It has been another busy year for us, with a number of new people joining the Department. These include Pierre Wiltzius, the new Susan & Bruce Worster Dean of Mathematical, Life, and Physical Sciences at UCSB. Pierre was selected through a comprehensive international search co-chaired by Jim Allen, my predecessor as Department Chair. We are very fortunate to have been able to recruit Pierre away from the Beckman Institute at the University of Illinois. We warmly welcome him back to UCSB; at an early stage of his distinguished career, he worked as a postdoctoral research fellow with Professor David Cannell.

We also welcome four other new faculty: Assistant Professors Ben Mazin and Ben Monreal, Adjunct Assistant Professor Andy Howell (also a member of the scientific staff of Las Cumbres Observatory), and Lecturer Doug Folsom. Recruitment of top quality faculty is one of our highest priorities, as we strive to maintain the highest levels of excellence in research, education, and outreach. You can read more about our new appointments on page two.

This year, we will continue searches for new faculty. The areas of research that we are targeting include experimental biophysics and experimental condensed-matter physics. Recruitment of a senior faculty member in these areas will be greatly aided by the newly endowed June and Guenter Ahlers Chair in Experimental Physics (see page seven). The Department and I are enormously grateful to the Ahlers’ for the high level of confidence they have expressed in our future through this generous gift.

We are pleased to note that our current faculty continued to receive numerous awards this past year; among these is the prestigious Dirac Medal to Professor Joe Polchinski. See pages two and three for more details on this and other awards.

A major event that received worldwide attention recently was the startup of the Large Hadron Collider (LHC) at the European Organization for Nuclear Research (CERN) near Geneva, Switzerland. More than forty UCSB Physics faculty members, graduate students, postdoctoral researchers, engineers, technicians, and undergraduates have worked for eight years to help construct part of the experimental apparatus that will be used in an international effort to try to answer fundamental questions about the universe. The UCSB group has played a key role in constructing the Compact Muon Solenoid (CMS), a complex array of instruments for detecting subatomic particles that weighs more than 12,000 tons and is as tall as a four-story building. See page three for more details.

While we should certainly take note of our successes, many challenges remain for the Department. We continue to burst at the seams in Broida Hall, and expanded space for our research and teaching efforts is a top priority. Complicating planning for this is the unfortunate fact that the fiscal situation of the University, and the state of California as a whole, remains unsettled; we are certainly not immune to the financial turmoil that has been so prominent in the news. Nevertheless, given the prodigious talent, dedication, and expertise of our faculty, staff, and students, we can only be optimistic as we look towards a future of exciting new scientific developments to be explored.

Mark Srednicki
Department Chair
UCSB Physics
**Appointments**

**Pierre Wiltzius** was named Dean of Mathematical, Life, and Physical Sciences at UCSB. Previously, he was director of the Beckman Institute for Advanced Science and Technology at the University of Illinois at Urbana-Champaign. Wiltzius is a highly regarded researcher and pioneer in the areas of soft-condensed matter, colloidal self-assembly, photonic crystals, and microphotonic.

**Ben Mazin**, Assistant Professor at UCSB Physics, attended Yale University, graduating in 1997. Ben went to the California Institute of Technology, graduating with a doctorate in Astrophysics in 2004. After a short postdoc at Cal Tech, Ben worked as a scientist at Jet Propulsion Labs.

**Benjamin Monreal** is an Assistant Professor. He received his BS from Yale in 1999 and his PhD from MIT in 2004. He works on experimental problems on the intersection of nuclear and particle physics and astrophysics, with a particular interest in new detector technologies.

**Andy Howell** is an Assistant Adjunct Professor and member of the Las Cumbres Oberservatory (LCO). A supernova observer, he received his BS in Astronomy at the University of Florida in 1995, his MS in Astronomy at the University of Texas, where he also received his PhD in Astronomy in 2000.

**Doug Folsom**, Lecturer, is a UCSB graduate, receiving his MA in Physics in 2000 and MS in Media Arts and Technology in 2004. He was a Lecturer for the Department for two quarters before accepting a teaching position in the College of Creative Studies from 2004-2006. Doug returns to UCSB after a two year hiatus, which he spent as a professional guitar player.

**Awards and Honors**

**Joseph Polchinski**, Professor of Physics and permanent member of the Kavli Institute for Theoretical Physics, has been awarded the 2008 Dirac Medal, one of the world’s most prestigious prizes in physics.

Polchinski is one of three scientists to share the 2008 award, which was announced by the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy. Polchinski will travel to Trieste in March 2009 to accept the medal and cash prize.

**Guenter Ahlers** received the 2007 Fluid Dynamics Prize from the American Physical Society for “pioneering experimental work on fluid instabilities, low-dimensional chaos, pattern formation, and turbulent Rayleigh-Benard convection.” The prize, awarded by the American Physical Society, is for outstanding contributions to fundamental fluid dynamics research.

The UCSB Academic Senate has bestowed its highest honor on **David Awschalom**, who was named Faculty Research Lecturer for 2008. The Senate noted that Awschalom “has made remarkable contributions to our campus in the fields of physics and engineering.” Awschalom’s research group explores magnetic and electron spin dynamics within a variety of semiconductor-based nanoscale systems.

**Tommaso Treu** received UCSB’s 2007-08 Harold J. Plous Award, one of the University’s most prestigious faculty honors. The award was established to honor Harold J. Plous, an Assistant Professor in UCSB’s Department of Economics until his untimely death in 1957. The award is presented annually to an Assistant Professor based on outstanding performance and promise as measured by creative action and contribution to the intellectual life of the college community.
Awards and Honors continued

David Gross, director of UCSB’s Kavli Institute for Theoretical Physics and co-recipient of the 2004 Nobel Prize in Physics, received the following honors in the past academic year: Associate Fellow, TWAS (Academy of Sciences for the Developing World), elected 2007; Doctor Philosophiae Honoris Causa, University of the Philippines, Manila, 2008; Doctor Philosophiae Honoris Causa, De La Salle University, Manila, 2008; Doctor Philosophiae Honoris Causa, University of Cambridge, England, 2008; Buhl Lecture, Carnegie Mellon University, 2007; Rothschild Lecture, Cambridge University, 2007; Brickwedde Lecture, Johns Hopkins University, 2007; Van Vleck Lecture, Minnesota, 2008.

Mark Sherwin (left) and collaborators (including Phil Lubin, right) were awarded a $1.75M grant from the Keck Foundation to use the Free Electron Laser (FEL) to study the motion of proteins.

Daniel Hone was awarded the Edward A. Dickson Emeritus Professorship for 2007-08 by the Council of UC Emeriti Associations. The award recognizes academic emeriti who continue to make significant contributions in the areas of university service, teaching, and research.

UCSB Physics ranked among the Top Ten Graduate Schools in US World News and Report. These data come from surveys of more than 1,200 programs and some 14,000 academics and professionals that were conducted in fall 2007.

- Number 1: Best Graduate School – Physics
- Number 4: Best Graduate School – Condensed Matter
- Number 7: Best Graduate School – Elementary Particles/Field/String Theory

A 2007 Chronicle of Higher Education survey also ranked UCSB Physics 8th out of 375 for faculty productivity in the Top Research Universities Faculty Scholarly Productivity Index. The 2007 index compiles overall institutional rankings on 375 universities that offer the PhD degree.

News

The silicon tracker of the Compact Muon Solenoid experiment at CERN – of which Joseph Incandela is the US Project Leader – has been installed. In December 2007, scientists of the US CMS collaboration joined colleagues around the world in announcing the successful installation of the world’s largest silicon tracking detector at CERN in Geneva, Switzerland. Just before midnight on December 12, the six-ton CMS Silicon Strip Tracking Detector began a ten-mile, three-hour journey from the main CERN site to the CMS experimental facility. Later that day, workers carefully lowered it 90 meters into the underground collision hall for the CMS experiment at the Large Hadron Collider particle accelerator.

Of the CMS collaboration’s approximately 2,300 physicists, about 500 are US scientists, from more than 45 U.S. universities and Fermilab, supported by the Department of Energy and the National Science Foundation. The US is the largest single national group in the experiment, and US scientists have built and delivered several key elements of the CMS detector to CERN.

Hubble Telescope Helps Physicists Find ‘Double Einstein Ring’

Assistant Professor Tommaso Treu and former UCSB Physics postdoc Raphael Gavazzi (now at the Institut d’Astrophysique de Paris) have made an impressive astronomical discovery – a form of gravitational lensing called a “double Einstein ring.” This phenomenon has never been observed before. The discovery was made using the Hubble Space Telescope and the Sloan Lens Advanced Camera for Surveys (SLACS) program.

In gravitational lensing, light from distant galaxies is deflected on its way to Earth by the gravitational field of any massive object that lies in the way. Because of this light bending, the galaxy is distorted into an arc or multiple separate images. When both galaxies are exactly lined up, the light forms a bull’s-eye pattern, called an Einstein ring, around the foreground galaxy.

In this case the line-up includes two background galaxies, [continued on page 11]
Articles

Physics Professors get Hands-on at Dos Pueblos High School Engineering Academy

Lars Bildsten and John Martinis’ involvement with a local robotics team has been a victorious one. This past spring, the Dos Pueblos Engineering Academy’s robotics Team 1717 won the regional FIRST (For Inspiration and Recognition of Science and Technology) Robotics Competitions in San Diego and Los Angeles. The team placed second in its division at the International FIRST competition. The Dos Pueblos Engineering Academy (DPEA) offers students a hands-on, college-preparatory four-year science curriculum at Dos Pueblos High School (www.dpengineering.org).

Team 1717, comprised of DPEA seniors, take the Engineering 2 and the FIRST Robotics courses offered with the support of the Santa Barbara County Education Office, through the Regional Occupation Program, in which they learn business and leadership skills in addition to more advanced physics and engineering. They also participate in specialty groups focusing on computer programming, electrical engineering, and mechanics. The DPEA Director, Amir Abo-Shaeer, is a UCSB alumnus, with a Bachelors in Physics and a Masters in Mechanical Engineering and Education. He was honored in 2008 as Educator of the Year by the Goleta Chamber of Commerce.

“The competitions were riveting! My daughter, Erika, was completely consumed for the three months of designing, building and competing,” says Lars Bildsten, Physics Professor and permanent member of the Kavli Institute for Theoretical Physics (KITP). “More importantly, the DPEA is getting kids excited by science and engineering in a very hands-on way. When I was a kid, you could at least work on your car, but today that is impossible. The DPEA’s approach is bringing back the ‘real world’ of what it means to design and build something that works.”

Fellow Physics Professor John Martinis’ involvement was also personal. “My son Scott was in the program for the last four years, and graduated from Dos Pueblos High last fall,” he says. “This was a great program for him, and gave him fantastic ‘hands-on’ experience with engineering through his work helping to build the robot. I was so impressed with the program that I decided last fall to volunteer to be on the Board of Directors.”

Both Bildsten and Martinis are now on the Board of Directors of the newly established non-profit DPEA Foundation (www.dpeaf.org) that is seeking $3,000,000 to match a grant from the State of California for the construction of a new 11,700-foot engineering facility on the Dos Pueblos campus. This facility will enable a three-fold expansion of the program, and provide modern machine shops, computer classrooms, and electronics shops.

A Surprising Connection Between Black Holes and Superconductivity

Recent research – conducted by UCSB Professor Gary Horowitz, Sean Hartnoll (formerly a KITP postdoc and now at Harvard) and Princeton University’s Chris Herzog – demonstrated that the physics of black holes can describe the physics of superconductivity. The paper was in Physical Review Letters this summer.

Black holes, which are among the strangest predictions of Einstein’s general relativity, are regions of space where the gravitational field is so strong that not even light, once it has fallen past the event horizon, can escape.

Superconductors, on the other hand, are materials of great technological interest that conduct electricity without any resistance at low temperatures. Electrical currents can persist for years in metals that have been cooled below the temperature $T_c$ at which they become superconducting. Until recently, it would have seemed impossible that there could be a connection between these two very different physical systems, but the connection between them builds upon the so-called gauge/gravity duality, first proposed ten years ago. The conjectured correspondence, which arose from string theory, is a dictionary that relates a classical gravitational theory – in this case, the black hole – to a strongly interacting field theory – in this case, the superconductor.

While most metals become superconducting only at temperatures below 20 K, certain cuprate compounds remain superconducting at the boiling point of liquid nitrogen, a comparatively balmy 77 K. The physics of these “high $T_c$” superconductors is poorly understood because the current carrying electrons interact strongly amongst themselves. By showing that a new approach to superconductivity is possible, using the surprising connection with gravitational physics, this work may ultimately contribute to a better understanding of high $T_c$ superconductivity.
Robin Snyder is multi-disciplined, both professionally and personally. She received her PhD in Statistical Physics at UCSB in 2001. She is now Assistant Professor of Theoretical Ecology at Case Western Reserve University (CWRU) and co-directs Research at the Interface of the Biological and Mathematical Sciences (RIBMS), a National Science Foundation-funded program that pairs undergraduates in the biological and mathematical sciences to work on projects at the math-biology interface. A Massachusetts native, she has a passion for music and the outdoors.

When and how did you develop your interest in science?
Astronomy was the gateway drug. I started getting into astronomy in elementary school. I remember ordering a book on black holes through a school program in fourth or fifth grade. I devoured it. Then, in middle school, when I learned about stellar evolution, I decided that astrophysics was for me. In high school, I realized that it was the physics part of astrophysics that I really liked.

What made you choose UCSB for your PhD program?
I knew UCSB was very strong in physics, and the Department seemed more interdisciplinary than other contenders. Climate was also a factor – I’d spent four years in northern Ohio and was tired of cloudy skies. Even more important was the scholarship that UCSB offered me. I knew I wouldn’t have to TA while I was taking courses, and that was a big incentive.

What was your area of study?
After a conversation with UCSB’s Roger Nisbet, a physicist-turned-ecologist, I started doing theoretical ecology. Theoretical ecologists use math to think about ecological dynamics, and I saw intriguing parallels with physics. In both statistical mechanics and population biology, we are interested in macroscopic properties like temperature or total population size and not in individual particles/organisms. I wrote a dissertation that bridged the boundaries between statistical mechanics, applied math, and ecology.

What is the focus of your current research?
I’ve spent years thinking about how spatial and temporal variation in environmental conditions affect species coexistence and trait evolution. On the one hand, variation represents risk. If you’re an organism that stays rooted to one spot, like a plant, you need ways of making sure that your progeny survive bad times or places, and that can lead to risk-reduction traits like seed dispersal or dormancy. On the other hand, environmental variation can also represent opportunity. Spatial or temporal partitioning of resources can enable species to coexist that otherwise wouldn’t.

Lately, I’ve been thinking about transient dynamics, the short-term dynamics that occur after a perturbation. These can be very different than the long-term dynamics that we usually study and may be more relevant than long-term dynamics to field studies, which usually take place on an (ecologically) short time scale. I’m particularly interested in what happens if we change the way the environment varies. This is happening all the time: we change fire suppression policies, we change grazing practices, weather patterns are changing. How long do populations take to settle into a new pattern? Do they undergo crashes or outbreaks along the way? What kinds of systems are prone to undergoing crashes or outbreaks?

Tell us about your fascinating alternate life as a troubadour!
My musical life has been as full of unexpected turns as my scientific life. After tendinitis cut short my piano and viola pursuits, I sang with Cappella Cordina, UCSB’s early music choir, throughout graduate school. Later, as a postdoc, I started performing Renaissance songs with a lutenist. Solo singing! Yikes! Chance events led me to record an album of medieval English music for Magnatune, and I’ve been singing medieval music ever since.

What is your advice for a student with lots of interests?
Many of the students I advise worry that they have to decide exactly what to do with their lives and believe that their fates hang on their choice of major. I tell them two things. First, you can change your mind. Yes, planning is important and if you have to change course it can be difficult, but you don’t need to work everything out now. Second, you can’t work everything out now. We have far less control over our lives than we imagine, which can be both frightening and comforting.

RELATED LINKS
Robin Snyder’s page at CWRU
www.biocluster.cwru.edu/~res29/

Briddles Roune: 13th century medieval English songs
www.magnatune.com/artists/briddles_roune
Physics Student Award Recipients 2007-08

Chair’s Certificate of Appreciation Award
Dan Balick

Excellence in Undergraduate Teaching
Harry Nelson, Everett Lipman

Excellence in Graduate Teaching
Omer Blaes

John Cardy Award
Kevin Lee Moore

Outstanding Teaching Assistant
Devin Thomas Edwards, Nicholas William Dellaripa, Christopher James Takacs

Hanan Baddar Fellowship
Kevin Lee Moore

Wheelon Fellowship
Idse Joannes Heemskerk

Ferrando-Fithian Fellowship
Hyejin Ju

Outstanding Senior
Evgene Anatoly Yurtsev

Arnold Nordsieck Prize
Stephen Patrick Parham

Distinction in the Major
David James Broesch, Anthony Joseph Guerrero, Robert Kingman Lanza, Jr., Wah Lun Mak

Physics Highest Academic Honors
Evgene Anatoly Yurtsev, Nicholas Daniel Dunn, Stephen Patrick Parham, Moses J. Marsh, William Evans Sowerwine, Grant Harlan Buchowicz, David James Broesch

Physics Academic Honors
Wah Lun Make, Susanna Kohler, Kyle James Bebak, Christopher Donald Phelps, Ryan Lowell Crites Hazelton, Paul S Luk, Nicholas Edward Pizzo, Robert Kingman Lanza, Jr., Chandriker Kavir Dass, Ian Richard McFarlane, Naushad Khakoo, Maria Matthews

Research Honors
Robert Kingman Lanza Jr., Ian Richard McFarlane, John Dean Billings III, Nile Edwin Fairfield, Grant Harlan Buchowicz, John Thomas Heron, Stephen Patrick Parham, Kathryn L. McGill, Tobias Siavash Mansuripur, Wan Lun Mak

Graduate perspective
As an incoming graduate student, there were too many great research opportunities to choose from in the Physics Department. UCSB Physics programs are among the strongest around, and the faculty are extraordinarily generous with their time. I became involved in particle physics after seeing a Departmental colloquium on black hole production by UCSB Professor Steve Giddings, who was among the first to point out that extra dimensional theories might mean one could make black holes at particle accelerators. I’d also had a great time taking field theory from a superb teacher, UCSB Physics Professor (and Chair) Mark Srednicki, and, of all the interesting graduate seminar talks, most enjoyed those by two of the major players in the 1995 discovery of the top quark, Claudio Campagnari and Joe Incandela. After talking with Joe, I ultimately teamed up with David Stuart, whose research interests were well-aligned with mine, and spent the last five years working at the center of the action, Fermilab, with the best particle physicists from around the world. UCSB continues to play a very important role as the focus now shifts to CERN and the Large Hadron Collider, and I’m very close to choosing one of the excellent postdoc jobs there.

Having seen how many other university groups operate, I’m convinced that UCSB offers a rare degree of support and freedom to follow one’s own path. That has been decisive in my success.

— Antonio Boveia. current UCSB Physics grad student
Thank You, Donors!

WE APPRECIATE THE GENEROSITY of the people and institutions who donated to the UCSB Physics Department.

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Calling All Physics Alumni

Visit our Alumni web pages for more information about how to get involved with the UCSB Alumni community. Find us online at physics.ucsb.edu/people/alumni or email alumni@physics.ucsb.edu.

Free Alumni Email Address

Graduates of UCSB Physics programs qualify for alumni forwarding email addresses (for example: janethedog@alumni.physics.ucsb.edu.) Email sent to that address will be automatically forwarded to a specified email address.

- Send an email alumni@physics.ucsb.edu
- Include your graduating name/year
- Indicate the @alumni address you wish to have
- Provide your forwarding email address

June & Guenther Ahlers Establish Endowed Chair in Experimental Physics

The Physics Department has received a $500,000 gift from Physics Professor Guenter Ahlers and his wife, June, to establish an endowed chair in experimental physics, his area of academic expertise.

The couple said they made the gift to express their appreciation to the University and the department, where he has been a faculty member since 1979. Initially, the Ahlers Chair will support the teaching and research of an outstanding scholar specializing in the subfield of soft condensed matter or biological physics.

Over the years, the couple has given generously to the campus. Their gifts include a large endowment to recruit and support outstanding graduate students in Physics and Affection, a bronze sculpture by Allan Houser.

UCSB Alumni Association

Keep your connection to UCSB by becoming a member of the UCSB Alumni Association. New Life Members receive a free fine art print from award-winning Santa Barbara artist Kate Yarbrough.

Join online at www.ucsbalum.com or call (805) 893-4206.

Members of UCSB’s Experimental Cosmology Group are working on deployment of a 2.2-meter cosmology telescope at the UCSB Millimeter Wave Cosmology Observatory in White Mountain, California. The telescope, pictured above, is called the B Machine and is a prototype for an experiment designed to probe the possible inflationary era of the early universe – an era from which no direct evidence, at this point, has been seen.
Quantum mechanics is perhaps the most mysterious and yet the most successful theory of nature that we have. Its predictions have been spectacularly confirmed in experiment after experiment, involving light, atoms, electrons, nuclei, solids, and subatomic particles. Quantum mechanics also provides a far-reaching understanding of many previously observed phenomena which were otherwise difficult to understand, such as the stability of matter. Nevertheless, quantum mechanics retains a strange, almost magical reputation among casual observers because its basic axioms are remote from – indeed, run completely counter to – our intuition and our everyday experience of the world. Meanwhile, understanding the quantum properties of matter remains a cutting-edge problem for current research. Recently, it was realized that the strange properties of quantum mechanics could be harnessed in new kind of computer, called a quantum computer. Much of the interest in quantum computers is driven by the observation that they could crack codes which are currently undecipherable. However, they are also uniquely suited for the far more useful and exciting (to those of us who are physicists) problem of simulating quantum systems. This has led to an intense effort to develop a specific architecture by which a quantum computer could be realized. Many different physical systems have been explored as possible platforms for quantum computation: ions in optical traps; nuclear spins in various molecules and solids; Josephson junctions in superconductors; even semiconductors, the platform for today’s computer technology, is a candidate, through trapped electrons in silicon or gallium arsenide. All of these systems face one serious obstacle: it is extremely difficult to precisely control a quantum system. In particular, the interaction between a quantum system and its environment is the very reason why the world looks classical. Through its interaction with the environment, a quantum system decoheres and the magic of quantum superposition and interference is lost – the very magic upon which a quantum computer depends. Preventing or avoiding decoherence is, therefore, a primary goal of research on quantum computation.

Together with his colleagues at Station Q and collaborators around the world, Professor Chetan Nayak has been taking an unorthodox approach to this problem. Whereas most researchers have tried to isolate individual ions, atoms, or electrons from the rest of the world and each other, Chetan has been studying systems of electrons which interact very strongly with each other. In such a system, it is hopeless to try to isolate the quantum information carried by a single electron. However, such systems have collective degrees of freedom in which one can encode quantum information. There is a particular class of strongly-interacting electron systems (and, in principle, ultra-cold atomic systems) called topological phases of matter for which the quantum information encoded in certain collective degrees of freedom simply doesn’t couple to the environment. The prime examples are fractional quantum Hall states. These states are observed in gallium arsenide devices in which are the electrons are confined to a two-dimensional layer. The devices are placed in high magnetic fields (~ 10 tesla) and cooled to millikelvin temperatures. Under these conditions, the electrons do not form a crystalline lattice (as was once expected) or a gas of nearly free electrons. Instead, they form a highly-correlated liquid ground state which is spatially homogeneous and isotropic. There is a finite energy gap to creating excitations above the ground state. The excitations are particle-like localized disturbances of the ground state, called “quasiparticles”. Quasiparticles in quantum Hall states have amazing properties: they carry a fraction of the charge of an electron and they are neither bosons nor fermions. When one quasiparticle is exchanged with another in a counter-clockwise manner, a phase which is different from ±1 can result.
A clockwise exchange is distinct from a counter-clockwise one, which a special feature of two-dimensional systems, so it results in the conjugate phase. The phase accrued does not depend on the particular path along which the exchange occurs; only its topological class is important. This is the inherent stability provided by a topological phase of matter, and this is the phenomenon which would be harnessed by a topological quantum computer. In a subset of topological phases, called non-Abelian topological phases, the effect of exchanging quasiparticles is not even a phase, but rather a matrix representing the way in which the state of the system is rotated into another degenerate state. Non-Abelian topological states have proven much harder to find in nature, but they would be more useful for quantum computation. Establishing that a system is in a non-Abelian topological phase is one of the major challenges facing condensed matter physics today.

Ironically, one of the reasons that this is difficult is that the very protection against external perturbations which makes topological phases attractive for quantum computation also makes them difficult to identify and unravel experimentally. However, remarkable progress has been made in recent years. In 2005, Professor Nayak, along with his Station Q colleague, M. Freedman, and Professor S. Das Sarma (Maryland), proposed a topological qubit device based on the hypothesis that the so-called \(\frac{5}{2}\) quantum Hall state is non-Abelian. This state was first observed in 1987, as a hint of a plateau in the Hall resistance. Over the years, as the quality of GaAs devices improved, this plateau became more and more robust. Professor Nayak, along with his PhD advisor, Frank Wilczek (now at MIT), analyzed a model originally constructed by Moore and Read and suggested for the \(\frac{5}{2}\) state by Greiter, Wen, and Wilczek. Nayak and Wilczek showed that the model is non-Abelian and unravelled the structure of the non-Abelian braiding properties of this model. In 2007, Professors Nayak and Fisher, along with two KITP postdocs, S.-S. Lee (now a Professor at McMaster) and S. Ryu (now a Miller Fellow at Berkeley) constructed another possible model (the so-called “anti-Pfaffian” state) for the \(\frac{5}{2}\) state which is also non-Abelian.

If the device proposed by Nayak, Freedman, and Das Sarma works, it demonstrates that this state is non-Abelian. This paper seeded a flurry of activity on related ideas on both the theoretical and experimental fronts. In particular, there has been renewed interest in an experiment probing non-Abelian statistics proposed in 1997 by Professor Nayak, along with his collaborators Professors E. Fradkin (Illinois), A. Tsvelik (Brookhaven), and F. Wilczek.

The qubit device and other “smoking gun” experiments rely on the properties of the gapless, current-carrying excitations which are present at the edge of the system. These excitations reflect the topological properties of the state and can be probed by electrical transport through a quantum point contact. In 2006, Professor Nayak, with Professors P. Fendley (Virginia) and M.P.A. Fisher, constructed a theory for electrical transport through a point contact in a non-Abelian quantum Hall state. A recent experiment by I. Radu et al., published in Science, is consistent with this theory. In fact, these experiments strongly hint that the \(\frac{5}{2}\) quantum Hall state is the “anti-Pfaffian” state which was proposed recently by Nayak, Fisher, S.-S. Lee, and S. Ryu. With his then postdoc (and UCSB PhD) Cristina Bena (now a professor at the University of Paris), Professor Nayak determined the lowfrequency quantum noise (“shot noise”) expected in a measurement of the current through a point contact. This prediction has also been confirmed by a recent experiment by M. Dolev et al., published in Nature.

With such a rapid accumulation of experimental evidence that the \(\frac{5}{2}\) quantum Hall plateau is non-Abelian, this is an exciting moment for the study of topological phases, raising hopes for topological quantum computing. Of course, nature surely has some surprises in store for us. There are some hints that the \(\frac{12}{5}\) quantum Hall state is also non-Abelian and supports a type of non-Abelian anyon called a “Fibonacci anyon,” which is advantageous for quantum computation. Recent experiments also indicate that the superconductor Sr\(_2\)RuO\(_4\) may also be in a non-Abelian topological phase. Thus, the field stretches, on the experimental side, from transition-metal oxides to semiconductor devices. On the theoretical side, it draws from semiconductor physics, correlated electron physics, topological and conformal field theory, knot theory, anyons, and computer science. The braiding together of all of these strands of theoretical and experimental physics and mathematics may form a powerful bridge to quantum computation and, at the very least, is uncovering some fundamental new properties of matter.

**RELATED LINKS**

Chetan Nayak’s research page:
stationq.cnsi.ucsb.edu/~nayak

Station Q: stationq.cnsi.ucsb.edu
Station Q is a Microsoft research group working on topological quantum computing. The group combines researchers from math, physics and computer science.
Debbie Ceder has deep connections to Santa Barbara and to UCSB. Not only was Debbie, her husband, and their daughter all born at the same hospital, they were delivered in the same room (at different times, of course), right here in Santa Barbara.

Debbie became familiar with UCSB at a very young age, visiting her mom on campus (who worked in the Cashier’s Office), and eventually working in the Billing Department. After an off-campus detour into the health care industry, Debbie landed in the Physics Department in 1987.

Consistency is a strong point of hers. As Faculty Assistant for the Experimental High Energy and Experimental Astrophysics group, she’s “been working in the same position for the same group using the same phone number for 21 years.”

The academic environment of the Physics Department suits her. “There was a time when I could carry on a fairly impressive layman’s conversation on high energy physics and state-of-the-art advances in that research,” she says. “It still tickles me whenever I’m typesetting a research manuscript and I’m able to present it to the professor that wrote it and find a tiny little mistake he’s made.”

One of the challenges to the Physics Department she’s observed is that as the Department has grown, there is little space left. “Even the lecture halls are dwarfed under the number of students enrolled in some of our mainstay courses.”

An interest in employee advocacy led her to a 10-year involvement with the Coalition of University Employees (CUE), the union representing clerical employees throughout the UC system statewide. During the “trying times” of the early 90s, Debbie saw the need for a new organized clerical union and to encourage upper management to ease their strict focus on the “bottom line.” She wore many hats during her involvement with CUE, as member of the bargaining team, as Southern Vice President, as Board member, as webmaster, and now, as Treasurer. “It has been a rewarding and fulfilling experience,” she says now. “It has taught me a lot.”

Debbie’s outstanding commitment to her work and to employee advocacy earned her a Citation of Excellence Award from Staff Assembly, UCSB’s chapter of the system-wide Council of University of California Staff Assemblies. “Stunned” by the honor, Debbie received her plaque and prize at the Chancellor’s Staff Celebration Barbeque in May.

Debbie shows as much commitment to her hobbies as to her work. She and her husband Vic have been square dancing together since they met, as teenagers, in a beginner’s program. They both dance at the highest program level and are among less than one hundred dancers capable of this worldwide. Vic’s in high demand as an experienced caller, and so the Ceders have travelled to Japan, Sweden, Germany, Denmark, Belgium, Mexico, England and Canada. “Square dance language,” says Debbie, “is an international language.”

She and Vic are also chocolate connossieurs, keeping an extensive online database of chocolate they have collected, sampled, and rated. “I started off quite the milk chocolate fan, but gradually through this experiment, my tastes have moved decidedly darker. Our daughter is moving to the dark side, as well.” Thirteen-year-old daughter Caitlyn, who has inherited her parent’s eclecticism and sense of organization, categorizes her collection of Beanie Babies on the family website.
Scout troop talks to NASA astronaut

The roof of the UCSB Physics building was the site of a once-in-a-lifetime outreach opportunity during the summer. Thanks to a special collaboration between UCSB Physics, Santa Barbara Amateur Radio Club (SBARC), and NASA, members of Boy Scouts Troop 105 were able to chat with an astronaut aboard the International Space Station (ISS).

NASA astronaut Greg Chamitoff, the flight engineer and science officer currently aboard the ISS, answered questions posed by the young members of Troop 105, based in Goleta. Discussing everything from experiments to sleep habits to meals, Chamitoff shared aspects and insights his life and routine during his six-month tour of duty. “It’s not like you’re falling, it’s more like somebody all of a sudden reached over to the light switch, turned it off, and found out it was a gravity switch,” said Chamitoff, when asked what weightlessness is like. “You don’t care what orientation you’re in any more. It’s wonderful. You feel like Superman, you feel like an acrobat up here.”

“Normally, it’s a five-year wait for this kind of event,” said Glenn Schiferl, who heads UCSB Physics Computing Services and is Scoutmaster for Troop 105. “But one of my Assistant Scoutmasters, John Schlesselmann, was a classmate of Greg’s at Cal Poly. They kept in touch and anticipated doing this.”

Santa Barbara Amateur Radio Club provided the equipment and engineered the contact during the 15-minute “window” during which the ISS passed above the area on August 19. The equipment consisted of a VHF band transceiver and a directional Yagi antenna (mounted on the edge of the roof of Broida Hall) which tracked the station automatically with software and specialized rotors. The club also set up a backup station in case the first station failed.

Several Physics staff are members of SBARC, including Instructional Lab Manager Bob Pizzi and Electronics Shop Manager Cyril Johnson. They were on hand to lend support during the proceedings.

The local chapter of Amateur Radio Emergency Services (ARES) was on hand to continue scout training after the radio contact, so that the scouts were able to earn their “Radio” merit badges.

Chamitoff launched to the station with the crew of STS-124 on May 31, and docked with the station two days later. He is scheduled to return to Earth on shuttle mission STS-125 in November. Previously, Chamitoff was a member of the crew on the Aquarius undersea research habitat for nine days as part of NASA Extreme Environment Mission Operations (NEEMO) 3.

Hubble Telescope Helps Physicists Find ‘Double Einstein Ring’

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thus causing the double Einstein ring. The stunning observation offers insight into the nature of dark matter, dark energy, distant galaxies, and the curvature of the universe.

Because the odds of seeing such a special alignment are estimated to be 1 in 10,000, Treu says that they “hit the jackpot;” the odds are less than winning two consecutive bets on a single number at Roulette.

“The twin rings were clearly visible in the Hubble image,” added Treu. “When I first saw it I said ‘wow, this is insane!’ I could not believe it!”

Photo: NASA, ESA, R. Gavazzi and T. Treu (UCSB), and the SLACS Team
**Where Are You Now?**

We will be featuring more news and information about UCSB Physics alumni and former faculty in future issues of *Inside Physics*. Drop us a line and tell us what you have been doing since attending UCSB. Please include your graduation date and degree.

Call the Publications Coordinator at (805) 893-5228 or email insidephysics@physics.ucsb.edu.

**CHANGE OF ADDRESS?**

Please contact UCSB Physics at the phone or email above.

Image: Helen Hansma’s research suggests that spaces between mica layers may have provided exactly the right conditions for earliest life on earth. Biological molecules tend to bind well to mica. This atomic force microscope (AFM) image shows four yellow loops of DNA on a blue mica surface with a damaged purple-red area on the left, where some of the top [blue] layer of mica peeled off. Dr. Arkadiusz Chworos, UCSB Physics project scientist, is starting research to test the hypothesis.

500 nm

*Photo: Helen Greenwood Hansma, UCSB*

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