all the required data and analysis can be done in one evening.

Weekly Coffee Hour for Graduate Students

Each Friday afternoon, the Physics Department hosts a graduate student coffee hour in the Faculty Lounge. The coffee hour features a short talk by a graduate student about their research and how they found a research group. It is an excellent opportunity to hone presentation skills in an informal environment, and it exposes incoming graduate students to the various exciting research opportunities available in the Department. In addition, the gathering is a regular social event that helps to build a sense of community among the graduate students.



Chenjie Wang

Physics Women in Science and Engineering (WiSE)

Physics WiSE is a student group dedicated to supporting and fostering the continued role of undergraduate women in Brown's Physics Department. The group enjoys learning as much as possible about physics and the research going on in the Department. Anyone, male or female, is welcome to join the group and listserv. Activities over the past year have included lunch seminars with professors from the Department as well as outside speakers from Yale, the University of Washington and NASA.

50 Years at Brown

2009 marked the 50th anniversary at Brown of Professors Charles Elbaum and Robert Lanou. The two professors arrived on College Hill in 1959 as assistant professors, and although they retired several years ago, they continue to be actively involved in their research and department activities.



Professor Charles Elbaum

Professor Elbaum, who received his Master's and Ph.D. degrees from the University of Toronto, has been a frequent advisor to government and industrial research laboratories. He is a Fellow of the American Physical Society. Professor Elbaum served as Chairperson of the Physics Department from 1980-1986, and in 1991 he was appointed the Hazard Professor of Physics. His research focuses on condensed matter at low temperatures.



Professor Robert Lanou

Professor Lanou is a Fellow of the American Physical Society and the American Association for the Advancement of Science. He has served on the High Energy Physics Program Advisory Committee of several National Laboratories, as well as the Executive Committee of the A.P.S. Division of Particles and Fields. His research interests are in elementary-particle physics.

A graduate of Worcester Polytechnic Institute, he received his Ph.D. from Yale University. Professor Lanou was Chairman of the Physics Department from 1986-1992.

Arthur O. Williams Lecture

On February 9, 2009, **Dr. Steven E. Koonin** delivered the annual A. O. Williams Lecture to a standing room only audience. Dr. Koonin spoke about emerging energy trends and technologies for the 21st century in a talk entitled "Energy, Environment, Security: Can we have it all?" At the time of the lecture, he was chief scientist of BP, the third largest energy company, a position he had held since 2004. In May 2009, Dr. Koonin was confirmed by the Senate as the second Undersecretary for Science in the U.S. Department of Energy (DOE). Prior to his post at BP, he had a distinguished career as a university professor and administrator at the California Institute of Technology. Dr. Koonin is a fellow of the American Physical Society, the American Association for the Advancement of Science, and the American Academy of Arts and Sciences, as well as a member of the Council on Foreign Relations and the Trilateral Commission. His research focuses on nuclear physics, computational physics, and energy and environmental change.



The Department gathered to celebrate their distinguished colleagues at a party at the Faculty Club. Professors George Seidel, David Cutts and Herb Fried provided witty remarks and read original poetry composed for the occasion. The fete began with the following poem written and recited by Prof. Leon Cooper. Prof. Cooper, who has yet to retire, has been at Brown for 51 years.

In Providence did Charles and Bob
A stately physics group decree
where S'konk the sacred river ran
Through caverns measureless to man
Down to a sunless sea.

So thrice ten yards of fertile ground
Did Barus-Holley girdle round.
The elevators never ran.
Not even under Chairman Tan.
The roof has leaked since time began.

You've now become Emeritus.
But please do not abandon us.
We need your counsel true and sage
To guide us through this trying age.

So thank you for your phonons cold
And thank you for neutrinos bold
For your great service to this town
And all that you have done for Brown.

We join to wish you luck and health.
And joy with friends you have in wealth
And many years Emeritus
Accept the best from all of us.

Dr. Harald J. Hess, a group leader at Howard Hughes Medical Institute's Janelia Farm Research Campus (JFRC), will present the 2010 A.O. Williams Lecture on Monday, March 8. Dr. Hess, who holds an A.B. in physics from the University of Chicago, completed his doctoral work in physics at Princeton. As a postdoctoral researcher at MIT, he devised the method to evaporatively cool hydrogen atoms in a magnetic trap into a Bose-Einstein condensate, a new state of matter that exists close to absolute zero temperature and today is widely studied by physicists all over the world. Hess went on to a very productive decade at Bell Labs where he developed innovative forms of microscopy—a pursuit he's returned to with the new photoactivated localization microscopy (PALM) technique he's developing with Eric Betzig, a collaborator from his days at Bell Labs. The approach takes advantage of a recent discovery in molecular biology: fluorescent probes



Ladd Observatory

continued from page 1. . .

In celebration of the International Year of Astronomy, the Ladd Observatory and Brown University Library presented "Beyond the Moon: 400 Years of Astronomical Observation." The exhibit displayed texts and images dating from the early 17th century drawn from the Library's incomparable history of science collections, historical records of the Ladd Observatory, and a range of astronomical instruments of the 18th century to the present day instruments and imagery used by Brown astrophysicists Ian Dell'Antonio and Greg Tucker.

This year we experimented for the first time with a special poster session highlighting research conducted by Physics Department graduate students, along with their faculty advisors, as well on astronomically-related projects in other departments. This event, co-sponsored by Physics and the RI Space Grant, was held December 1 on the first floor of the observatory. It was very well received by members of the public, who were able to learn first-hand about the physics, mathematics, computation, and instrumentation used by scientists to explore the universe as seen directly through the telescopes upstairs. Graduate students Jeremy Chapman, James Verbus, Paul Huwe,

Angela Stickle, Scott Field, Andrei Korotkov, Alex Geringer-Sameth, and Jerry Vinokurov presented papers about dark matter, galactic lensing, cosmic microwave background, impacts on the planets, and computational methods in relativity. Faculty involved included Ian Dell'Antonio, Greg Tucker, Rick



From the Hay Library Collection

Arthur O. Williams

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that can be linked to molecules inside cells, and then switched on or off by exposing them to light. When Hess moved to JFRC, he expanded both his physical workspace and scientific focus considerably. As director of the Advanced Physics and Instrumentation Group, his role is to identify areas where technological advances can benefit a broad group of Janelia researchers. Much of the work this group will do remains to be determined as Hess, a physicist who has only recently begun to interact with biologists, consults with colleagues about needs and opportunities. Dr. Hess says that JFRC is something rare—a place for "professional scientists," referring to their freedom to be completely dedicated to research without other obligations.

Gaitskell, Savvas Koushiappas, Pete Schultz (Planetary Science) and Jan Hesthaven (Applied Mathematics.)

The Ladd Observatory continues to be an active center for public access to cutting edge research in astrophysics. At the same time, it continues its 118 year tradition as a source of inspiration to thousands of members of the public and school children who, guided by experienced members of the Ladd staff and faculty from the Department of Physics, can view the objects of our study directly through our telescopes and with the naked eye from our observation deck.



A visit by school children to Ladd Observatory shows the Sunspotter telescope (foreground) and the H-alpha solar telescope (background)

Do you want to receive engaging weekly news stories about events in the night sky over Providence? More than 800 people have signed up for Ladd's Listserv, which provides information on events at Ladd and celestial happenings overhead. To sign up, go to <http://www.physics.brown.edu/physics/commonpages/ladd/>

Promotions

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The Department's recommendation to promote **Vesna Mitrovic** to associate professor with tenure has been accepted by the Provost. Vesna joined the Brown Physics Department in 2003. A graduate of Illinois Institute of Technology, she received her Ph.D. from Northwestern University in 2001, and did postdoctoral work at Grenoble High Magnetic Field Laboratory in Grenoble, France. Her research interests include study of the quantum phenomena arising in strongly correlated electron systems at low temperatures and high magnetic fields using NMR spectroscopy. Vesna is the recipient of a Richard B. Salomon Faculty Research Award, an NSF CAREER award and a Sloan Fellowship. In 2007, she was named the Manning Assistant Professor of Physics.



Faculty Seminar Series

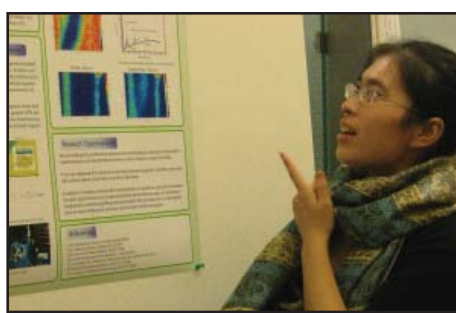
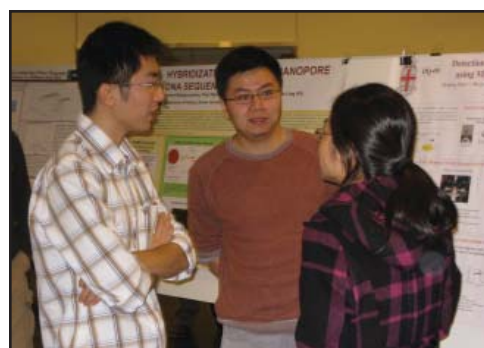
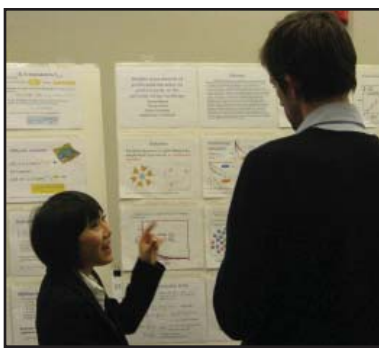
A new series of talks starring the faculty of Brown's Physics Department began in the fall. The Faculty Seminar Series has featured talks in neuroscience, high energy experiment, biophysics, and string theory given by Professors Leon Cooper, Greg Landsberg, Derek Stein, and Mark Spradlin respectively. Third-year graduate student Shawna Hollen conceived and organized this highly successful ongoing series. Two graduate students, Andy Blaeser and Scott Field, commented that "the faculty talks show the wide range of interesting, cutting-edge science going on in our department" and "they are very accessible and I have always left feeling like I've learned something new." Max Abrahams and Eric Rudisale, both undergraduates, remarked that "the poster session usually leaves us with just a taste of what our professors are working on," "[the Faculty Talks] feel like getting an inside look at what the physics community is all about."

The talks are held at 3:00 pm on the first Friday of each month. The upcoming roster for the spring includes Professors Ian Dell'Antonio, Dima Feldman, and Vesna Mitrovic. For a complete schedule of talks with posters and abstracts, please visit http://www.physics.brown.edu/physics/userpages/students/shawna_hollen/facultyseminars/schedule.html.

2009 Poster Party

On November 18, 2009 the Department held its annual "Poster Party", where faculty and their undergraduate and graduate students displayed posters to illustrate the exciting research being carried out over a broad range of physics. Research groups in the Department as well as affiliated groups in the Department of Chemistry and the Division of Engineering were represented. The lobby of Barus-Holley was filled with 45 posters, and students and faculty spent several hours in the lobby engaged in discussion.

The event provides students with an easy and welcoming way to learn about research opportunities in the Department. First-year graduate students typically join research groups at the end of their first year, and the poster session provides an overview of the many opportunities available to them. The informal atmosphere allows ample time for one-on-one conversations with potential research advisors and their current graduate students. The event also provides an opportunity for undergraduates to learn about departmental research and develop connections with faculty which will lead to summer participation in a research group through the University's UTRA program as well as senior thesis projects.



Team Schrodinger's Bat



Top (L to R): Alex Geringer-Sameth, Andy Blaeser, Scott Field, Seshu Tirupathi, Aaron Glaim, Dave Malling, Chris Rhea. Bottom (L to R): Ryan Michney, John Macaluso, Andy Fischer, Mike Antosh. Not pictured: Steve Palefsky, Kenny Morabito, Il-Yong Jung

Team Schrodinger's Bat was formed in the Fall of 2008 and is the representative intramural softball team of the Physics Department. With their overwhelming athletic prowess and expert knowledge of projectile motion, the team finally won first place in the Fall 2009. They look forward to defending their title during the new season.

In Memoriam

David Feldman, Professor Emeritus of Physics December 29, 2009

Dr. Feldman received a B.S. from the CCNY in 1940, an M.S. from New York University in 1946, and a Ph.D. from Harvard University in 1949. He was involved in defense work at the National Bureau of Standards during WWII. From 1949-1950 he was an AEC Post-Doctoral Fellow at the Institute for Advanced Studies; 1950-1956 he was assistant professor of physics at the University of Rochester; 1956-1959 he was associate professor of physics at Brown University; and from 1959-1991 he was professor of physics at Brown University. Dr. Feldman was a fellow of the American Physical Society, and a member of Phi Beta Kappa and Sigma Xi. He played a signature role in modernizing the physics department at Brown and broadened the program there to include particle and nuclear physics. He developed the High Energy Theory group and worked with C.N. Yang, a Nobel Laureate, defining asymptotic states in Quantum Field Theories, an important contribution to the development of modern particle physics.

Stavros Fallieros, Professor Emeritus of Physics December 21, 2009

After graduating from the University of Athens and serving in the Greek army, Dr. Fallieros was awarded a CERN fellowship at The Niels Bohr Institute in Copenhagen, Denmark. He began graduate studies in 1955 at the University of Maryland where he was awarded a Ph.D. in nuclear theory in 1958. He then spent nine years at the Bartol Research Foundation before coming to Brown as a tenured professor of physics. His research, for which he received international recognition, ranged over various areas of nuclear physics, including studies of collective phenomena (some of which he pioneered), photon- and electron scattering-induced excitations, and the roles of gauge and relativistic invariance in nuclear phenomena. Dr. Fallieros was a fellow of the American Physical Society and a principal investigator on various US government contracts and grants for many years. Although his research took up much of his time, he never stinted when it came to teaching, becoming one of the Physics Department's consistently best teachers throughout his tenure at Brown. He taught for several years after his retirement in 1995, during which time he continued to receive accolades from students.



Orion (Joint Astronomy Centre in Hilo, Hawaii)

Extragalactic Astronomy and High Energy Astrophysics

This new course, taught by Prof. Ian Dell'Antonio, provides an introduction to the astrophysics of galaxies, their structure and evolution, with an emphasis on physical introduction of the observations. Underlying physics concepts such as radiative transfer, nuclear reactions and accretion physics will be introduced. The course is part of a two-course sequence with PHYS 1250: Stars and the interstellar medium. The course emphasizes gravitational and radiative processes that determine the structure of galaxies, the evolution of their stellar populations, the clustering of galaxies and the high energy emission phenomena associated with quasars and radio galaxies.

Astronomy to Astrophysics Lecture Series

Professors Ian Dell'Antonio and Gregory Tucker were awarded funding from Brown's Charles K. Colver Lectureship to support a lecture series, "Astronomy to Astrophysics." The series kicked off in October with a screening of *BLAST! The Movie*, a film about the trials and triumphs of the team of scientists, some of whom are in Brown's Physics Department, working on the Balloon-borne Large-Aperture Sub-millimeter Telescope (BLAST). Two lectures were given during the month of November. Dr. David Latham of Harvard University gave a talk, "Kepler and the Search for Habitable Planets" and Prof. Miguel Morales, University of Washington, delivered a lecture entitled "The First Galaxies: Peering Through the Primeval Hydrogen Fog with Radio Light." A presentation in December by Prof. George Wallerstein rounded out the series. Dr. Wallerstein '51 and a professor emeritus of the University of Washington, discussed the chemical composition of stars.

Fall 2010 NES-APS Meeting

The Brown Physics Department will host the Fall 2010 joint meeting of the New England Sections of the American Physical Society (NES-APS) and the American Association of Physics Teachers (NES-AAPT) on October 29-30. This semi-annual event typically draws between 100 and 200 participants from around New England. The meeting will revolve around the theme of "nanobiophysics", but will accept contributed papers from all other areas of physics. The meeting will include invited talks and a banquet, and the active participation of students (undergraduates and graduates) is strongly encouraged. For more information, please contact Prof. Derek Stein, or check the meeting website: http://www.physics.brown.edu/NES_APS/index.asp.

Hanoi University of Science

In October 2008, a memorandum of agreement was signed by Brown's Department of Physics and the Hanoi University of Science (HUS) to formalize cooperative relations between the two entities. Since then, a total of six faculty members from HUS have spent time at Brown observing classes and reviewing curriculum materials. The visitors met with various faculty in the Department to discuss teaching methods and spent time with laboratory staff to learn about demonstration experiments involving mechanics, electricity and magnetism. Nguyen Dinh Dung, an associate professor from HUS, observed PHYS 0070 Analytical Mechanics and PHYS 2030 Classical Theoretical Physics during his time on campus. He recently wrote that the "two months of working and studying at Brown were very useful to me, and laid the foundation to prepare my new lecture on theoretical mechanics." Additional HUS faculty are expected to visit Physics this year.

In the spring of 2009, Emeritus Prof. H. M. Fried of Brown's Physics Department spent a week lecturing at the Chemistry Faculty of the Hanoi University of Science (HUS). The first week's lectures were in Basic Electromagnetism, at the level of Electrostatics (Gauss' Theorem, Green's Formula) and introductory Magnetism. It was possible to cover this much material because each lecture lasted three hours, five days in a row! A quiz took up the sixth day's three-hour period.

The purpose of this invited visit was for HUS to see first-hand the American style of teaching science: informal, with eye-contact between professor and student, and questions posed to and answers received from the students during the lecture. It was a learning experience for them, to have the possibility of speaking up in class – answering a professor's question, or questioning the professor's last statement – things that are usually not done in Eu-



ropean or Russian university education. In a private communication, the Dean of the Chemistry Faculty explained that they wanted to learn American educational methods, and that they preferred having physics taught to their chemistry students by professional physicists.

All the instruction was in English, which the young students understood and spoke with a reasonable fluency. Perhaps the most striking aspect was the ubiquity of (American) English, and the open and warm welcome shown to Americans, who were treated with a friendliness that went far beyond what any business transaction required. Prof. Fried returned with many pleasant memories and new things learned. For example, he now often heads to a Vietnamese restaurant in the Providence area to sample Pho, which he pronounced "a delightful and filling lunch." He says it's not bad for breakfast either.

Tenth Workshop on Quantum Chromodynamics

The Tenth Workshop on Quantum Chromodynamics was held June 8-12, 2009 at the Institut d'Astrophysique de Paris, France. Prof. Chung-I Tan, together with Berndt Mueller, J.B. Duke Professor of Physics at Duke University, served as co-directors. Ten half-day sessions, dealing with various and distinct themes within

the general QCD framework, were organized and chaired by leading high-energy physicists to form the principal part of the workshop program.

These workshops have been a witness to the evolution of our understanding of QCD, from perturbation theory to non-perturbative lattice and analytic formulations, and more recently to the age of gauge/string duality; and one cannot help but look forward to profound non-perturbative developments in years to come. Topics covered at this workshop ranged from calculating gluon amplitudes using AdS/CFT, high density phenomenon at RHIC, diffraction and Higgs production at LHC, conformal windows beyond the standard model, lattice gauge theory, to cosmic ray/astro-particle physics and cosmology.

The June workshop marked a milestone for Prof. H. M. Fried, who, with Prof. Berndt Mueller, originated this series of workshops 20 years ago. The conference banquet concluded with a tribute to Prof. Fried in honor of his 80th birthday from many of his colleagues and former students. A special thank you goes to Mary Ann Rotondo, the Physics Department's conference coordinator, whose skillful management has contributed greatly to the success of these workshops since their inception.



Chung-I Tan, Herb Fried, and Berndt Mueller celebrating Professor Fried's 80th birthday

Faculty Research

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Gerald Guralnik is pursuing research that increases theoretical understanding of the phase structure of quantum field theories through the application of ADS/CFT approaches and through the development of new calculational tools. He is formulating new methods to find and classify solutions to quantum field theory using a complex contour path integral formalism which has helped to understand previously ambiguous computations in stochastic Quantum Field Theory. With cognitive scientists, he is working on the “Ersatz Brain project” which is a mathematical approach to model brain functions. This work has been supported by DOE, DOD and the Julian Schwinger foundation.

Savvas Koushiappas works in theoretical studies of dark matter physics and cosmic structure in the non-linear regime, especially in the context of current and future experimental efforts. His work is focused on building a framework where cosmological predictions can be used to interpret data from dark matter experiments, by utilizing numerical and analytical descriptions of non-linear growth, coupled with new and existing statistical and analysis tools.

Sean Ling is working on two projects, one in nanobioscience and another in condensed matter physics. In nanobioscience, his nanopore group is developing a DNA sequencing technology using solid-state nanopores; in condensed matter physics, his vortex physics group is using neutron scattering to probe the Bragg glass phase, a novel state of matter with topological order that exists in the presence of random pinning. His work on nanopore DNA sequencing is funded by NIH, and his vortex physics project is funded by DOE.

Humphrey Maris is working with the group of Sebastien Balibar at the Ecole Normale in Paris to study the properties of solid helium at very low temperatures. In this experiment the elastic properties of the solid are measured at down to 20 mK in order to determine if there is a transition to the supersolid state. This work is being funded by a grant from The European Research Council.

Brad Marston is developing a statistical mechanics of the Earth's climate. At present, climate scientists run modified models

of weather for decades of model time to determine (for instance) the average temperature of the Earth. This is a little like trying to deduce the properties of a gas by following the motion of billions of molecules -- not a very efficient way to proceed! By contrast, statistical physics permits a direct route to relatively simple laws such as the ideal gas law. Marston's NSF-funded group of graduate and undergraduate students is investigating whether or not a similar approach works for climate.

Bob Pelcovits is working with an interdisciplinary group at Brandeis on understanding the role of material properties in the structure and function of cells and cellular components. He is building on his expertise in soft matter physics to model simple liquid crystal systems to understand how constraints typically found in biology, such as confinement and chirality, lead to emergent properties such as self-assembly. His work is being funded as part of an NSF MRSEC grant based at Brandeis.

George Seidel is supported by NASA for research on microcalorimeters for use as high energy-resolution, single photon detectors in focal plane arrays of x-ray imaging/spectroscopic observatories. In this effort, he works with collaborators at the NASA Goddard Space Flight Center, the University of Heidelberg, and the Korean Research Institute. He also is a member of a DOE-funded collaboration to set new limits on the electric dipole moment of the neutron at Oak Ridge National Laboratory.

Marcus Spradlin's work in theoretical particle physics and string theory relates to dualities between quantum gravity and ordinary quantum field theory. Recently his research has focused on theoretical and computational aspects of perturbative gauge theory and gravity, where the discovery of hidden mathematical structure in scattering amplitudes has led to the development of new algorithms which help to make some previously impossible calculations in Yang-Mills theory possible. His work is funded by a DOE Outstanding Junior Investigator award.

Derek Stein is working on various problems at the interface of nanoscience, soft condensed matter physics, and biological physics. His group uses nanotechnologi-

cal tools such as nanofluidic channels and solid-state nanopores in pursuit of both fundamental understanding and practical applications. Ongoing projects include the study of highly confined polymers, and of slip at the solid-liquid interface. Practical goals include the rapid sequencing of a single DNA molecule, and the development of advanced membranes for fuel cell and energy harvesting applications. His work is being funded by the NSF, the NIH, the DOE, and Intel.

Chung-I Tan's current research has focused on non-perturbative aspect of Quantum Chromodynamics (QCD) and its consequences at high energies. The Gauge/String duality conjecture, through the AdS/CFT String duality conjecture, through the AdS/mechanism, now allows explicit calculation in some QCD-like supersymmetric theories. The challenge is to abstract from these models fundamental concepts applicable to QCD. He is carrying out a series of investigations for a range of problems involving high-energy collisions, based on the work he developed recently in collaboration with R. Brower, J. Polchinski and M. Strassler. This work is supported in part by a grant from DOE.

Jay Tang and his senior associate, Dr. Guanglai Li, recently made headlines on their study of bacterial swimming, with publications in scientific journals such as *Proceedings of the National Academy of Sciences* (PNAS) and *Physical Review Letters* (PRL). In the 2009 PRL article, Tang and Li demonstrate that collision and rotational Brownian motion give rise to accumulation of swimming microbes and animal sperms near any surface boundary. These research findings shed new light on the biological functions of these micro-swimmers, such as bacterial adhesion, infectivity, and perhaps even human fertility.

Greg Tucker's group has observed the very earliest galaxies formed in the universe, when the universe was 1/3 of its present age, using the Balloon-borne Large Aperture Submillimeter Telescope (BLAST) to help understand how galaxies and structures of galaxies formed. BLAST has identified these dust-enshrouded galaxies which are brightest at submillimeter wavelengths and which hide about half of

Faculty Research

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the cosmic starlight. Familiar optical images of the night sky contain many fascinating and beautiful objects, but they are missing half of the picture describing the cosmic history of star formation. Read more in *Nature*, 458, 737 (2009).

Jim Valles' lab discovered that Cooper pairing of electrons, which normally leads to superconductivity, can also produce a strongly insulating state of matter. Their experiments have shown that the resistance of this Cooper pair insulator state grows by more than an order of magnitude in an applied magnetic field. This work is lending new insight into the phases that can form in materials with strong correlations between their valence electrons.

Anastasia Volovich is a high energy theorist working on particle physics, general relativity and string theory. Her research is focused on relations between gauge theories, gravity and string theory. She is developing string theory inspired tools to explore hidden aspects of gauge and grav-

ity theories. Her work is funded by an NSF CAREER/PECASE award and a DOE grant.

Gang Xiao has been working in the emerging field of spintronics, or spin-based electronics, which rely on the electron's spin or its magnetic moment for electronic operation. The advantage of spintronics is that they are nonvolatile compared to charge-based electronics, and quantum-mechanical computing based on spintronics could achieve speeds unheard of with conventional computing. His research has led to a new class of magnetic sensors having the highest sensitivity at room temperature. His research goal is to discover new spintronic devices by understanding the basic properties of spin-dependent electron transport in new materials and nano-structures.

Over the past year, achievements from the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider (LHC) included the first collisions at center of mass energies up to the new record of 2.36 TeV, and acceptance for publication of the first paper based on this data. The Brown

group is involved in several aspects of the experiment, including hadron calorimeter, silicon tracker, and trigger. **Greg Landsberg** is co-leading the Exotics Physics group of the CMS Collaboration. The current focus of his interest is a test of models with extra spatial dimensions, in particular a possibility of producing mini-black holes at the LHC, which he predicted theoretically in 2001. **Meenakshi Narain** and **Ulrich Heintz** are studying top quark production at the LHC, and Prof. Narain is co-leading the group that is conducting searches for new massive Z bosons.

A particular milestone for D0 was the definitive observation of the production of single top quarks. Prof. Narain and graduate student Monica Pangilinan carried out one of the analyses that led to this result; Prof. Heintz and postdoc Shabnam Jabeen also contributed to the study. **David Cutts** and graduate student Yunhe Xie published their search for charged massive long-lived particles, based on Yunhe's PhD thesis. Prof. Heintz and graduate student Daniel Boline completed a new measurement of the top quark mass in the dilepton channel.



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