# Physics at Brown

News for Alumni and Friends

2002 Issue

Greetings! Welcome to the Brown University Physics Department Newsletter. Now is a very exciting time for Brown. Ruth Simmons, Brown's dynamic new President, has in her first year stimulated vigorous activity on campus and in Physics. For President Simmons, a top-rank university such as Brown must continually renew and strengthen itself. She has launched a number of initiatives such as increasing faculty size by 20% over the next 5-10 years, instituting undergraduate need-blind admissions, and significantly improving graduate student support. Her academic enrichment program has taken our breath away! Naturally we are holding animated discussions about how Physics, as the core science, should best contribute to this enrichment.

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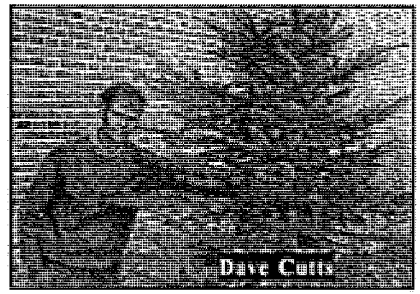
Brown University

With all the attention to enrichment and evolution, we look to our junior faculty to see some of our future. Currently we have six Assistant Professors, who were caught by our enterprising photographer as they were meeting privately to discuss the Department's future (back cover).

Three faculty members, Charles Elbaum, Bob Lanou and George Seidel, chose last year to leave the teaching ranks and become Professors (Research). As this appointment indicates they are now full-time in research: Charles, in liquid and solid helium, with a new interest in carbon nanotubes; Bob, in non-accelerator particle physics, particularly the liquid helium solar neutrino detector prototype HERON, and George, in collaboration with Bob and Humphrey Maris on HERON, and in research developing a new calorimetric magnetic x-ray detector. This work is thriving, attracting students and funding; and Charles, Bob and George's decision to leave the teaching ranks has also made possible new and additional exciting programs. One such is here, with Rick Gaitskell's arrival, and currently we have two open positions being filled soon.


Dave Cutts

The Department celebrated the life of Jack Lubrano, in a memorial service this winter (see p.4). Jack coordinated Physics instruction for many years, and was a good friend to students and faculty. For Jack, physics was fun, and he made it so for everyone.

The generosity of our friends is much appreciated. This year we awarded the Galkin Foundation Fellowship to Stefan Badescu (p.2). Stefan with his PhD advisor See-Chen Ying, uses novel techniques to model the motion of H atoms on crystalline metal surfaces. A new gift in memory of Dr. Raymond Goloskie '53 supported three starting graduate students last summer (p.6).

I hope this Newsletter conveys a sense of the excellence here at Brown. Dave Cutts, Chair, *cutts@physics.brown.edu*

## Theater in Physics 10

**Margrethe:** *Like that particle.*
**Heisenberg:** *What particle?*
**Margrethe:** *The one you said goes through two different slits at the same time.*
**Heisenberg:** *Oh, in our old thought-experiment. Yes. Yes!*
**Margrethe:** *Or Schrödinger's wretched cat.*
**Heisenberg:** *That's alive and dead at the same time.*
**Margrethe:** *Poor beast.*
**Bohr:** *My love, it was an imaginary cat.*

and so on . . . **thus began a recent Physics 10 class.**

This bench reading of "Copenhagen" was followed by some remarks by Professor of History Abbott Gleason, followed by a smattering of physics questions handled by Thomas J. Watson Sr. Professor of Science Leon N. Cooper. Yet other discussions and queries of the class of about 50 were facilitated by Professor of Political Science Thomas Biersteker and Oskar Eustis the artistic director of Providence's nationally acclaimed Trinity Repertory Company.


Anne Scurria, Stephen Thorne, Timothy Crowe

In his Tony Award Winning play, Michael Frayn recreated and examined an historic meeting between two physics

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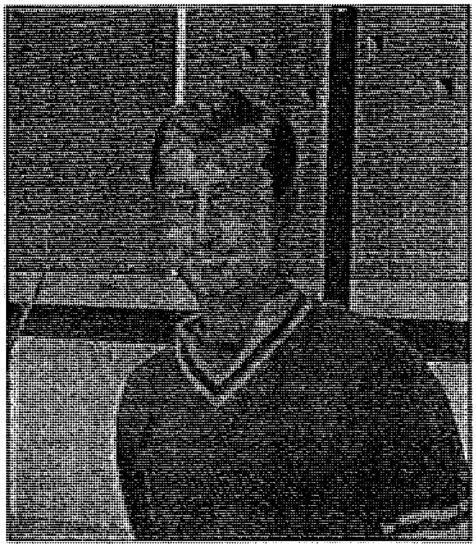
# The Galkin Foundation Fellowship

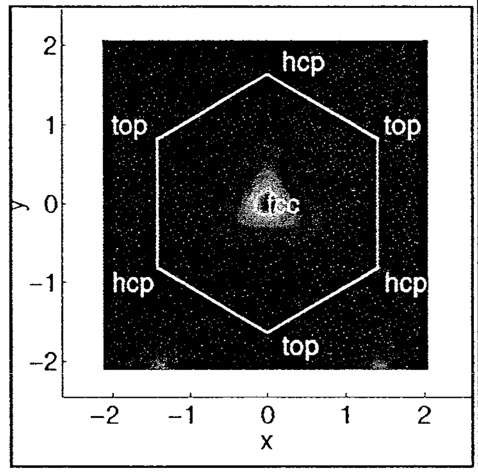


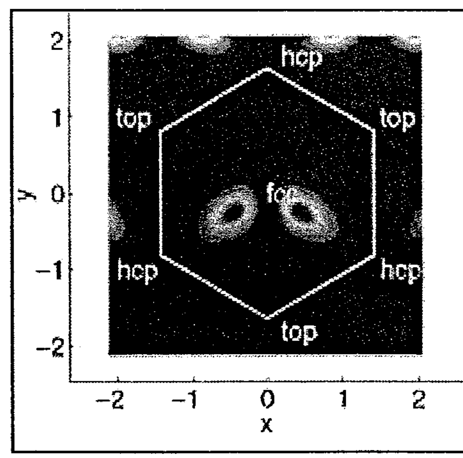
Imagine a hydrogen atom stuck to the surface of a metal crystal, such as nickel. While the metal holds it down quite effectively, the ultralight H atom can move rapidly about parallel to the surface. Recently, Stefan Badescu, this year's Galkin Foundation Fellow, and collaborators have performed numerical calculations that demonstrate the necessity of treating the H atoms as quantum mechanical waves rather than simple classical particles to describe their observed dynamics. Moreover, their novel techniques can also be applied to understand single particle quantum transport in nanostructures.

Stefan has performed his work in close collaboration with his PhD advisor Professor See-Chen Ying in the Condensed Matter Theory Group at Brown and a group at Helsinki University of Technology led by Professor Ala-Nissilä. The project started with the aim of explaining experimental data showing that quantum mechanical effects dominate the diffusion of hydrogen on the Ni(111) surface at very low temperatures. Stefan and coworkers adopted the point of view that the light atom on top of the metal is very similar to an electron in a crystal lattice. The average interaction potential between the hydrogen atom and the surface is periodic in directions parallel to the surface and thus its wave functions are Bloch waves, like those used for describing electrons. Also, like the electrons in a periodic potential the Bloch waves are grouped in bands. For the hydrogen atom case, the different bands correspond to different vibrational states of the hydrogen atom on the surface. With this picture, our Galkin Fellow found that the motion of hydrogen on the metal surface involves an interesting combination of thermal and quantum mechanical processes. An atom is thermally excited into an upper vibrational band and quantum mechanically tunnels via states in that band. The atoms tunnel at a faster rate in the higher bands. This theory accounted for data that could not be interpreted by other theories, which consider only single band motion (S.C. Badescu, S.C. Ying, T. Ala-Nissilä - Phys. Rev. Lett. **86**, 22, 5092 (2001)).

To achieve a quantitative understanding of both the short time vibrational and long time diffusive motion, Stefan and collaborators developed a new quantum trajectory numerical method. They performed large-scale first-principles calculations at the Center for Scientific Computing in Helsinki to find the interaction potential and then they used a very efficient parallel method implemented to find the lowest energy states of a large-dimensional Hamiltonian. The results were compared with Professor Jacobi's Electron Spectroscopy Group in Berlin who have measured the vibrational energies of hydrogen on the Pt(111) surface.

The figures show the calculated probability density distributions $|\psi(r)|^2$ in the plane of the surface. The top figure is the lowest state and the bottom figure is one of the first excited states. The energy required to excite to these states corresponds precisely to one absorption peak in the high resolution electron energy loss spectra. The experimental reciprocal space measurements of these states agree with the calculations, and thus provide direct proof of the delocalization of hydrogen on the surfaces of some metals. This delocalization is a long-standing theoretical idea which had not been supported by direct experimental evidence until the experiment by the Berlin group. A joint experimental and theoretical paper reporting on this appears in Phys. Rev. Lett. **88**, (13) 136101 (2002) S.C. Badescu, P. Salo, T. Ala-Nissilä, S.C. Ying, K. Jacobi, Y. Wang, K. Bedürftig, and G. Ertl.




**The Galkin 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.**

# Newest Faculty Member Hunting WIMPS

**Richard Gaitskell joined the Physics Department at Brown in October 2001, from University College London, UK, where he was a Senior Lecturer. Prior to this he worked for six years at Berkeley (at the Center for Particle Astrophysics) and at Stanford. His graduate and undergraduate training were completed at Oxford.**


Knowing the mass density of the universe is critical to knowing its fate. Experiments designed to measure the density of normal matter (baryons) by studying the abundances of helium and deuterium suggest a certain value. On the other hand, experiments that measure the gravitational effects of matter come up with a much larger number. The newest member of the Brown physics department, Professor Richard Gaitskell, searches for "missing mass" in the form of cold dark matter in an effort to solve this vexing fundamental inconsistency in particle astrophysics and cosmology.

As a member of the executive committee of the Cryogenic Dark Matter Search (CDMS) Experiment, Professor Gaitskell is one of the leaders of the most sensitive experiment in the world looking for WIMPs (Weakly Interacting Massive Particles). Their detection would have profound consequences for both cosmology and particle physics. On the cosmology side, WIMPs are a possible solution to the Cold Dark Matter problem, which itself is part of the wider set of missing mass/energy conundrums that challenge our understanding of the composition of the Universe on the largest scales. On the particle side, WIMPs could be a direct manifestation of Supersymmetry (SUSY) in the early Universe. SUSY is the currently favored theoretical model that will take us beyond the Standard Model of particle physics.

The hypothesis is that WIMPs were created in very large numbers during early stages of the Big Bang. About 1 ns into the evolution of the universe they fell out of equilibrium with the fire-ball and subsequently interacted with the rest of the universe through their gravity. The mass of our own Milky Way would be dominated by them (by a factor of 10 relative to conventional matter). They are so prodigious that at any given time a beaker in a laboratory on earth contains about ten of these particles.

If WIMPs really exist, it will be possible to detect their occasional collisions with nuclei. The CDMS experiment uses novel detectors buried in underground sites based at Stanford, CA, and more recently in Soudan, MN. The detectors operate at 20 mK above absolute zero, and look for the occasional recoils of WIMPs from target nuclei. These "cryogenic detectors" are single crystal semiconductors (250g Ge, or 100g Si) with thin film microfabricated superconducting circuits on their surface (see Photograph). Incredibly, the current detectors are sensitive to WIMP interactions at a level of 1 event per kg of detector per day. This should be compared, for example, with the typical cosmic ray bombardment at sea level of the order of 1 muon per hand (50 cm$^2$) per second. As a second example the human body emits approximately 10,000 gamma rays per second. In order to shield the detectors from cosmic rays and other radioactive contamination, the experiments have to be sited underground and enclosed by very high purity materials.

There is considerable controversy in the field at the moment since an Italian group has claimed a positive detection of a WIMP signal. The CDMS experiment at Stanford is in direct contradiction with this result. (see the Science Times section of the New York Times on 23 Feb 2002, or follow the links at the web site address given below.) This contradiction will be resolved with the next generation of experiments currently being built. The new phase of the CDMS experiment (II) is being constructed at Soudan Mine, Minnesota, which is about 1 km deep. "First Dark" (as opposed to "First Light" for telescopes) will be this year (2002). It will push the sensitivity to WIMPs a further two orders of magnitude from existing limits down toward an even more incredible one event per kg per year.

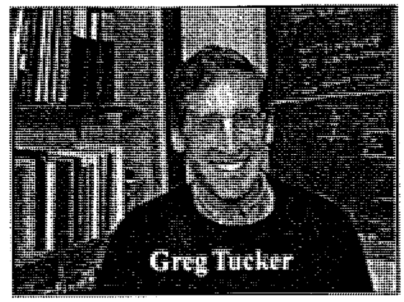
*(For further details follow the links at http://cdms.brown.edu)*

**Photograph of CDMS detectors prior to assembly. The 250 g Germanium disk in the foreground is 8 cm across and 1 cm thick, and is enclosed in a high purity copper surround. When in operation the detectors are assembled in a stack of six per tower and are run at 20 mK. Up to 7 towers of detectors will be in operation.**

# Invited AAAS Speakers


This year's American Association for the Advancement of Science National Meeting featured invited presentations by Professors Sean Ling and Greg Tucker. Each spoke on his respective research areas of vortices in superconductors and the cosmic microwave background radiation.

Ling's recent research with doctoral student Sang Ryul Park and junior Bridget McClain together with Sungmin Choi, Daniel Dender and Jeff Lynn of the NIST Center for Neutron Research settled a fiercely debated question about whether superconductors in an applied magnetic field truly have zero resistance. They showed that the magnetic field induced vortices in a superconductor, whose motion causes resistance, form an immobile rigid solid phase.



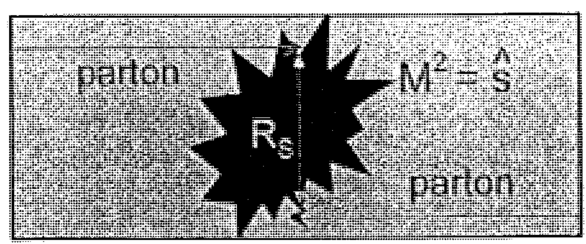

Tucker described his ongoing studies of the radiation left over from the Big Bang and concentrated on the goals of the current MAP (Microwave Anisotropy Probe) satellite mission. MAP, the product of a multiinstitutional collaboration which includes Brown, Princeton, UCLA, the Universities of Chicago and British Columbia and NASA Goddard, was launched in 2001. It is providing precise measurements of the variations in the temperature or microwave radiation across the sky. The details of these variations are expected to reveal "what the fate of the universe will be," Tucker said. "All indications now are that it will continue to expand forever."

## Internet Inter-university Courses

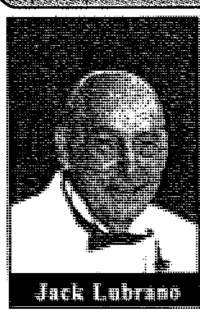
Using a "smart board", the Internet and collaborations with faculty at Syracuse University and Case Western Reserve University, Professor David Lowe has made new special topics courses available to our physics graduate and undergraduate students. Last semester, Professor Lowe broadcast his Brown course on "Quantum Theory of Fields II" to each of these institutions.Currently Professor Laurence Krauss from Case Western, author of "The Physics of Startrek" is broadcasting a course entitled "Astrophysical and Cosmological Constraints on Particle Physics" and Professor Balachandran of Syracuse is lecturing on "Selected Topics in Quantum Mechanics: Fuzzy Physics". This innovation allows for real-time interactions between all the participants and takes full advantage of the high bandwidth Internet II connections that link these different universities.

## Black Holes in the Lab?!

The New York Times and a host of other media recently reported Professor Landsberg's startling prediction that black holes, objects generally relegated to distant parts of the universe, could be produced in the laboratory. The laboratory is the soon to be completed Large Hadron Collider. Confirmation of this conjecture would strongly support models of quantum gravity that invoke extra dimensions beyond the four space-time dimensions with which we are familiar.




## Jack Lubrano 1900-2002




A memorial service celebrated the 102 year life of Jack Lubrano, husband, educator, and member of the Brown physics family who passed away this winter. His wife of 76 years, Ruth, survives him. We remember him with great warmth. Jack was at the heart of the Department's teaching program for many years as the coordinator of the teaching labs and lecture demonstrations. He was dynamic, gregarious and committed to the students. He brought a wonderful sense of humor and balance to the classroom. Typical of his approach was his work with the "Red Ball Express". Phil Bray recounts that Jack would bring this box into class, open it up and pull out various toys useful in capturing students' attention (or in waking them up - especially when tossed in the air towards them) and illustrating some principle of physics. He was a friend to new faculty as they arrived young and green; always easy to approach and helpful. He clearly loved Brown and frequented departmental holiday gatherings and the Ivy Room in the years after he left the department. Upon meeting Dean Hudek at a holiday party, Jack, who was well into his 90's, asked Dean to take him on in the demonstration area!

## 2001 PhD Recipients

**Joseph Adams**, "Energy Deposition by Electrons in Superfluid Helium"
*Advisor: George Seidel*

**ChinSung Bae**, "Chemisorption of H on Cu surfaces: Simulation and First Principles Calculation Studies"
*Advisor: James Doll*

**David Dooling**, "Physics of Flavor and Mass in and Beyond the Standard Model"
*Advisor: Kyunsik Kang*

Daniel Ferrante, Dave Cutts, Luk Chong Yeung, Wessyl Kelly, with PhD grad Shan Wen Tsai

Ben Schrag congratulates Snorri Ingvarrson

**Hsin-Yi Hao**, "Long-wavelength Dispersion and Soliton Formation of Longitudinal Acoustic Waves in Crystalline Solids"
*Advisor: Humphrey Maris*

**Snorri Ingvarrson**, "Magnetization Dynamics in Transition Metal Ferromagnets Studied by Magneto-tunneling and Ferromagnetic Resonance"
*Advisor: Gang Xiao*

**Nicola Neretti**, "An Adaptive Approach to Wavelet Filter Design"
*Advisor: Leon Cooper*

**Shan Wen Tsai**, "Systematic Analytical and Numerical Studies of Highly Correlated Electron Systems"
*Advisor: Brad Marston*

**Hailong Zhou**, "Wide Bandgap Semiconductor Quantum Well heterostructures-Exciton Physics and Light Emitters"
*Advisor: Arto Nurmikko*

## 2001 Senior Honors Recipients

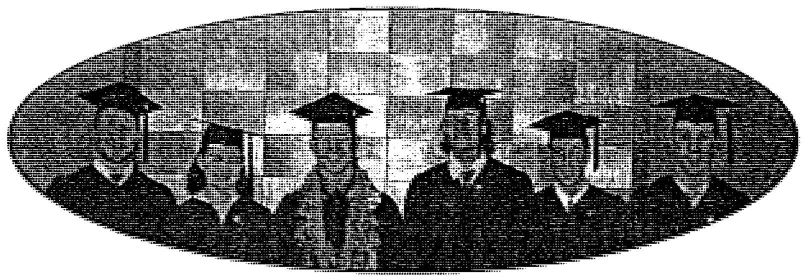
**James Battat**, "A Fast Calculation of the CMB Temperature Correlation Function with NNCorr"
*Advisor: Greg Tucker*

**Nathaniel Brahms**, "The $Z \rightarrow \tau + \tau$ Decay At D0"
*Advisor: Richard Partridge*

**Peter Buchak**, "Suppression of Chaos in a Pair of Nonlimearly Coupled Oscillators"
*Advisor: Herbert Fried*

**Carolyn Ernst**, "Observation and Analysis of Light Intensity Generated by hypervelocity Impact"
*Advisor: Peter Schultz*

**Dagny Atl Maria Kimberly**, "Loitering: A Solution to the Brane Problem in Brane Cosmology"
*Advisor: R. Brandenberger*



**Matt Bycer, Carolyn Ernst, Chris Irwin, Nate Brahms, David Schuster, Peter Buchak**

**David Schuster**, "Real-time Environment for Feature detection, Tracking and Recognition"
*Advisor: Leon Cooper*

**Jason A. Young**, "Evaluating Simplified IKKT Partition Functions Using Monte Carlo Methods"
*Advisor: David Lowe*

**Caterina Schweidenback**, "Studies of Magnetic Field Reorientation of Cleavages"
*Advisor: James Valles*

Tony Houghton, Bob Pelcovits, Brad Marston, See Chen Ying, taken at the 2001 undergrad graduation ceremony


**Physics at Brown**

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*We welcome comments or requests for copies!*

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## Theater in Physics 10

giants. Werner Heisenberg visited his former mentor, Niels Bohr, in German-occupied Copenhagen in September of 1941 and the two had a private discussion that has been the source of speculation ever since. These giants of physics could understand as well as anyone the potential for developing an atomic bomb and the absolute power it would provide the side that obtained it first. Yet, they should not discuss the matter as Bohr, who was half-Jewish and would later work on the Manhattan project and Heisenberg, as head of the Nazi Atomic Energy Project were nominally on opposing sides.

With that play, Professor Cooper saw the opportunity to bring physics to a wider audience within a context that uniquely appeals to the diverse interests of our Brown undergraduates. Ideally, "I think you have to teach science in a historical context because you have to understand why people posed questions as they did.While some standard subjects are left out, my impression is that the students leave with a much deeper understanding of the physics than is usual." Lecture demonstrations ably managed by Jerry Zani make many of the physics concepts come alive.

The students come from a wide range of concentrations including political science, history, and biology. They explore not only physics, but how understanding the physics, history and political science can enhance their appreciation and the actors portrayal of the work. Professor Gleason notes that one of the beneficial effects of the course "is to show the interconnectedness of most human knowledge."


Gleason, Cooper, Biersteker, Crowe, Eustis, Thorne, Scurria

The actors performing the bench readings, Margrethe as played by Anne Scurria, Heisenberg as played by Stephen Thorne, and Bohr as played by Timothy Crowe are preparing for a spring Trinity Repertory Company production.

## PIRA's New President

Physics departments in need of ideas for lecture demonstrations and laboratory experiments across the country make use of the web site and personal expertise of members of the Physics Instructional Resource Association (PIRA). Over the years, the Brown physics department has played a prominent role in this organization, running well attended demonstration workshops, discussion groups at the annual AAPT meetings and other activities. A mark of this prominence came recently, when Jerry Zani, the Manager of Lecture Demonstrations in physics, was elected to serve as president of PIRA. The many faculty who have worked with Jerry and the students who have seen his demonstrations will immediately agree with this well placed recognition.


Jerry Zani

## Summer Fellows Work on Levitation, Correlated Electrons and Superstrings


Karine Guevorkian

The Raymond Goloskie '53 Summer Stipend, a generous gift by Susan G. Nicholson '79 and James A. Nicholson '79 in memory of her father, Dr. Raymond Goloskie '53, a physics professor at WPI, supported the summer research of three promising graduate students.

Karine Guevorkian commenced investigation of the mechanisms by which living creatures sense and are sensitive to gravity. In the near future, she and Professor Jim Valles will test magnetic levitation of biological specimens as a means for dissecting their gravisensing methods.

Sootaek Lee addressed the question of whether the electrons in high temperature superconductors behave as a conventional "Fermi liquid" or as a new state of matter. Recent experiments suggest that the latter is true. Sootaek's calculations in collaboration with Professors Brad Marston and Tony Houghton agree and provide strong evidence that the spin and charge degrees of freedom separate in this new state.

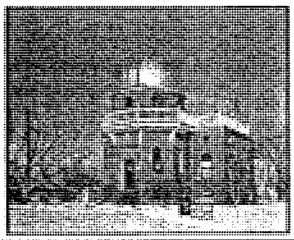
Scott Watson focused on how to unite the theory of the very small (Quantum Mechanics) to the theory of the very large (General Relativity). He uses what is considered to be the most promising avenue, superstring theory. Under the tutelage of Professors Antal Jevicki and Robert Brandenberger, Scott has been investigating fundamental aspects of superstring theory and the constraints placed on it by cosmological observations.

## Seidel Celebration

Former and current students, postdocs, faculty colleagues and friends gathered early this past June to celebrate Professor George Seidel's formal retirement and entry into full time research. The weekend featured a morning full of presentations, replete with reminiscences, on topics in low temperature physics and particle astrophysics; fields upon which George has had and continues to exert a strong influence. The speakers were Bruce McCombe, Sung Ho Cho, Humphrey Maris, Jim Smith, Frank Szofran, Scott Porter, Bob Lanou, Tom Kennedy, and John Quinn.

George and Terry Seidel

**Ladd Observatory**
**210 Doyle Avenue**
**Providence, Rhode Island**
**(401) 521-5680**



**Open Tuesday evenings after dark if the sky is clear.**

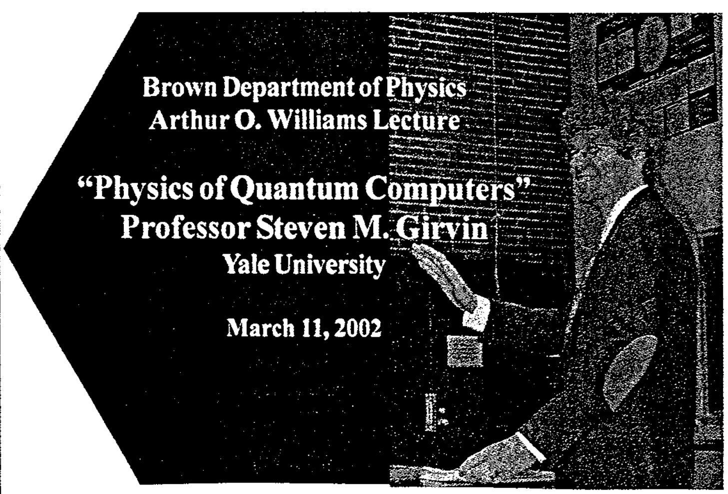
## Brown University Senior, Rachel Pepper, Wins Marshall Scholarship

Rachel Pepper '02, a biophysics concentrator, was one of forty students awarded a prestigious Marshall scholarship this past December. She will use the award to study theoretical physics at the University of Cambridge over the next two years. Her senior thesis research is guided by Professor Sean Ling.

Rachel Pepper

## Brandenberger becomes APS Fellow

Congratulations to Professor Robert Brandenberger who was just elected to the status of Fellow in the American Physical Society. This honor is bestowed on no more than one-half of one percent of the current membership of the society. His citation reads: "For his contributions to the development of inflationary Universe cosmology, in particular the theory of cosmological perturbations and the analysis of reheating."




## Harlow Shapley Lecture

Dr. Wendy Hagen Bauer, Professor of Astronomy at Wellesley College presented "Red Giants, White Dwarfs and Black Holes: the Life History of a Star" at the Starr Auditorium on March 5, 2002. The Shapley Lecture was sponsored by the Department of Physics, AAS, WiSE and the Shapley Endowment Fund.

Dr. Wendy Hagen Bauer

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Physics at Brown Newsletter
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**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**



## Our Junior Faculty

*From left to right* is **Sean Ling**, whose study of vortex physics in superconductors was featured in last year's Newsletter (see also, page 4) and who has another forefront effort in colloidal physics (see Rachel Pepper, page 7). **Ian Dell'Antonio** and **Greg Tucker** are experimental cosmologists; Ian studies the distribution of mass in the universe using gravitational lensing, and co-leads the Deep Lens Survey collaboration, while Greg conducts precise measurements of the cosmic microwave background as part of the Microwave Anisotropy Probe (MAP) satellite team (see page 4) as well as other experiments. **David Lowe**'s research in the frontiers of string theory, "brane-worlds" and the theory of black holes, has caught the imagination of students, for whom he has tunneled through the ether to enrich our program with interactive, inter-university lectures (page 4). Speaking of black holes, **Greg Landsberg**'s calculation of mini black hole production at particle accelerators generated much interest in his particle physics community as well as the public press. Our newest hire, **Rick Gaitskell** is involved in a direct search for "dark matter"; see page 3 for details.