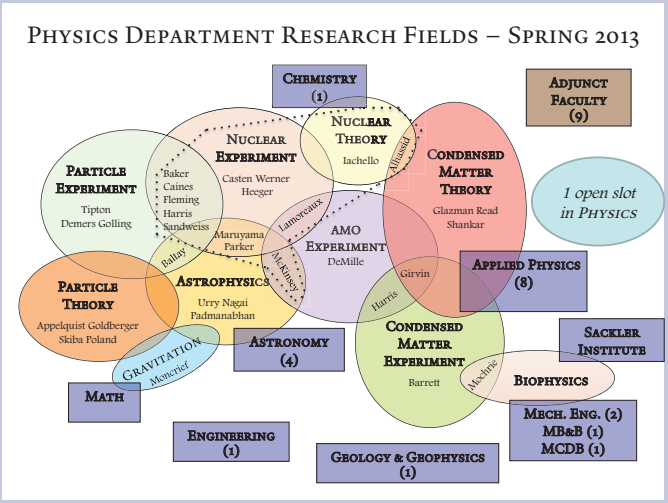
Yale Department *of* Physics

Summer 2013

Greetings from the (Former) Department Chair –

When I became Department Chair in 2007, I immediately began planning my first Newsletter. It is now 2013 and you are reading the one and only newsletter I've managed to put together during my term. It's a sign that a lot of other things were happening, and as I step down as Department Chair, I am really pleased to tell you about all the wonderful things we have accomplished, despite some challenging financial times.

My first priority as Chair was strategic planning for the coming decade. Over a period of several months in the fall of 2007, we held faculty discussions nearly every week. Six faculty members gave overview talks, outlining the science landscape in nuclear physics, particle physics, condensed matter physics, atomic/molecular/optical physics, biophysics and astrophysics. Discussions about the challenges and opportunities then led to a prioritized list of future research directions. The Venn diagram illustrates the interdisciplinary nature of our Department, with research that overlaps within and outside the Department.



The Venn diagram of research areas in the Yale Physics Department (ovals), with faculty listed in their area(s) of expertise. Dotted line indicates WNSL faculty. Our strong ties to other Yale science and engineering departments (boxes) are indicated by the number of faculty in those departments with joint appointments in Physics (numbers in parentheses).

One of the key issues was the future of the Wright Nuclear Structure Lab, which has been such an important part of the Department and of Yale. With two senior WNSL faculty members likely to retire within the 10-year horizon of the Strategic Plan, it was crucial to understand which future directions made the most sense for us. We had many long discussions within the Department, with our partners at the Department of Energy, and with colleagues across the wider physics community, and during this time, the Tandem accelerator was shut down. Ultimately (skipping over the many details), this process culminated in the appointment of **Karsten Heeger** as a senior faculty member and new Director of WNSL, as well as the junior appointment of **Reina Maruyama** *(see article on faculty appointments on page 3)*. Together with colleagues in particle and AMO physics, WNSL now represents a center of excellence in weak interaction physics, as well as a leader in the development of detectors based on noble gases, including the liquid Argon technology that will be used for an eventual long-baseline neutrino oscillation experiment.

The Physics Department grew and turned over significantly over the past decade, bringing a lot of excitement and vitality. My predecessor as Chair, **Shankar**, hired 16 new faculty, and I have hired 7. Roughly half of the current 33 faculty members have been at Yale fewer than 10 years. These new faculty strengthened the particle physics group just in time for the Large Hadron Collider; added new astrophysics expertise in dark energy, dark matter and cosmology; expanded and broadened the AMO group; added to condensed matter theory; and are now leading the rejuvenation of WNSL. This has meant a lot of attention to mentoring and faculty development: by my count, I oversaw more than two dozen faculty reviews, including 12 promotions and 9 tenure cases – including the first two women ever tenured from within the Department.

The students have responded very positively to all this change. Our undergraduate enrollments have increased to all-time highs and the number of physics majors has grown by a factor of 3-4 over the past decade. They volunteer for our outreach programs and have all sorts of extracurricular fun, like launching rockets, flying on NASA's weightless airplane, and organizing the annual Northeast regional Conference for Undergraduate Women in Physics *(see article on page 17)*, which we regularly host.

Our graduate population hovers just above 100 and applications are increasing each year. Early in my term we revamped and improved the graduate qualifying exam and devised a new advising and oversight process for Ph.D. students (thank you to **Mike Zeller** for chairing that committee). The graduate school also increased our target admission number by 10% and provided new fellowships in biological physics and engineering (thanks to the Sackler foundation), astrophysics and cosmology (thanks to the Gruber foundation), and nuclear physics (the "D. Allan Bromley Fellowship," made possible by the generosity and vision of Physics Department alumni). A 2012 Visiting Committee to the Department documented high levels of satisfaction and happiness among Physics students at graduate and undergraduate levels.

Attention to excellence and diversity have gone hand in hand. In just 12 years we have gone from zero women faculty to

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Chair's Message *continued from page 1*

3 tenured and 2 untenured women plus one African-American man, all top-ranked scientists whose research, teaching and citizenship have added enormously to the Department. Roughly 1/3 of our undergraduate physics majors are women, compared to the national average of 20% – indeed, we have the highest percentage of women receiving physics bachelors degrees of any of the top 12 physics departments ranked by *US News & World Report* (based on IPEDS data for 2007-2011;thanks to MIT Physics Chair Ed Bertschinger for quantifying this). At the graduate level: the 2013 incoming class of graduate students includes 8 women and 18 men (31% female). Yale Physics now recruits graduate applicants at meetings of the National Society of Black Physicists, the National Society of Hispanic Physicists, and the Society for Advancement of Chicanos and Native Americans in Science.

Elsewhere in this newsletter you can read about the Graduate Alumni Reunion we held in November 2008, which was a wonderful occasion for finding old friends and meeting new ones. I think our current graduate students benefitted enormously from it, seeing the many post-graduate avenues our alumni have taken. I hope we can maintain close ties with all of you, whether you have visited campus recently or not. I know the new Department Chair, **Paul Tipton**, will be very interested in hearing from you. If you'd like to know more about what we are doing these days, do ask him for a copy of our Strategic Plan.

Alumni visiting in 2008 saw classrooms in Sloane Physical Laboratory that were largely unchanged from their graduate days, with quaint wooden seats painted with gold numbers. Although some of you may be nostalgic for those (uncomfortable!) days, I am very happy to report that SPL classrooms were thoroughly renovated just over one year ago *(see article on page 24)*. The Yale administration also initiated a new planning process for Science Hill, which we hope will include a long-term plan for co-locating physics faculty scattered across 3 buildings (4, including Applied Physics).

A number of teaching innovations preceded the classroom renovation. For more than a decade we have been "flipping" the classroom, using interactive and peer-to-peer learning techniques in introductory physics (Physics 180-181) and other classes. Physics faculty were among the first to use the new high-tech "TEAL" classroom (Technology-Enhanced Active Learning) in the former Health Services building at 17 Hillhouse, for classes and for our nightly Study Halls for intro physics. Responding to new guidelines from the American Association of Medical Colleges, **Simon Mochrie** created a very successful life science-oriented introductory physics class (Physics 170-171), and **Rick Casten** and **Sid Cahn** revamped the intro physics lab (Physics 165-166) to incorporate life science-related demonstrations. And we are continually improving our pedagogical approaches: more Physics faculty attended the 2012 National Academies Summer Institute on Undergraduate Science Education (held at the new West Campus) than faculty from any other single science department.

Yale College Dean Mary Miller has asked all the science departments to step up their teaching. As part of this initiative, the Physics Department created a suite of classes to appeal broadly to students across campus. **Sarah Demers** initiated "The Physics of Dance" and "The Physics of Music," both heavily oversubscribed. Similarly, **Frank Robinson** and **Stephen Irons** have to turn away applicants for "Movie Physics," which teaches basic physics to the less mathematically sophisticated using some attention-grabbing film clips. **John Harris** and **Helen Caines** teach "Modern Physics" (all the cool stuff) to non-majors, many of whom proudly report being astonished that they now understand quantum mechanics and other complicated concepts. Most recently, **Rick Casten** developed a course on "How Things Work" with input from undergraduates.

Some of you probably remember the "Science and Public Policy" class that Allan Bromley used to teach. I'm delighted to tell you that **Bonnie Fleming** revived this offering, and it satisfies a writing credit no less. She brought an impressive array of policy leaders to campus as guest speakers, including a former NASA Administrator, a former Presidential Science Advisor, a former congressman/physicist, the former head of Fermilab, a member of the President's Council of Advisors on Science and Technology (our own President, Rick Levin), and senior officials from the National Science Foundation, the National Institutes of Health, and the Department of Energy.

We provide many opportunities for undergraduate research, taking dozens of students into our laboratories every summer and throughout the year. **Tobias Golling** experimented with building interest in physics research by taking students from his intro physics class on a tour of Brookhaven, and each summer the entire particle experiment group has taken a dozen or more undergraduates to CERN.

Goodness, this Chair's column has gotten very long indeed. And I haven't even mentioned our expansion in astrophysics, including a new partnership in the Keck telescope (jointly with the Astronomy Department and with critical support from the provost's office), the largest fully-instrumented telescope in the world, as well as in the Sloan Digital Sky Surveys III and IV. Or that the Vekselberg foundation generously supported several long visits by Russian scientists. Or the gifts that have supported other vital initiatives in the Department. Or the great outreach programs we're known for. I hope you'll read about many of these things elsewhere in the Newsletter.

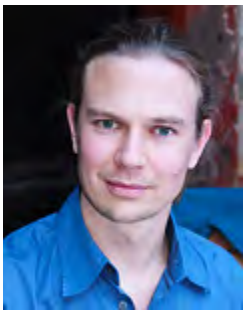
But it's time to bring this long greeting to a close. I'm personally very proud of what we have managed to accomplish in the past 6 years but of course my departmental colleagues have done most of the heavy lifting and the Provost's office has provided the essential resources. I'd also like to acknowledge the incredible support from a crack Physics staff, starting with **Pam Bosward**, the invaluable Chair's assistant on whom I leaned very heavily. All the other administrative assistants work hard to make the Department run smoothly, pitching in whenever and wherever needed, as do our Business Managers, headed up by the hard-working **John Fox**. The talented scientists in the instructional support group, led by **Stephen Irons**, continually invent and improve the classroom demonstrations and labs, as well as teach the occasional class. And finally, the whole Department is motivated and energized by the students and research staff who are where the physics starts. This is a remarkably collegial, effective and impressive group of people and I'm lucky to be a part of it.

As for you, dear Reader, please stay in touch! We'd love to see you if you are in New Haven, especially if you'd like to talk about your career path to students. Or just drop us a line or "like" our Facebook page (maintained by the amazing **Daphne Klemme**). We look forward to hearing from you.

– Meg Urry, Physics Department Chair 2007-2013

Faculty News — New Faculty

Sarah Demers was appointed as an Assistant Professor of Physics in 2009. She is a member of the ATLAS Collaboration at CERN's Large Hadron Collider. Her group's focus is on using tau leptons to discover and characterize new particles like the Higgs boson, taking advantage of this heavy, short-lived, third generation particle's unique characteristics and strong couplings to many theorized new particles present in theories beyond the current standard model of particle physics. She recently succeeded in the difficult quest to measure tau polarization, which marks the first time this has been achieved at a hadron collider. Sarah received her Ph.D. from the University of Rochester and was a Research Associate at the SLAC National Accelerator Laboratory before coming to Yale in 2009. She was awarded a Department of Energy Early Career Award in 2011 and Yale's Poorvu Family Award for Interdisciplinary Teaching in 2012; she was also awarded the Seton Elm-Ivy Award in 2012 for co-directing (with Professor Bonnie Fleming) Girls' Science Investigations, an outreach program for middle school girls.



Tobias Golling was appointed as an Assistant Professor of Physics in 2009 and is a member of the ATLAS Collaboration at the LHC. His group is searching for new physics beyond the Standard Model using the highest energy proton-proton collisions, searching specifically for the supersymmetric partner of the top quark, known as the "stop," and looking at top-quark final states, including boosted top quarks and searches in multi-jet final states. He also works on advancing particle-identification techniques at ATLAS, in particular bottom- and charm-tagging, the discrimination of gluon- and quark-initiated jets, and top-tagging. Tobias received his Ph.D. from Universität Bonn, Germany, was a postdoctoral fellow at the Lawrence Berkeley National Laboratory, and an Alexander von Humboldt Foundation Feodor Lynen Fellow at Berkeley, prior to coming to Yale in 2009. He won an Alfred P. Sloan Foundation Fellowship in 2012 and the Cottrell Scholar Award from the Research Corporation in 2013.

Karsten Heeger has just been appointed Professor of Physics and Director of the Wright Nuclear Structure Laboratory (taking over from Professor Keith Baker), starting July 1, 2013. This appointment signals a new emphasis on weak interaction physics at WNSL, a direction that focuses on the interests and expertise of other Yale Physics faculty and hits the sweet spot encompassing high priority science for the Department of Energy and the National Science Foundation. Karsten comes to Yale from the University of Wisconsin, where he was an unprecedented double recipient of prestigious young investigator awards, from both the High Energy Physics and Nuclear Physics divisions. He is well known for his work on low-energy neutrinos, making key contributions to the Daya Bay reactor experiment and to CUORE, the European-led double beta decay experiment. His expertise in neutrinos and particle detection generally has obvious synergies with Profs. Bonnie Fleming (neutrinos), Dan McKinsey (dark matter), Keith Baker and Steve Lamoreaux (axions). Karsten's other claim to fame is that he is married to the talented and accomplished Reina Maruyama (read on).

Reina Maruyama has just been appointed Assistant Professor of Physics, starting July 1, 2013, also coming to Yale from the University of Wisconsin. Though she specialized in atomic physics for her Ph.D. at the University of Washington ("Optical Trapping of Ytterbium Atoms") and in her early postdoctoral years at Berkeley (UCB and the Lawrence Berkeley Laboratory), she then turned to weak interactions, joining the CUORE neutrinoless double beta decay collaboration and convincing her mentor, Stuart Freedman, to join as well (his words). She then moved to Wisconsin, where she joined the IceCube experiment, which searches for energetic astrophysical neutrinos using Antarctic ice as the interaction volume – her interest is in neutrinos from supernovae. She then started a new dark matter detection experiment, DM-Ice, of which she is the Principal Investigator, designed to understand the earlier results from the DAMA experiment. DM-Ice is currently operating in Antarctica. Reina won an NSF Career Award in 2012.

Daisuke Nagai was appointed to the Yale faculty in 2008. He is a computational cosmologist interested in understanding the origin, structure, and formation of the universe. His research focuses on clusters of galaxies and the hot intergalactic gas bound by the cluster potential. By investigating the "gas-trophysics" of the baryonic matter, he has better constrained the properties of the dark matter that dominates the gravitational potential of the cluster and of the dark energy that is causing the expansion of the universe to accelerate at the present epoch. (The discovery of this acceleration earned the Nobel prize in Physics in 2011.) Daisuke's work has helped drive the increasing power of high performance computing (HPC) at Yale, in which the university has made significant investments, and he has been a key member of Yale's HPC advisory committee. Daisuke received his Ph.D. from the University of Chicago and was the Sherman Fairchild Postdoctoral Scholar at Caltech before coming to Yale in 2008. He was awarded the IUPAP Young Scientist Prize in Astrophysics in 2011 and the Cottrell Scholar Award from the Research Corporation in 2012; in 2012 he was promoted to Associate Professor on Term in 2012.

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New Faculty *continued from page 3*

Nikhil Padmanabhan became an Assistant Professor of Physics at Yale in 2009. His research is at the interface of theoretical and observational cosmology, using massive galaxy surveys, like the Sloan Digital Sky Survey, to determine the properties of dark energy. The technique, called Baryon Acoustic Oscillations (BAO), depends on the fact that the very early universe was a thermal plasma with standing waves determined by the volume at the time; those fluctuations were amplified by gravity, and peaks in the density distribution became today's galaxies. By measuring spatial correlations of galaxies at different epochs, Nikhil is able to constrain the equation of state of dark energy and its (possible) evolution in time. In a recent paper, he invented a clever statistical reconstruction of the galaxy distribution that reduced the errors in the measurement by nearly a factor of two – equivalent to increasing the survey area by a factor of three. Nikhil came to Yale in 2009 from the Lawrence Berkeley Laboratory, where he was a Hubble Postdoctoral Fellow and a Chamberlain Fellow, after a Ph.D. from Princeton. He won an early career grant from the Department of Energy in 2012, a Sloan Research Fellowship in 2013, and he was promoted to Associate Professor on Term in 2013.

David Poland started his position as an Assistant Professor of Physics on July 1, 2012. He is is a high-energy theorist specializing in conformal field theory, physics beyond Standard Model, and dark matter. David received his Ph.D. from the University of California at Berkeley, and came to Yale after a postdoctoral fellowship at the Institute for Advanced Study School of Natural Sciences. Conformal field theories comprise a class of quantum field theories that are invariant under scale transformations. They are important effective descriptions of certain statistical mechanical systems, and they may play a key role in elementary particle physics beyond the standard model. David has been pioneering a new approach to strongly coupled conformal field theories making use of symmetry properties and unitarity.

Yale Physics is Family Friendly

Eight faculty members had a total of 13 babies over the past decade, most well before getting tenure. Yale offers faculty members one semester of teaching relief for parents who bear or adopt a child, or whose spouse or civil union partner bears or adopts a child.

This past January at the American Astronomical Society, Yale was singled out as the leader on maternity leave policies for postdocs (in a talk by Harvard Professor Dave Charboneau). The NSF recently changed its policies to be much more family friendly, too.

Faculty News — Retirements and Departures

Professor Michael Zeller, June 2010 - Henry Ford II Professor of Physics, B.S. Stanford University, Ph.D. UCLA, Yale faculty member since 1969, international expert in experimental particle physics, with interests in the matter-antimatter asymmetry. He was the spokesperson for KOPIO, an experiment to measure the rate of a rare K-meson decay. Later he helped build detectors for the Large Hadron Collider at CERN, the world's largest and most advanced particle accelerator ever. He is a Fellow of the American Physical Society, where he chaired the Division of Particles and Fields; he represented the United States on the C-11 Commission to The 1st International Particle Accelerator Conference; he was a member of the High Energy Physics Advisory Panel to the Department of Energy. At Yale, he chaired the Physics Department, and ever after was the resident sage at Physics Department faculty meetings. His excellent teaching was recognized with the William Clyde DeVane Medal for excellence in Teaching and Scholarship and the Yale College Prize for Undergraduate Teaching.

Professor Peter Parker, June 2013 - Professor of Physics and Astronomy, B.A., Amherst College, Ph.D. Caltech, faculty member at Yale since 1966, world renowned nuclear astrophysicist. He studied nuclear processes that generate the chemical elements in the sun and other stars, including explosive nucleosynthesis. His work helped prove that neutrinos undergo oscillations while travelling from the sun to Earth, a discovery that indicated neutrinos are not massless. In recent years, he participated in the Large Underground Xenon (LUX) experiment that aims to detect the elusive particles of Dark Matter. This work was carried out at the Wright Nuclear Structure Laboratory, which he helped make one of the leading laboratories in the world for studies in nuclear structure and nuclear astrophysics. He served as Associate Director and Director of WNSL, and advised 26 Ph.D. students, many of them now in leading positions in universities and laboratories around the world. He was an exemplary university citizen, serving as Director of Undergraduate Studies twice (1973–1984, 2007–2013), chair of the FAS Review committee (2008–2013), and a long-serving member of the Yale College Sexual Harassment Grievance Board (1987–2011).

Our thanks to Penny Laurans, from whose citations these summaries were adapted.

Richard Easther – Accepted a position as Chair of the Physics Department at the University of Auckland, New Zealand, 2011.

Karyn Le Hur – Accepted a position as Research Director in the CNRS (Centre national de la recherché scientifique), Paris, 2011.

Faculty News — Awards and Recognition

O. Keith Baker – Appointed Director of WNSL, 2010; Head, United States ATLAS Analysis Support, 2007.

Helen Caines – Named American Physical Society Woman Physicist of the Month, 2012; elected Fellow of the United Kingdom Institute of Physics, 2008.

Richard Casten – Awarded the 2012 LANSCE (Los Alamos Neutron Science Center) Rosen Scholar Award; the Tom W. Bonner Prize in Nuclear Physics of the American Physical Society, 2011; the Division of Nuclear Physics Mentoring Award (for mentoring women scientists), 2009; Honorary Doctorate from Surrey University, 2008; Honorary Fellow of the Hellenic Nuclear Physics Society, 2008; Mercator Professorship, Germany 2008.

Sarah Demers – Poorvu Family Award for Interdisciplinary Teaching, 2012; Yale's Seton Elm-Ivy Award for co-directing Girls' Science Investigations Awards, 2012; Department of Energy Early Career Award, 2011.

Yale Physics Faculty in the Popular Press

A number of faculty have been writing about science for major news publications.

Meg Urry writes regularly for CNN.com, with previous articles on dark energy, the Russian meteor, asteroids, exo-planets, gamma-ray bursts and science politics.

Paul Tipton wrote last summer about the discovery of the Higgs boson for the Los Angeles Times.

Sarah Demers has done pieces about the Higgs and women in science for the Huffington Post and TED.

Links to these articles are posted on the Department's Facebook page so watch for them.

Bonnie Fleming – Awarded Yale's Seton Elm-Ivy Award for co-directing Girls' Science Investigations Awards; elected a Fellow of the Connecticut Academy of Science and Engineering, 2012; named Kavli Frontier Fellow, 2007, by the National Academy of Sciences.

Steven Girvin – Appointed Deputy Provost for Science and Technology, 2007; Fellow, American Association for the Advancement of Science, 2007; Foreign Member, Royal Swedish Academy of Sciences, 2007; Member, Connecticut Academy of Sciences, 2007; Oliver E. Buckley Prize of the American Physical Society (with AH MacDonald and JP Eisenstein), 2007.

Steven Girvin

Leonid Glazman – The Leverhulme Trust Visiting Professorship, UK, since 2012; Chair of Excellence of Nanosciences Foundation, Grenoble, France, 2008-2011.

Walter Goldberger – Ernest Kempton Adams Research Fellowship, Columbia University Physics Department, 2011; Department of Energy, Outstanding Junior Investigator Award, 2007-present.

Tobias Golling – Cottrell Scholar Award, 2013; Alfred P. Sloan Research Fellow, 2012.

Jack Harris – Arthur Greer Memorial Prize, 2009; DARPA Young Faculty Award, 2009; *Discover Magazine* "20 Best Brains Under 40", 2008; Sloan Research Fellowship, 2007.

John Harris – Director, Wright Nuclear Structure Laboratory, 2008-2010; Robert Hofstadter Endowed Lectures, Stanford University, 2007.

Francesco Iachello – Elected to the Galilean Academy of Arts and Science, Padua, Italy, 2011; Somaini Volta Prize, 2010; elected to the Mexican Academy of Science, 2010; Enrico Fermi Prize from the Italian Physical Society, 2010; Honorary Fellow, Hellenic Nuclear Physics Society, Athens, Greece, 2009; Commemorative Medal from Charles University, Prague, Czech Republic, 2008; Majorana Prize, 2007; Italian Medal of Science, 2007.

Steve Lamoreaux – American Physical Society Outstanding Referee, 2008.

Simon Mochrie – Arthur H. Compton Award from the U.S. Department of Energy's Advanced Photon Source (APS) at Argonne National Laboratory, and the APS Users Organization, 2009.

Daisuke Nagai – Cottrell Scholar Award, 2012; International Union of Pure and Applied Physics Young Scientist Prize in Astrophysics, 2011.

Nikhil Padmanabhan – Alfred P. Sloan Research Fellow, 2013; DOE Early Career Award, 2012.

Peter Parker – Outstanding Referees of the *Physical Review* and *Physical Review Letters* Journals, 2011.

Nicholas Read – Elected to the American Academy of Arts and Sciences, 2013; Appointed the Henry Ford II Professor of Physics, 2012.

R. Shankar – Distinguished Alumnus Award from the Indian Institute of Technology, 2013; Lilienfield Prize of the American Physical Society, 2009.

Witold Skiba – Simons Fellowship in Theoretical Physics, 2013.

Paul Tipton – Appointed Chair, Department of Physics, July 2013.

Paul Tipton

Meg Urry – Elected President of the American Astronomical Society, 2013; George Van Biesbroeck Prize of the American Astronomical Society, 2012; Woman in Space Science Award from the Adler Planetarium, 2010; Honorary Degree of Science from Tufts University, 2009; elected to the American Academy of Arts and Sciences, 2008; elected to the Connecticut Academy of Science & Engineering, 2007; appointed Chair, Department of Physics, 2007-2013.

Vekselberg Visiting Scholars Program

Thanks to the generosity of the Vekselberg Foundation, the Yale Physics Department has established an exchange program with Russian physicists, as part of the larger Vekselberg effort to establish grass-roots ties between our two countries. The objective of this program was to build on previously successful collaborations between Yale and Russian scientists in order to advance theoretical physics research, provide novel insights into some of the most prominent challenges in physics, and promote continued collaborative projects. In 2010, the Yale Physics Department welcomed Kirill Nagaev from the Institute of Radioengineering and Electronics, Moscow, to work with Professor Leonid Glazman, and Mikhail Kozlov, from Petersburg Nuclear Physics Institute, to work with Professor David DeMille. In 2011, Professor Glazman invited Yakov Fominov from the Landau Institute for Theoretical Physics, Moscow to be the third Vekselberg Visiting Scholar.

Professor Glazman's work with Professor Nagaev and Dr. Fominov resulted in the publication of two papers in the journal *Physical Review*.

The success of the Vekselberg Visiting Scholars Program has allowed the Department of Physics at Yale to leverage additional sources of funding for research collaboration from the Nanosciences Foundation based in Grenoble, France. These efforts led to a paper by Professor Glazman, Dr. Fominov, and Nanosciences Foundation physicist Dr. Manuel Houzet (2011, *Phys. Rev.* B 84, 224517). Establishing collaborative relationships with researchers from international institutions like these is crucial to the dissemination of knowledge and advancement of physics research.

Kirill Nagaev (Institute of Radioengineering and Electronics) *and* **Leonid Glazman** – Professors Nagaev and Glazman collaborated on a project devoted to understand the low-temperature resistive losses in a superconductor. This problem was initially addressed theoretically by Mattis and Bardeen over 50 years ago. Recent low-temperature experiments revealed systematic deviations from the Mattis-Bardeen formula, apparently due to non-equilibrium effects. Professors Nagaev and Glazman developed a proper generalization of the Mattis-Bardeen formula and applied it to a particular practical setting. Professor Nagaev's specialized expertise was crucial to all aspects of the research. The visit provided enough momentum to resolve the remaining issues by an extended long-distance collaboration, culminating in a paper in *Physical Review B* (G. Catelani, L. I. Glazman, and K. E. Nagaev, 2010, *Phys. Rev.* B 82, 134502).

Two additional areas of research discussed during Professor Nagaev's time at Yale form the basis of ongoing collaboration: the low-temperature resistivity of carbon nanotubes (in collaboration also with **Dan Prober**, Professor of Physics & Applied Physics at Yale) and the effect of electron-electron interaction in metallic point contacts.

Mikhail Kozlov (Petersburg Nuclear Physics Institute) *and* **David DeMille** – Professors Kozlov and David DeMille collaborated on a project to examine minute deviations from ordinary physical laws to infer the existence of unknown particles and forces. They worked jointly on theoretical calculations based on the interactions between small mass particles to identify parity violation, or conditions in which a reversal in all three directions of space results in a fundamental change, as a means to discover novel particles. Professor Kozlov's expertise has been critical in developing sophisticated calculations and novel approaches to measure these effects. During his time at Yale, Professor Kozlov presented a seminar entitled "*Using microwave spectra of molecules to study variation of electron-to-proton mass ratio in astrophysics,*" which allowed the entire department to benefit from the unique expertise and cultural distinction of this world-renowned scientist.

Currently, Professors Kozlov and DeMille continue to collaborate (remotely) on precise calculations to address parity non-conservation, and they expect to finalize a paper in the fall. There are also plans for Professor Kozlov to give a series of pedagogical lectures for graduate students as part of a joint program between Yale and Harvard that is led by Professor DeMille. This will enrich the experience of the future generation of scientists through discussions with this renowned scientist.

IN MEMORIAM

Professor Michael Schmidt died November 18, 2007. Michael received his Ph.D. from Yale in 1979, then was a postdoc from 1979 – 1981 and then became a faculty member at Yale in 1981. Michael Schmidt remained at Yale as he advanced from a post doctoral position to Full Professor. In 1986 he received a Sloan Foundation fellowship. In his early research he collaborated with Yale professor Robert Adair on K decays. These studies included CP violation through the muon decay mode, ε'/ε measurements, and searches for rare decay modes of the Kaon. In 1991 he joined the CDG collaboration at Fermilab, bringing his interest in collider physics in general and a specific interest in B physics. He designed and built the trigger system that is central to the operation of the detector. He co-authored some 300 papers. He rose in the CDF collaboration to leader and co-convener of several efforts of the collaboration. His interest was always in B physics, and with his colleague at Yale, Professor Colin Gay, he led a paper on the lifetime differences between the heavy and light B_s mesons.

Turning his attention to the large Hadron Collider at CERN, Professor Schmidt joined the ATLAS collaboration in 2003. At ATLAS he was Yale's institutional representative and he was in the Transition Radiation Tracker group. His group at Yale designed and built critical electronic components for the tracker system.

Professor Schmidt was a member of national committees charting the future of High Energy Physics in the United States, most recently the Particle Physics Prioritization Panel. He was also on committees advising other institutions about their plans. At Yale he served in several ways, from Director of Graduate Studies for the Physics Department to membership on the Yale College Executive Committee.

Yale Gains Access to Large Telescopes in Hawaii

Chemists and biologists have their labs on campus but astronomers and astrophysicists have theirs on remote mountaintops. In 2009, Yale gained access to a powerful new laboratory, the twin 10-meter telescopes of the W. M. Keck Observatory in Hawaii. Completed in 1993 and 1996, the two telescopes are the largest fully-instrumented optical and infrared telescopes in the world.

The summit of Mauna Kea is widely considered to be one of the best observing sites in the world. The Keck telescopes sit at 13,796 feet above sea level, with no nearby mountain ranges to roil the upper atmosphere, and only a few city lights, usually blocked by low clouds, to pollute the night sky. Due to their large size, the telescopes offer some of the best available sensitivity and clarity. On most nights, the atmosphere is clear and still, with what astronomers call excellent "seeing," and further improvements to the image quality are made using adaptive optics (AO) to correct for residual atmospheric turbulence. AO works by measuring the image distortions caused by turbulent air, then using a deformable mirror that changes shape 2,000 times per second to compensate for the distortions.

Additionally, the observatory possesses a powerful array of instrumentation. These include four optical (DEIMOS, ESI, HIRES, and LRIS) and three near-infrared (MOSFIRE, OSIRIS, NIRSPEC) spectrographs. DEIMOS is the most advanced optical spectrograph in the world, capable of gathering spectra from 130 galaxies or more with one exposure. In its "Mega Mask" mode, it can take spectra of more than 1,200 objects at once. MOSFIRE, newly commissioned, is the most advanced multi-slit near-infrared spectrometer in the world. There are also two near-infrared cameras (NIRC and NIRC2/AO) and an interferometer that can combine light from the two telescopes to measure the diameters of stars, disks orbiting nearby stars and the orbital characteristics of binary systems.

In 2009, Yale signed a $12 million dollar, 10-year agreement with the California Institute of Technology granting Yale University 15 nights of observation per year. This was increased to 20 nights per year in 2012. An additional 5 nights per year are available for collaborative proposals with Caltech faculty. This represents a huge step forward for astronomy and astrophysics at Yale, instantly making us competitive with the best peer institutions.

In 2011, Yale and the NASA Exoplanet Science Institute (NExScI) collaborated to open a remote observing facility in the J. W. Gibbs Laboratory. Using a computer and four large monitors, researchers can carry out their Keck (or other) observing programs sitting in the teleconference room on the fourth floor of Gibbs rather than in an observing room at Keck Headquarters on the Big Island of Hawaii. (Almost no astronomers observe from the summit of Mauna Kea because of the downside of low oxygen levels. Keck Headquarters in Waimea, about an hour's drive away, is 3000 feet above sea level and thus much more hospitable.) Yale's remote observing access to Keck is the first such facility on the East coast.

These developments represent a significant investment on the part of the University in astrophysics research. Since the field is so dependent on technology, having guaranteed observing time on one of the world's best telescopes makes Yale attractive

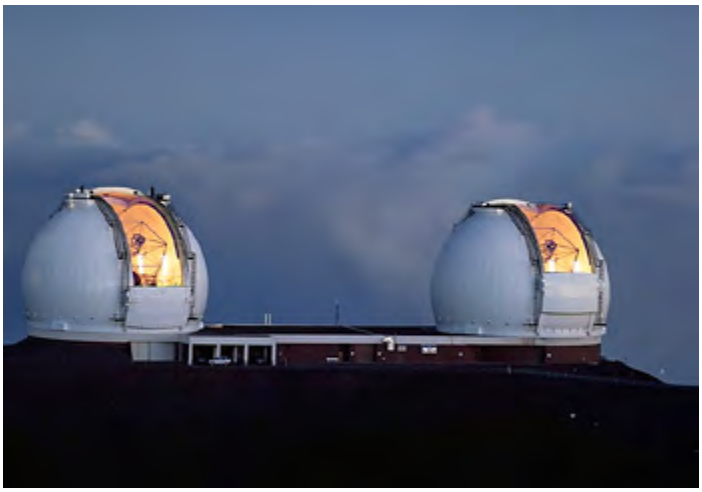


Photo by Rick Peterson

The Keck telescopes on the summit of Mauna Kea

to the very best faculty, post-docs, and graduate students. The first years of Keck access have been remarkably productive, with headline results like tripling the estimate of the number of stars in the universe, finding evidence for dark matter in nearby small galaxies, discovering some of the most distant, youngest galaxies and supermassive black holes and confirming exoplanet candidates as bona-fide worlds around other stars.

Yale's remote observing access to Keck is the first such facility on the East coast.

Just as labs and buildings need regular updates and replacement, Keck will be superseded, in another decade or so, by the next generation of telescopes, which are 20, 30 and even 45 meters in diameter. Yale faculty are particularly interested in the Thirty Meter Telescope (TMT) planned for the summit of Mauna Kea. It's a natural follow-on to Keck since the principal players are Caltech and the Universities of California (current partners in Keck), as well as leading Asian countries like China, India and Japan.

The universe is filled with hundreds of billions of galaxies, each containing millions to billions of stars, all of which evolved from an initial "Big Bang" of energy and particles not unlike those produced in the Large Hadron Collider. Starting from something smaller than an atomic nucleus, our universe developed over the ensuing 13.7 billion years into a vast space dotted with galaxies in a sea of dark matter, dark energy and atomic gas. The baryonic matter emits light at wavelengths from radio to gamma-ray, with some of the most useful diagnostics of temperature and density located in the near-infrared and optical regions of the spectrum. Using cutting-edge tools like Keck (and perhaps its successors), Yale astronomers and astrophysicists will continue to produce key discoveries about how our universe – and the Sun and Earth we call home – came to be.

Graduate Student News — Physics Ph.D.s 2007-Summer, 2013

2007

Betty Abelev, "Multi-strange baryon correlations at RHIC," John Harris

Yang Bai, "Explorations of SU(3) family gauge symmetry," Thomas Appelquist

Sarah Bickman, "Progress towards a Measurement of the Electric Dipole Moment of the Electron using PbO*," David DeMille

Hongzhi Cheng, "Nonadiabatic Dynamics at Metal Surfaces," Sohrab Ismail-Beigi

Kevin Koch, "In Vivo Static Field Perturbations in Magnetic Resonance," Douglas Rothman/Robin deGraaf

Dale Li, "Unexpected Spin Echoes in Dipolar Solids: Intrinsic Effects of Finite Pi Pulses on Quantum Coherence," Sean Barrett

Ruoxin Li, "Phase Variations in microwave carvities for atomic clocks," Kurt Gibble/ David DeMille George Mias, "Domains of Quantum Magnetism," Steven Girvin

Julie Wyatt Love, "Resolved Dynamics of Single Electron Tunneling," Robert Schoelkopf

Jessie Petricka, "A New Cold Molecule Source: The Buffer Gas Cooled Beam," David DeMille

Stephen Powell, "Quantum phases and transitions of many-body systems realized using cold atomic gases," R. Shankar/ Steve Girvin

Aric Sanders, "Optical Properties of Metallic Nanostructures," Mark Reed

Veronica Savu, "The Light at the End of the Tunnel Junction - Improved Energy Resolution of UV Single-Photon Spectrometers Using Diffusion Engineering," Daniel Prober

David Schuster, "Circuit Quantum Electrodynamics," Robert Schoelkopf

Benjamin Turek, "Precision Measurements with the Single Electron Transistor: Noise and Bacaction in the Normal and Superconducting State," Robert Schoelkopf

Mary Vasu, "First order perturbation study of Bianchi III manifolds: dust and radiation," Simon Mochrie

Chun Yang, "Measurement of the Bs Lifetime using Semi-Leptonic Decays with the Collider Detector at Fermilab," Michael Schmidt

Jun Wang, "Scanning Tunneling Microscopy Study of Surface Nucleation and Thin Film Growth: Semiconductors and Metal Oxides," Eric Altman

2008

Anne Bauer, "AGN Variability and Candidate Blazars in the Polomar-QUEST Survey," Charles Baltay

Oana Catu, "Studying parton energy loss in hot nuclear matter using dihadron correlations," John Harris

Catherine Deibel, "The ^26m{Al} (p,g)^27Si Reaction Rate in ONe Novae," Peter Parker

Fei Du, "Studies of Strong Parity Violation and HBT Correlation using Hyperons in Au+Au Collisions Measured with the STAR Detector," Jack Sandweiss

Ran Duan, "On the inverse scattering problem in the acoustic environment," Vladimir Rokhlin

Gustavo Fernandes, "Elastic Light Scattering from Aerosol Particles and Direct Coupling of Micro-Resonators," Richard Chang

Samuel Flores, "Protein flexibility and domain dynamics," Mark B. Gerstein

Tom (John) Giblin, "Using observation to constrain early universe cosmology," Richard Easther

Russell Hart, "Direct Measurement of Quantum Scattering Phase Shift Differences," Kurt Gibble/David DeMille

Yuan Huang, "Statistical Properties of Nuclei in the Interacting Shell Model," Yoram Alhassid

Yong Jiang, "Progress Towards Searching for Electron Electric Dipole Moment Using PbO," David DeMille

Michael Metcalfe, "A new microwave resonator readout scheme for superconducting qubits," Michel Devoret

Sebastian Schmidt, "Electron Interactions in Chaotic Metallic Grains," Yoram Alhassid

John Teufel, "Superconducting Tunnel Junctions as Direct Detectors for Submillimeter Astronomy," Robert Schoelkopf

Christopher Wrede, "Nuclear Energy Levels of 31S and Astrophysical Implications," Peter Parker

Fan Xiao, "An Experimental Study of the Thermal Correction to the Casimir Force using a Torsion Pendulum," Steve Lamoreaux

2009

Stephen Baumgart, "A Study of Open Charm Production in 200 GeV Heavy Ion Collisons," John Harris **John Challis**, "Theory of p-Orbital Bosons," Steven Girvin

Yanqun Dong, "Effects of Hard but Finite Pi Pulses: From Uncontrolled Coherence Flow to Extreme Line-narrowing and MRI of Solids," Sean Barrett

Jiji Fan, "Leptogenic supersymmetry," Witold Skiba

David Glenn, "Development of Techniques for Cooling and Trapping Polar Diatomic Molecules," David DeMille

Ke Han, "Search for Stable Strange Quark Matter in Lunar Soil," Jack Sandweiss

Guoji Lin, "Electro-magnetic Physics Studies at RHIC," Jack Sandweiss

Angel Manzur, "Relative scintillation efficiency in the XENON10 direct dark matter search," Daniel McKinsey

Dennis Murphree, "Nuclear Spin Dependent Parity Non-conservation in Diatomic Molecules," David DeMille

Christine Nattrass, "System size, energy, and particle type dependence of di-hadron correlations in heavy ion collisions," John Harris

Jing Qian, "Commissioning of a New Focal Plane Detection System of SASSYER and Spectroscopy of 257Rf," Andreas Heinz

Wade Rellergert, "Detecting and Imaging He2 Molecules in Superfluid Helium by Laser-Induced Fluorescence," Daniel McKinsey

Elizabeth Williams, "A study of transitional collective behavior in heavy nuclei," Volker Werner

Ryan Winkler, "Spectroscopy of 215Ac and (p,t) Studies of the Stable Palladium Isotopes," Andreas Heinz

continued on page 10

Graduate Student News —

Two Yale Graduate Students Attend 62nd Lindau Nobel Laureate Meeting

In July 2012, 27 Nobel Laureates and 592 young researchers descended upon Lindau, Germany, to discuss current research in physics and build international networks. Two of us, Nicole Larsen and Meredith Frey, were honored to represent Yale Physics and to be among the 80 graduate students who made up the American delegation to the 62nd Lindau Nobel Laureate Meeting. *(Ed. Note: Student delegates had to be nominated by their advisors and submit an application describing why "participation in the Lindau meeting is important for the nominee's graduate education." Four nominees from Physics had to compete for only six nomination slots across all of Yale, then the final selection was made by the meeting organizers.)*

Lindau is a small Bavarian town on Lake Constance, near the German, Austrian, and Swiss borders. All the meeting events were held in various locations on the small island of Lindau, which is packed with medieval buildings and cobblestone walkways. In the mornings, several Nobel Laureates presented prepared talks on their choice of topic and in the afternoon these speakers led informal discussion sessions. There were breakfast science panels, lunch with different delegations, and themed dinner nights. (The dinners hosted by Bavaria and Singapore were particularly lavish – with food, drink, dancers, and singers from the host country.) Without question, the meeting was an amazing fete of well-organized decadence, but the true magic came from the small-scale interactions between young researchers and Nobel Laureates. Below we describe some of our individual experiences at this memorable meeting.

Merideth Frey (Ph.D. 2013, "Using Novel Pulse Sequences for Magnetic Resonance Imaging of Phosphorus-31 in Hard and Soft Solids," Advisor: Sean Barrett): *I had great long, informal chats with the other graduate students from the US, as well as young researchers from all over the world. We discussed our research, professional goals, the various Nobel Laureate personalities, as well as shared information about the culture and politics of our respective countries. I had a great discussion with German students about Germany's transition away from nuclear power, as well as the upcoming US presidential election.*

The meeting also provided a lot of time for young researchers to interact informally with the Nobel Laureates themselves. Throughout the week I had several memorable discussions with various Nobel Laureates: a one-on-one discussion with Dudley Herschbach about improving science education; a lunch with Dan Shechtman where we chatted about life after the Nobel Prize, and a dinner with both Bill Phillips and his wife talking about the day he won the Nobel Prize and the best place to put a name tag.

The final day of the meeting we all took a luxurious ferry ride from the Lindau harbor to the botanical garden island, Mainau. The island was beautiful, but my favorite part of the trip was watching Nobel Laureates dancing to live music on the ferry on the trip back. I left the meeting with a stack of business cards from new contacts, and memories to last a lifetime.

Nicole Larsen (Ph.D. expected May 2015, thesis will be in part on the LUX experiment, which is a xenon-based dark matter direct detection experiment, and also on PIXeY, which is a smaller xenon-based detector that uses the same technologies for imaging of radioactive materials subject, Advisor: Dan McKinsey): *My time at Lindau was a week I will never forget. I went to talks by some of the greatest minds in all of physics. I met students from all over the world, with interests ranging over all areas of science. I ate lunch with Brian Josephson, who won a Nobel Prize for his work with superconductors; I had dinner with Doug Osheroff, who discovered superfluidity in helium-3; and I drank beers with one of my greatest heroes, Brian Schmidt, who regaled us with hilarious stories of being stopped by the TSA while trying to get his Nobel Prize medal through airport security. All of this on my first time ever traveling abroad!*

There were two days in particular at the Meeting that will always stand out in my memory. First, on the morning of July 4, an announcement came from the CMS and ATLAS collaborations at CERN about the 5-sigma discovery of a new elementary particle: the Higgs boson, first postulated over four decades ago and the last particle in the Standard Model to be observed. The Nobel Laureates had a panel discussion with the leaders of CERN about the implications of this discovery. This final verification of the Standard Model represents an enormous victory for particle physics, and indeed, for all of science. How lucky we were to be present in person when this historic event took place!

The following day I participated in a series of debates produced by Nature and Scientific American called "Confronting the Universe". I was partnered with fellow students Sean Bartz and Peter Zinn and Laureates George Smoot and Martinus Veltman to ruminate on the future of the Standard Model. Dr. Veltman shocked us all by flatly asserting that he does not believe in any sort of physics beyond the Standard Model. As a particle physicist who works on a direct dark matter detection experiment, I was suddenly forced to defend the very foundations on which my research is based. I learned a lot, and I loved every second of it. By compelling us to hold our ideas up to a higher level of scrutiny, skeptics like Dr. Veltman are some of the most important people in science.

The motto of the Lindau Meeting is "Educate. Inspire. Connect." Without a doubt, we experienced all three during our time at Lindau. We were educated, inspired, and encouraged when Nobel Laureates were as eager to hear about our work as they were to share their own. We learned a lot, both about physics and about ourselves. Just as important were the connections that we made with other students from around the world. We compared our experiences and our struggles and we talked about the questions that intrigue us the most, and in many cases we forged lasting friendships. To this day we keep up regular correspondences with several of our fellow Lindau-ites and have even traveled to visit some of them in person. During this one week at Lindau, we gained a sense of how our work connects into the big picture and became a part of the global scientific community in a way that we never had before.

– by Merideth Frey and Nicole Larsen

Physics Ph.D.s 2007-Summer, 2013 *continued from page 8*

2010

Peter Adshead, "Cosmological Perturbation Theory and the Early Universe," Richard Easther

Mara Baraban, "Low Energy Excitations in Quantum Condensates," Steven Girvin

Lev Bishop, "Circuit Quantum Electrodynamics," Steven Girvin

Robert Casperson, "Experimental and Numerical Analysis of Mixed-Symmetry States and Large Boson Systems," Volker Werner

Caroline Cardamone, "AGN On The Color-Magnitude Diagram: New Results from Deep Medium-Band Subaru Imaging of the MUSYC ECDFS," Meg Urry

Jerry Chow, "Quantum Information Processing with Superconducting Qubits," Robert Schoelkopf

Li Ge, "Self-consistant Ab Initio Multi-mode Lasing Theory and its Applications in Random and Complex Media," Douglas Stone

James Gilmore, "Binary Dynamics, Black Holes, and Inflationary Perturbations: Applications in General Relativity and Field Theory," Walter Goldberger

Paul Hamilton, "Preliminary results in the search for the electron electric dipole moment in PbO*," David DeMille

Thomas Jackson, "Properties of minimum spanning trees and fractional quantum Hall states," Nicholas Read

Jonathan Jerke, "Study of Quasar Variability," Charles Baltay

Hugh Lippincott, "DEAP/CLEAN: Detecting dark matter with liquid argon and liquid neon," Daniel McKinsey

Xinhui Lu, "Dynamic and Static Structure Studies of Colloidal Suspensions with XPCS, SAXS and XNFS," Simon Mochrie

David Rahmlow, "Towards a measurement of parity nonconservation in diatomic molecules," David DeMille

2011

Anson D'Aloisio, "Cosmology with Cluster Strong Lensing," Priyamvada Natarajan

Colin Anderson, "Measurement of muon neutrino and antineutrino induced single neutral pion production cross sections," Bonnie Fleming

Benjamin Auerbach, "Study of ppbar Collisions that Contain Leptons, a Photon and a b- quark using the CDF II Detector," Paul Tipton

Hal Finkel, "Relics of Preheating After Inflation," Richard Easther

Kevin Garrity, "Ab Initio Studies of Surfaces and Interfaces," Sohrab Ismail-Beigi

Nathan Gilfoy, "Experiments with Trapped RbCs Molecules," David DeMille

Pai-hsien Hsu, "First measurement of Z-->ee cross section with the ATLAS detector and its applications," O. Keith Baker

Anders Knospe, "Yield and suppression of electrons from open heavy-flavor decays in heavy-ion collisions," John Harris

Blake Johnson, "Circuit Quantum Electrodynamics: Volume III," Robert Schoelkopf

Steven Linden, "Measurement of the neutrino charged current pi+ to quasi-elastic cross section ratio in MiniBooNE," Bonnie Fleming

Jason Merrill, "Many-body force and mobility measurements in colloidal systems," Eric Dufresne

Ethan Neil, "Flavor dependence of Yang-Mills field theories," Thomas Appelquist

Peter Orth, "Dissipative dynamics and novel quantum phases in strongly correlated cold-atom mixtures," Karyn Le Hur

Will Shanks, "Persistent currents in normal metal rings," Jack Harris

Joshua Spitz, "Measuring Muon-Neutrino Charged-Current Differential Cross Sections with a Liquid Argon Time Projection Chamber," Bonnie Fleming

Amar Vutha, "A search for the electric dipole moment of the electron with thorium monoxide," David DeMille

Cheng (Brian) Yang, "Progress toward observation of quantum effects in an optomechanical system in cryogenics," Jack Harris

2012

Hanghui Chen, "A first principles study of oxide interfaces," Sohrab Ismail-Beigi

Stephen Eckel, "A Search for the Electron EDM using Europium-Barium Titanates," Steve Lamoreaux

Andrew Jayich, "Laser cooling a 261 kHz harmonic oscillator," Jack Harris

Benjamin Kaplan, "Testing the Standard Model of Particle Physics: A Search for New Phenomena in Multilepton Events with the ATLAS detector at the LHC," Paul Tipton

Sarah Lockwitz, "A Search for the Standard Model Higgs Boson in CDF II Data," Paul Tipton

Vladimir Manucharyan, "Superinductance: a New Element for Quantum Circuits," Michel Devoret

Matthew Phillips, "Sensory Processing in the Olfactory Bulb: From Lateral Inhibition to Behavior," Gordon Shepherd

Carl Schreck, "Mechanical and vibrational properties of model granular media," Corey O'Hern

Brooke Simmons, "Black Hole Growth and Host Galaxy Co-Evolution Over 8 Billion Years of Cosmic Time," Meg Urry

Hasuk Song, "Entanglement in Quantum Many-Body Systems," Karyn Le Hur

Benjamin Zwickl, "Progress Toward Observation of Radiation Pressure Shot Noise," Jack Harris

2013

Christopher Gilbreth, "Ultracold Fermi Gases: Effective Interactions and Superfluidity," Yoram Alhassid Archana Kamal, "Nonreciprocity in active Josephson junction circuits," Michel Devoret

Louis Kastens, "Calibration of Liquid Xenon Time Projection Chambers for the Direct Detection of Dark Matter," Daniel McKinsey

Nicholas Masluk, "Purifying the environment of the fluxonium artificial atom," Michel Devoret

Richard Wall, "A study of heavy flavor quarks produced in association with top quark pair events at sqrt(s) = 7 TeV using the ATLAS detector," Paul Tipton

Blazing the Trail: Essays by Leading Women in Science, co-authored by **Emma Ideal** '15 and Rhiannon Meharchand, is a collection of 35 personal histories meant to educate young women and inspire them to pursue a career in science.

Graduate Student News – Awards and Recognition

The following current graduate students are recipients of honors and awards:

Camille Avestruz – elected to the Bouchet Graduate Honor Society, 2013.

Alexander Cerjan – Yale University Prize Teaching Fellowship, 2012.

Stephen Eckel – Yale University Prize Teaching Fellowship, 2010.

Benjamin Elder – Gruber Science Fellowship, 2012.

Douglas Endrizzi – AAPT Barbara Loetz Scholarship for future high school physics teachers, 2009.

Merideth Frey – featured as one of Scientific American's "30 Under 30", 2012; NSF Graduate Research Fellowship, 2009.

Emma Ideal – elected to the Bouchet Graduate Honor Society, 2013; Kirsten R. Lorentzen Award from the Association for Women in Science Educational Foundation, 2012.

Nicole Larsen – NSF Graduate Fellowship in Physics, 2009.

John Murray – named one of Forbes "30 Under 30" in Science and Healthcare, 2012.

Christine Nattrass – Gertrude Scharff-Goldhaber Prize, 2008; currently an Assistant Professor at the University of Tennessee at Knoxville.

Alice Ohlson – first runner up, Young Scientist Award, Quark Matter Conference, 2012; Nuclear Physics Young Scientist, Quark Matter Conference, 2011.

Matthew Phillips – Ruth L. Kirschstein National Research Service Award from the National Institutes of Health, 2010.

D. Allan Bromley Prize

The D. Allan Bromley Fellowship Fund for Graduate Research in Physics was established in 2005 to honor Professor D. Allan Bromley, Sterling Professor of the Sciences at Yale University and former Presidential Science Advisor to President George H. W. Bush. The Fellowship was created by Prof. Bromley's former students Joel Birnbaum (Yale Physics Ph.D. '65), Joe Allen (Yale Physics Ph.D. '65), and John Manoyan (Yale Physics Ph.D. '87), because of their "deep affection and respect for" Prof. Bromley, in order to "memorialize his exceptional teaching and research career at Yale." The Fellowship is awarded annually to graduate students in Physics who have advanced to candidacy in the Ph.D. program, particularly those "who exhibit a broader interest than just physics, including, but not limited to, science and public policy, engineering, and applied science." Candidates are nominated by the Physics faculty and selected by the D. Allan Bromley Professor of Physics (currently Rick Casten) and the Director of Graduate Studies. The indenture for the award says, "In this way, the recipients will reflect and celebrate Dr. Bromley's distinguished and honorable persona in the exceptional scope, standing, talent, and character of his distinguished personal, public, and academic life." Recent recipients are:

Camille Avestruz, 2013
Aaron Mertz, 2012
Merideth Frey, 2011
Stephen Eckel, 2010
Benjamin Zwickl, 2010

Postdoctural Scholar News – Awards and Recognition

Lilian Childress won the L'Oreal USA Fellowship Women in Science, 2012.; accepted a position as an Assistant Professor at McGill University beginning January 2013.

Johannes Erdmann received the Feodor Lynen Fellowship, sponsored by Alexander von Humboldt Foundation, 2012.

Tetelman Lecture

Physics Department alumnus **David Lee** (PhD '59), the James Gilbert White Distinguished Professor in the Physical Sciences at Cornell (emeritus), visited Yale in October 2010 to give the Tetelman Lecture (an endowed lecture series in memory of Alan S. Tetelman, a Jonathan Edwards College alum and professor of metallurgy at UCLA) about his Nobel prize-winning discovery of super-fluidity in Helium-3.

Moshe Goldstein accepted a position as Assistant Professor at The School of Physics and Astronomy at Tel Aviv University, Israel (starting October 2013).

Anna Henrichs received the Feodor Lynen Fellowship, sponsored by Alexander von Humboldt Foundation, 2012; ATLAS Thesis Award, 2012; Dissertation Prize 2013 of the Divisions Gravitation and Relativity, Hadronic and Nuclear Physics and Particle Physics of the German Physical Society (DPG) for her PhD thesis with the title "Precision Measurements of the Top Quark Pair Production Cross Section in the Single Lepton Channel with the ATLAS Experiment."

Ania Bleszynski Jayich won the L'Oreal USA Fellowship Women in Science, 2008; appointed Assistant Professor at the University of California, Santa Barbara.

Kevin Schawinski won an Einstein Postdoctoral Fellowship, 2009; appointed a professor at ETH Institute of Astronomy.

Tim Schuster received the Feodor Lynen Fellowship, sponsored by Alexander von Humboldt Foundation, 2012.

Physics Alumni Conference: "Today's Physics for Tomorrow's World"

The Physics Department, along with the Graduate School of Arts and Sciences, hosted its first alumni conference in nearly 20 years, on November 7-9, 2008. Current faculty and graduate students welcomed almost 100 alumni from the Physics and Applied Physics departments to discuss physics, tour labs, attend poster sessions and reconnect with one another. Attendees traveled from places as far away as the UK, Turkey, and Australia, and included researchers, business leaders, a Nobel Laureate and even a former astronaut. The event included a banquet at the newly remodeled Silliman College dining hall, enlivened by an after dinner talk by Michael Lubell (Ph.D. '69, currently a Professor at the City College of CUNY) entitled "Symmetry Breaking, Chaos and Dark Energy: Washington's Grand Challenges."

The conference included four panel sessions moderated by Physics Department faculty with guest panelists.

Yale Alumni at the Frontiers of Physics Research,
moderated by **Francesco Iachello**

PANELISTS

Baha Balantekin '82 Ph.D.
University of Wisconsin

Gordon Cates '87 Ph.D.
University of Virginia

Michael Dine '78 Ph.D.
University of California, Santa Cruz

Senta V. Greene '92 Ph.D.
Vanderbilt University

David M. Lee '59 Ph.D.
Cornell University, Emeritus

Marlan Scully '65 Ph.D.
Texas A & M University

Science Policy and Its Implications for Research at Universities and Laboratories,
moderated by **Michael Zeller**

PANELISTS

Charles Baltay '63 Ph.D.
Yale University

Dennis Kovar '70 Ph.D.
U. S. Department of Energy

Arthur Ramirez '84 Ph.D.
LGS - Bell Labs Innovations

Allen Sessoms '72 Ph.D.
University of The District of Columbia

From Yale Physics to the World of Business, Finance and Industry,
moderated by **Thomas Appelquist**

PANELISTS

Joseph Allen '65 Ph.D.
NASA and Private Sector, Retired

Joel Birnbaum '65 Ph.D.
Hewlett-Packard Co., Retired

Piotr Karasinski '87 Ph.D.
HSBC, London

Shiva Kumar '86 Ph.D.
IBM, New York

Zhiping Zhao '93 Ph.D.
CreditSights, New York

Modern Trends in Physics Education,
moderated by **Peter Parker**

PANELISTS

Mark Caprio '03 Ph.D.
University of Notre Dame

Peter M. Koch '74 Ph.D.
SUNY Stony Brook

Richard A. Lindgren '69 Ph.D.
University of Virginia
2008 - Physics | Association of Yale Alumni

Cindy B. Schwarz '85 Ph.D.
Vassar College

Richard N. Steinberg '87 M.S., '92 Ph.D. (Applied Physics)
City College of New York

Alumni Conference photos by Harold Shapiro













Undergraduate Student News —Awards and Recognition

Matthew Adams (ES '07), deForest Pioneers Prize.
Sofia Magkiriadou (ES '07), deForest Pioneers Prize.
Daniel A. Rubin (ES '07), Howard L. Schultz Prize.
Jared W. Schwede (TC '07), Howard L. Schultz Prize.
Douglas Swanson(MC '07), Howard L. Schultz Prize.
Jeffrey D. Thompson (MC '07), Howard L. Schultz Prize.
Ruth B. Toner (ES '07), deForest Pioneers Prize.
Gabriel Humphrey Billings (DC '08), Howard L. Schultz Prize.
Matthew James Gummess (CC '08), deForest Pioneers Prize.
Joseph Michael Larese (JE '08), deForest Pioneers Prize.
David Jonathan Price (BK '08), Howard L. Schultz Prize.
Nicholas Raymond Sedlet (BR '08), Howard L. Schultz Prize.
Rebecca Yale Taft (SY '08), deForest Pioneers Prize.
Adam Michael Bouland (SM '09), Howard L. Schultz Prize.
Eli Aaron Luberoff (CC '09), deForest Pioneers Prize.
Samuel James Post (TD '09), deForest Pioneers Prize.
Lauren Taylor Rosenblum (PC '09), Howard L. Schultz Prize.
Nathaniel Roth (PC '09), Howard L. Schultz Prize; NSF Graduate Research Fellowship (to the University of California at Berkeley).
Axel W. Schmidt (BC '09), deForest Pioneers Prize.
Madeleine Richards Udell (JE '09), Howard L. Schultz Prize.
Rebecca Harding Jackson (TD '10), Howard L. Schultz Prize.
Elizabeth Rose Jerison (SM '10), Howard L. Schultz Prize.
Patrick Martin Madden (MC '10), deForest Pioneers Prize.
Susan Elizabeth Scanlon (TD '10), Howard L. Schultz Prize; Russell Henry Chittenden Prize (given annually to the senior in Yale College majoring in natural sciences or mathematics who ranks the highest in scholarship), 2010.
Matthew Napaaqtuk K. Smith (SY '10), deForest Pioneers Prize.
Michele Diane Trickey (DC '10), Howard L. Schultz Prize.
Ivan Kozyryev (CC '11), deForest Pioneers Prize.
Diana Qiu (ES '11), Howard L. Schultz Prize.
Michael David Weiner (SM '11), Howard L. Schultz Prize.
William J. Zeng (BK '11), deForest Pioneers Prize; Rhodes Scholar, 2010.
Daniel Steven Kapec (SM '12), DeForest Pioneers Prize.
Zachary Michael Sethna (JE '12), Howard L. Schultz Prize.
Emma Berat Alexander (SM '13), Howard L. Schultz Prize.
Ellen Doyle Klein (TC '13), Howard L. Schultz Prize.
Rachel Chava Kurchin (PC '13), Howard L. Schultz Prize; Gates Scholar to study at the University of Cambridge, 2013.
Dominic Tan Shing Kwok (ES '13), deForest Pioneer Prize.
William Henry Wilkin (DC '13), deForest Pioneer Prize.
Michael Karl Medina (ES'14), APS Scholarship recipient for 2012-2013.
Liang Yu (BK '14), junior fellow in the Science, Technology and Research Scholars (STARS) program, 2012.
Carlos del-Castillo-Negrete (TD '15), APS Scholarship recipient for 2011-2012, 2012-2013.

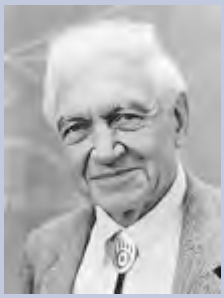
Alyssa Picard is a senior Physics and Classics double major. Unless otherwise noted, she is the author of the articles in this edition of the *Department of Physics Newsletter*. Alyssa is currently the News Editor for the *Yale Scientific Magazine*.

Leigh Page Lectures

Leigh Page first came to Yale in 1909 as an Assistant Professor in drawing and as a graduate student working with Henry Andrews Bumstead. Shortly thereafter, he switched to physics and was appointed Instructor in Physics in 1912. He presented his doctoral dissertation on the photoelectric effects in 1913. In March 1916, Page was appointed Assistant Professor of Physics and in 1922 as Professor of Mathematical Physics. Page held the chair of Mathematical Physics for close to 31 years during which time he advised nine theses. He died just as he reached retirement age in 1952. The Yale Physics Department has held an annual Leigh Page Lecture since 1967. Recent lectures were:

2012 (April): Nima Arkani-Hamad,
Institute for Advanced Study
2009 (September): John Mather, NASA, Nobel Laureate
2009 (April): Carlo Beenakker, Instituut-Lorentz
for Theoretical Physics, Leiden University
2007 (April): Roger Blandford, Kavli Institute of
Particle Astrophysics and Cosmology

Vernon Hughes Lectureship



Former Physics Department Chair, Vernon Hughes, established a fund to support a new lecture series. The inaugural Vernon Hughes Lecture was given in 2009 by Nobel Laureate T. D. Lee, and subsequent lectures have been given by other well-known physicists. Professor Franco Iachello has organized the lecture series every year and Miriam Hughes, Vernon's widow, has been an honored guest at each of the lectures, along with Emlyn Hughes, Vernon's son and Professor of Physics at Columbia University. Here we list the lectures to date:

2009 – Tsung-Dao (TD) Lee, Nobel Laureate
Columbia University
2010 – Gerald Gabrielse
Harvard University
2011 – Samuel Ting, Nobel Laureate
Massachusetts Institute of Technology
2012 – Art McDonald
Queen's University, Kingston, Ontario, Canada

The Yale Drop Team

The Yale "Drop Team" is an organization of around twenty undergraduates who conduct science and engineering-related experiments in microgravity, during a flight on a special "weightless" NASA airplane. Each fall, teams of around five to seven students apply to two of NASA's educational research programs: the Reduced Gravity Student Flight Program and the Systems Engineering Educational Discovery Program. Both programs are very competitive, but at least one Yale Drop team has been successful each year, and sometimes as many as two or three are accepted. Students then design and construct an experiment that they will ultimately test in a reduced gravity aircraft flight out of Houston, Texas, the following summer. This Boeing 727 jet, which flies in a series of parabolic maneuvers, has the unofficial nickname "Vomit Comet" due to the nausea and airsickness it occasionally produces.

A more palatable nickname is the "Weightless Wonder." With a normal flight consisting of 15 periods of equivalent Lunar or Martian gravity, and 25 periods of zero gravity, each lasting around 18 seconds and interspersed by a mix of partial G's between 0 and 1.8, the flight is quite the thrill ride. The periods of zero gravity – the calm in the storm of the roller coaster like flight – are truly incredible. Yale Drop Team member Ariel Ekblaw, called the feeling "exhilarating." She said,

> *"The sensation of microgravity creeps gradually, until the exhilarating realization that you are in fact completely free from any surface. One moment, I was lying on the floor, and the next my body began floating effortlessly upwards, sideways and in all directions. I remember moving the camera for our experiment as my feet and legs stretched out behind me, completely unsupported, as if moving with a mind of their own."*
>
> – Ariel Ekblaw, Class of 2014

Ariel Ekblaw "floating."

Yale Drop Team president, Phillip MacEachron, said the experience was "liberating:"

> *"Weightlessness suddenly makes you all too aware of Newton's laws of motion. If you push a button on your experiment, it pushes back, sending you into a wall. After several parabolas of getting used to the new feeling, it begins to feel truly liberating. When the flight crew calls "feet down," and a foreign force gradually mounts, pressing you to the floor, you feel restricted and held down, no longer able to float freely with control over every force on your body."*
>
> – Phillip MacEachron, Class of 2015

The Yale Drop Team was founded in 2006 when a group of five students submitted their first proposal to NASA. Once selected, they designed an experiment to test quantitatively the effects of hysteresis in the response of uncharged, conducting liquid drops to changes in strong electric fields. These drops (from which the Drop Team took its name) were released in a region of spatially uniform electric field and as the strength around the droplet was increased, electrical forces began to dominate surface tension in determining its shape. As the field was decreased, the hysteretic threshold was measured quantitatively. Performing this experiment in microgravity allowed the use of drops large enough to retain volume and also permitted a wide domain of drop sizes to be tested in an electromagnetic field.

Since 2006, the Drop Team has successfully completed five projects through the NASA programs, many of which were carried out for two or three years and tested in multiple flights. These projects range from creating an apparatus development for a 3D cell culture to analyzing regions void of dust in a complex plasma. Two years ago, a team conducted an investigation into the growth of mushy layers from aqueous ammonium chloride solution in normal, micro, and hyper gravity environments. In the fully developed chimney state, the chimney plume dynamics differed strikingly when conditions changed from micro to hyper gravity. In microgravity, plume motion was fully arrested and convection was suppressed. As gravity exceeded Earth conditions,

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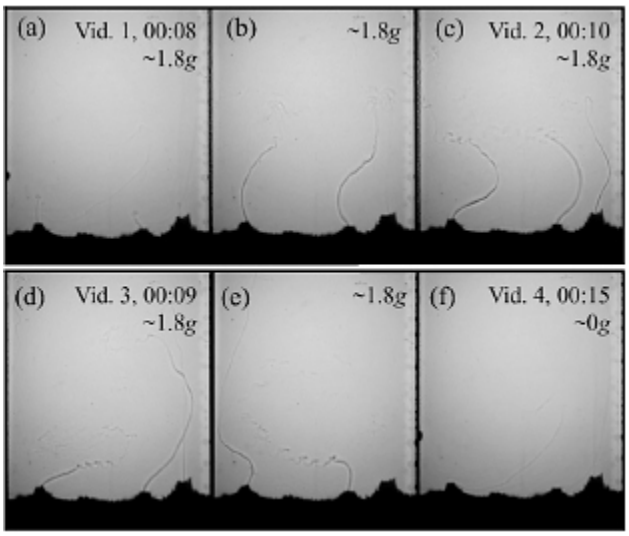
Yale Drop Team *continued from page 15*

a host of phenomena were observed, ranging from arched plumes that undergo forced Rayleigh-Taylor instabilities to in-phase multiple plume oscillatory behavior. For the same initial solute concentrations and fixed boundary cooling temperatures, the students found that, in runs of over two hours, the averaged effects of microgravity and hypergravity result in suppressed growth of the mushy layers, a phenomenon caused by a net enhancement of convective heat and solute transport from the liquid to the mushy layers. These behaviors are understood in the context of the theory of convecting mushy layers as studied under normal laboratory conditions.

In 2013-2014 the Drop team will be continuing a project to quantify the effects of various factors (including curvature and material type) on surface tension screens, which are used to separate gas and liquid interphases in NASA spacecraft. This project is being carried out with the help of two Lockheed Martin engineers. The apparatus the students have designed consists of many pressurized cells that contain two different screen types at different curvatures. At a certain pressure, the screens wetted with isopropyl alcohol will reach a "bubble point" when the air pressure on one side becomes stronger than the force of surface tension of liquid between the pores of the screen. During this transition point, bubbles rush through the screen, which can be seen with the naked eye. The Drop Team will be traveling to the Johnson Space Center in Houston during the last week of July to test their project in microgravity. They hope to present their findings at the 2014 AIAA Science and Technology Forum and Exposition in January 2104.

– by Phillip MacEachron and members of the Yale Drop Team



Photographs of the evolving mushy-layer system featuring freshwater plumes in various gravities: Panel (a) shows freshwater plumes beginning to rise from chimneys shortly after the onset of hypergravity. Panels (b) and (c) illustrate the coupled oscillatory behavior of the plumes in hypergravity. Panels (d) and (e) provide a clear view of the Rayleigh-Taylor instabilities in horizontal jets observed in hypergravity. Panel (f) features inertial plumes shortly after the onset of microgravity.

Yale Drop Team images provided by Phil MacEachron.

From left: Christine Stewart (Lockheed), Jonathan Braun(Lockheed), Michael Cruciger, Nafeesa Khan, Emma Alexander, Manjari Randeria, Sarah Flintgruber, Stephen Irons, Phil MacEachron.

Yale Hosts 2012 Northeast Conference for Undergraduate Women in Physics

In 2006, Yale Physics Professor Bonnie Fleming took a group of undergraduates to the University of Southern California's Conference for Undergraduate Women in Physics (CUWiP). Their goal was to see what the conference was about and to think about enacting a similar effort in the Northeast. The following year, with University and Departmental support, Yale hosted the first Northeast Conference for Undergraduate Women in Physics, an event we have hosted and organized 3 more times since.

Six regional CUWiP meetings are now held simultaneously across the country, with a keynote speech simulcast to all venues. Participants come from all over the country; nearly 200 people registered for the 2012 meeting at Yale. Last January, when Cornell was unable to accommodate all the Yalies who wanted to attend their 2013 NCUWiP meeting, there was enough interest to organize a last-minute "rump" conference at Yale, with local speakers and participants.

The mission of these conferences is "to help undergraduates continue in physics by providing them with the opportunity to experience a professional conference, information about graduate school and professions in physics, and access to other women in physics of all ages with whom they can share experiences, advice, and ideas." The NCUWiP attempts to redress the relatively large disparity between the numbers of women and men in physics, which persists in the face of larger gains in other science disciplines. "The hope is that this conference will help young women realize that they can do physics, and that there are role models, that there are women in physics who have succeeded," explains Fleming.

Prof. Fleming and later, Prof. Sarah Demers, served as faculty advisors for this activity, but make no mistake about it, the conferences were organized by dedicated groups of undergraduate students. "Undergraduates do the bulk of [the organization], and it is a lot of work," says Demers, "Ariel Ekblaw and Ellen Klein were the two co-leaders [of the 2012 NCUWiP], but there were very many people…everyone had different roles." Planning the conference involved everything from identifying and contacting speakers, to coordinating transportation and lodging for the participants, to ordering food and tablecloths. The undergraduate committee, under the leadership of Demers and with help from the Physics Department Chair and staff, put together a successful three-day event for over 180 students from 52 institutions.

The conference included a Liquid Nitrogen Ice Cream Social.

Meg Urry delivered the opening-night keynote speech.

The 2012 conference, like those of previous years, included talks by faculty from around the country on diverse physics research topics, as well as talks about issues for women in physics, talks from students, a poster session, a career panel, a graduate student panel, and laboratory tours. Over meals, students had opportunities to connect with both female and male faculty. More casual events, like a Liquid Nitrogen Ice Cream Social, gave participants the chance to get to know one another.

Feedback from those who attended was very positive. "We had a lot of people say they left energized and excited, and that they learned things about ways they could use physics in the future that hadn't occurred to them," said Demers. "They networked, their confidence had gone up, they had a better idea that they wanted to go to graduate school," added Fleming. Students from the earliest NCUWiP conferences at Yale show up later in our graduate classes and at professional meetings. More than one student has told the Department Chair that the meeting crystallized their intention to study physics.

The 2012 NCUWiP conference was dedicated to Michele Dufault, a Yale Astronomy and Physics major who passed away in April 2011 in a tragic accident while working on her senior project. "She was a huge driver of the NCUWiP, even when it went to MIT [in 2011]," says Fleming. "She's been an inspiration for all of us," says Demers. "We miss her," says Urry, "and I see a bit of her in every student."

Fleming, Demers and Urry hope that the conference will continue with its trajectory of growth and eventually expand to the international level. Yale will host the conference again in January 2015.

CUWiP conference photos by Michael Marsland

Departmental Outreach Programs Teach 6-12th Graders that "Physics is Fun"

Stephen Irons

Several times a year, the Yale Physics Department hosts middle and high school students with outreach programs created by members of the Department. The Yale Physics Olympics, now organized by Stephen Irons (following Peter Parker and Con Beausang), is a lighthearted one-day competition for teams of high school students addressing various physics-themed challenges. Girls' Science Investigations (GSI), organized and run by Bonnie Fleming and Sarah Demers, gives 6th – 8th grade girls the opportunity four times a year to conduct scientific experiments and learn a new science topic. Both the Olympics and GSI benefit from a highly motivated army of volunteers, from staff to students to faculty.

Though the two outreach programs differ in target audience, they share the goal of teaching the participants that physics can be fun and accessible. Irons explains that the Yale Physics Olympics was started "to get Yale's name out there and promote science to the general public, to show that it can be exciting and interesting." As for GSI, Fleming says, "the point of the program is to show, at the specific time when girls are starting to lose confidence and think maybe that they can't be the person who's building the radio – to show them that they can, and to do it in an environment where it's only girls and where the role-models are women."

The Yale Physics Olympics, which occurs in October, consists of four or five timed events in which teams of four high school students compete for points. "There are teachers out there who take it very seriously, who train their teams," Irons says. "It's serious business for some of them. Some teams just come for the fun of it, and that's good too. We try to make it fun whether you win or not." Previous challenges included: building a boat that could support as much weight as possible out of only duct tape, constructing a pendulum with a specified period of oscillation, building an electromagnet out of wire and nails, measuring the

density of sand using a certain method, and building the strongest possible bridge structure out of a fixed number of popsicle sticks and glue. These events are designed to test ingenuity and creative thinking, as well as scientific knowledge and the ability to make empirical measurements.

At the close of the day, awards are given out for each challenge, as well as for overall performance. There is even an award for best costumes, since teams choose their own names and often come dressed to match the theme. "The value in [the Physics Olympics] lies in making science a normal thing, and showing that it's a fun activity that you can do, that it's accessible to just about anybody. It's about the exposure and showing that science is an important part of society," explains Irons.

Yale has been holding the Physics Olympics every year since 1998. By the 2012 competition, it had grown to fifty teams competing. Indeed, it is capped at 200 participants since there is no Science Hill lecture hall that can hold more. "The teachers who come every year are always really thrilled that we're doing this, and that they get to bring their students onto campus and get a little taste of what Yale is like," Irons says. Alongside Irons, who has organized the event since 2001, various members of the department are involved in the organization. As early as the beginning of summer before the competition, a committee of

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Departmental Outreach *continued from page 18*

faculty and graduate students works to come up with and test the challenges for the participants. On the day of the event, around twenty undergraduate, graduate, and faculty volunteers help to keep things running smoothly. Faculty leaders of the event often include Charlie Baltay, Sid Cahn, Helen Caines, Tobias Golling, Jack Harris, Dan McKinsey, and Sarah Demers.

Girls' Science Investigations began in 2008 when Bonnie Fleming started the program as a "broader impacts" component of her NSF Career award. When Sarah Demers joined the faculty in 2009, she became a co-organizer. Fleming explains that it is important to target sixth to seventh grade girls because "one of places in the pipeline where women leave physics is at the middle school level… Girls tend to excel more than boys in math and science before middle school and less than boys after."

GSI meets four times per year, routinely attracting 140 participants each session. Many of the girls attend multiple sessions. Each convening addresses a different science theme. One session, for example, explored concepts from Quantum Mechanics, while another covered electro-magnetism. The girls participate in hands-on activities, which in the past have included building a radio and constructing a rocket that they can launch outdoors. "We give them activities … they can use to understand science in general, but also things that are fun and that they'll remember as fun, says Fleming. And, she adds, "we try to send them home with instructions so that, if they want, they can repeat the experiments at home."

In April 2012, Fleming and Demers received the Elm-Ivy Award from Yale President Richard Levin and New Haven Mayor John DeStefano in recognition of the important role their program plays in the enrichment of the greater New Haven community.

The Physics Olympics and Girls' Science Investigations outreach programs have been successful in bringing young people to campus and introducing them to the world of physics. Some of these students may grow up to be scientists, some may become Yale students, but the Department is not particularly focused on those few. Rather, the most important thing is that young people learn about the value of science and that science is not a dry, boring subject of interest to only a few nerds and geeks. Especially in those terms, the Physics Department's outreach programs have been a huge success.

Sources:

Sarah Demers and Bonnie Fleming. Personal interview. 6 March 2013.
Stephen Irons. Personal interview. 5 March 2013.

The Yale Undergraduate Aerospace Association

The Yale Undergraduate Aerospace Association (YUAA) is one of Yale's largest undergraduate engineering and physics clubs, with over 30 active members (before freshman recruitment), including not just physics and engineering majors but also students majoring in philosophy, chemistry, English, and many other subjects. What unites these students is an interest in building things that fly and blast off, and a passion for engineering ingenuity and aerospace innovation. Only three years old, the YUAA has already accomplished a lot for such a young organization.

Last year, we sent a helium balloon to 60,000 feet (higher than the cruising altitude of commercial jets!) and were able to track its route, height, and gather data live. Not only that, but we also won a Connecticut Space Grant, funded by NASA, to build a modular Command Center to power and control all our flight modules, something that has not been done before by any other student group. In addition, we traveled to Culpeper, Virginia, to represent Yale University and win the Federation of Galactic Explorer's Battle of the Rockets, safely sending an egg to 1570 feet (that's higher than the Empire State Building is tall) and then safely back down to the ground without a parachute in our rocket — the YSS (Yale SpaceShip) Eli Whitney!

In the upcoming year, we have even greater hopes and aspirations for where we go next. Now that our unique Command Center has been completed, we hope to place it in our upcoming Unmanned Aerial Vehicle (UAV) project, where we plan to launch a rocket with an UAV onboard, and to deploy the UAV with full navigation and aerial control at apogee. In addition, we will also be optimizing and designing our own rocket engines, in our quest to not only make things go higher, but to get there better. Continuing into its second semester of work, our quadcopter, equipped with onboard cameras and navigational controls, will soon be ready to take flight, allowing us to see Yale from new angles and heights. And of course, we intend on demonstrating and representing Yale's tradition of physics and engineering excellence, especially in the rocket competitions that we will participate in as well.

But the YUAA is about more than just winning competitions and building bigger rockets. Since its founding, the YUAA has focused on preparing and training our members, no matter their background. Yale lacks an aerospace department, and thus we offer all our students and members hands-on experience to design, innovate, and create flight modules that push the edge of engineering excellence in a way that no other club or department at Yale does. We strive to make all our projects not just impressive, but also accessible to all of our members, regardless of their previous experiences with aerospace. At its core, the YUAA aspires to inspire the next generation of aerospace enthusiasts, engineers, and leaders.

From all of us with the Yale Undergraduate Aerospace Association, we look forward to our next year with you, and we hope that you'll join us as we continue to take Yale to new heights. **— by Austin Long**

Research at CERN: An Undergraduate Perspective

Before even applying to college, I had dreamed of working at CERN (Centre Européen de Recherche Nucléaire), yet never imagined that the opportunity to do so could come so soon. Their Large Hadron Collider inspires a plethora of cutting-edge research in particle physics and I expected that joining the multi-country collaboration of thousands of scientists constituted a long-term career achievement. The summer after my freshman year, I joined Professor Tobias Golling's lab for an eight-week research internship in Geneva, Switzerland, working on the ATLAS experiment. This experiment, with a particular focus on proton-proton collisions, is one of seven major detector experiments at the Large Hadron Collider. When I joined the Yale-ATLAS team in 2011, I met a thriving Yale group of over 25 undergraduates, graduate students, post-docs and professors. Joining Golling's team in particular and contributing research at the forefront of physics has transformed my college experience.

Photo courtesy of 2012 CERN

By camping out in line all night, Yale students got front-row seats in the CERN Auditorium for the announcement of the discovery of the Higgs Boson on July 4, 2012.

Hanan Rosenthal Memorial Lectures

The Hanan Rosenthal Memorial Lecture was established in honor of physicist Hanan Rosenthal, a brilliant graduate student at Columbia University and instructor at Yale. This annual lecture in atomic physics, Rosenthal's field, is given by a distinguished leader in the field. Originally, the lecture series, started in 1973, alternated between Columbia and Yale, which were both significant in Hanan Rosenthal's career; in recent years, the lecture has been held only at Yale University. Recent lectures were:

2013: Markus Arndt, University of Vienna
2012: Margaret Murnane, JILA
2011: Tilman Esslinger, ETH
2009: David Pritchard, Massachusetts Institute of Technology
2008: Tilman Pfau, University of Stuttgart
2007: Jean Michel Raimond, Université Pierre et Marie Curie, Paris, France

I first heard of the opportunity to work at CERN during my freshman fall. After inquiring with several particle physics professors and passing a selection process, Professor Golling welcomed me to his team. Several of the students he had mentored the previous year were returning to CERN and they offered their knowledge and experience to help the new students prepare. This culture of camaraderie and mutual support among the undergraduate researchers has become a wonderful tradition, giving rise to many of my favorite memories within the Yale research group. The University's Science and Quantitative Reasoning Center generously funded my research and basic living expenses for two eight week internships (Summers 2011 and 2012) through the Alan S. Tetelman Fellowship for international research in the sciences.

I knew little particle physics initially, yet determined to improve my knowledge base for CERN, I proved my ability to master material on a steep learning curve. The first summer, under the mentorship of Professor Golling and a CERN fellow, I developed a coding framework to test proton-proton collisions for a particular configuration of charm jets (narrow showers of hadronized quarks and gluons originating from a charm quark). To represent the results graphically, I worked on an innovative method to distinguish two variables of interest for this analysis: Chi-squared (related to particle track trajectory) and relative-transverse momentum. This first eight-week project culminated in a final presentation to the Yale-ATLAS group.

Contributing to particle physics research early in my college career proved to be an invaluable opportunity to refine research skills (particularly computer programming) and explore the physics discipline. Over the next summer and fall of 2012, I continued my research with the Yale Particle Physics group. I investigated a hypothesized decay mode of the supersymmetric partner to the top quark, known as the 'stop' quark. This involved testing for the presence of a particular decay signature and analyzing kinematic properties (momentum, angle of ejection, etc.) of products from collision events. I shaped this research in Supersymmetry into my Senior project for physics and successfully defended my thesis over a year in advance of the university deadline.

I found the CERN environment incredibly invigorating and I greatly value the enthusiastic mentoring I received. Most memorably, I enjoyed the unparalleled excitement of observing the announcement of the Higgs-like Boson on July 4th, 2012. Together with my Yale peers, I camped out the night before (to beat a line of several hundred) and secured a front-row seat in the formal presentation by spokespersons Joe Incandela of CMS and Fabiola Gianotti of ATLAS. I will never forget that exhilarating morning—I watched as the largest scientific experiment in history announced evidence for the key to the Standard Model, and more importantly, I had learned to understand the technical graphs and figures that pointed with such high certainty in that direction. These formative experiences at CERN continue to inspire my pursuit of an advanced degree in experimental physics. I am driven to enlarge our science horizons through creatively designed and expertly implemented research.

— by Ariel Ekblaw

Remembering (Always) Michele Dufault SY'11

A few weeks before her graduation from Yale in 2011, astronomy and physics major **Michele Dufault** died in a tragic shop accident. Yale College Dean Mary Miller, who was Master of Saybrook when Michele arrived as a freshman, called her a "shining star" in the Department and in the University. Her loss hit everyone very hard. Upon hearing the awful news, many friends and colleagues gathered in the Physics Chair's office to remember Michele and simply to try to cope. Out of that shared sorrow came a plan to honor Michele's memory by supporting other young women in science, with a summer fellowship and inspiring networks for young women like the Northeast Conference for Undergraduate Women in Physics (NCUWiP) and Girls' Science Investigations (GSI) outreach programs). This June, Yale announced the creation of a $14 million dollar fund in Michele's name, to support young women following in her footsteps.

Michele was in the shop working on her senior research project, an investigation of the possible use of liquid helium to detect dark matter particles. She was, typically, busy with many things in addition to her studies. She always had time to help other students with their problem sets, particularly those younger students coming up behind her. With the slightest provocation, she would regale friends – even, or perhaps especially, those not in science – with an animated lecture on how the Universe works and what role dark matter plays in its evolution. In early April, she was working to put online the plenary talks from the Fourth International Conference on Women in Physics taking place in Stellenbosch, South Africa, working with graduate student Emma Ideal and Physics Chair Meg Urry, who attended the Conference in person. Typically, Michele was too busy to attend the meeting herself but not too busy to make things better for others.

On the evening of April 13, a candlelight vigil to honor and remember Michele was held in the courtyard of Saybrook College. She was laid to rest on April 16th in her hometown of Scituate, Massachusetts. Over 400 people attended the funeral service, including about 100 Yale undergraduates, graduate

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Michele and I once spent hours during a smoldering summer day arguing about laser containment in a NASA aircraft hangar. The newest additions to the Yale Drop Team, our crew of reduced gravity adventurers, were off preparing for zero gravity, leaving Michele and me struggling to assemble our recalcitrant experiment. Michele would never compromise her deeply held beliefs, not on moral matters and not on scientific and technical issues. So, our debate on that tumultuous afternoon was intense. However, when the Drop Team rookies returned from a battery of training exercises looking bedraggled and drained, Michele's personal concerns instantly vanished as she focused on their welfare. A day's manual labor in thousand-degree weather with a million percent humidity could not dampen her generosity. Michele and I trekked to Ben and Jerry's to buy everyone ice cream, after quickly resolving our technical difficulties. Without Michele, not only would our hardware have been in shambles, but also the team's morale would have cratered. Michele was much more than a physics buddy. What I loved about her was that she made everything an adventure. Walks down science hill became epic quests, where jumping in leaf piles was equivalent to slaying dragons. Class projects were an excuse to chart romantic interplanetary voyages. Service projects in New Haven were chances to change the world for everyone we helped. Discoveries of new extrasolar planets were license to dream fantastic dreams. Throughout it all,

Michele remained superlatively humble, always shying away from deserved acknowledgment of her numerous good works. Now, without Michele, we are missing an incredible friend and inspiration. Although I knew her relatively briefly, I know that she is ***the*** *example of enthusiasm, strength, and generosity towards which I will forever strive. Every beautiful thing in the Universe will forever remind me of Michele, inspiring all of us to have grand adventures and, most importantly, to make the path as exciting as the destination.* – Joe O'Rourke, Astronomy & Physics and Geology & Geophysics, '12

Remembering Michele Dufault *continued from page 22*

As I got to know Michele last year, I was struck by three profoundly amazing characteristics of hers. She deeply cared for others. She regularly stayed up past three in the morning to help me and others on our next Physics problem set, long after she had completed it herself. She was dedicated to the pursuit of knowledge. Her love of learning was never more clear than when she was doing research, in the Yale labs or in the opportunities she took over the summer.

But what has stuck out in my mind the most in these past couple weeks has been her absolute passion for everything she did, and for sharing that passion with others. She was committed to her Physics studies, to the tenor saxophone, and to the oceans. She was committed to convincing me to take Quantum Mechanics, to bringing me to the Women in Physics conference, to making sure I understood what was going on after every class. She was committed to playing Frisbee in the rain, committed to late night study breaks watching ridiculous YouTube videos, and committed to putting a smile on the face of every person she met.

These were all things she cared about, and she will always be an inspiration to us all in following our own passions the way she did. – Zach Kagin, Physics & Economics '11

students, postdocs, and faculty members, a sign of the profound impact she had on the Yale community. Another memorial service was held later that month in a packed Battell Chapel. Friends and professors told stories about the impact Michele made on them (3 physics-related memories appear in the blue boxes).

In July 2011, Michele's colleagues in Physics arranged to have an asteroid named in her honor. 15338 Dufault (1994 AZ4) is five to ten kilometers in diameter with an orbit on average 2.92 AU from the Sun, between Mars and Earth. It seemed a fitting tribute to someone who always thought in cosmic terms. This is the link to the asteroid's official page.

On April 12, 2012, the one-year anniversary of Michele's death, a tree was planted in her memory at the Marsh Botanical Gardens, on the corner of Prospect and Munson streets. The tree is a Pagoda Dogwood (*Cornus alternifolia*), native to the eastern United States, including Michele's home state of Massachusetts and Connecticut.

We remember Michele as a very bright and enthusiastic student, a lover of science, and a caring friend. During her time at Yale, she worked as a member of the Drop Team (see article on page 15), was co-president of the Society of Physics Students, played for the Yale Precision Marching Band, volunteered for the Yale Physics Olympics and GSI outreach programs (p. 18), and was the tireless leader and organizer of NCUWiP (p.17).

In her first summer after freshman year, Michele did research at Yale with Meg Urry's group, identifying galaxies in a deep survey of the cosmos. The next summer she worked with Urry's colleagues at the Institute for Astronomy in Hawaii, studying infrared emission from merging galaxies. The summer before her senior year, Michele was a Summer Student Fellow at Woods Hole Oceanographic Institute, where she worked with Dr. Dave Fratatoni and met Dr. Amy Bower, who later gave the keynote speech at the NCUWiP meeting dedicated to Michele. After graduation, Michele planned to continue research in ocean sciences at the University of Washington.

Our ways of remember and honoring Michele are only small steps toward easing the loss felt by her family, friends, and colleagues, but they remind us of the bright young woman and future scientist whose path to greatness was cut far too short. We will always think about Michele and try to channel our deep sorrow into helping others following a similar path. There could be no more fitting tribute to her memory.

Michele took a course on quantum mechanics with me. She was a great student. However, I would like to tell you about something that happened outside of the classroom. One day while walking to lunch, I saw Michele crouched on a sidewalk. When she noticed me, she looked slightly embarrassed. Of course, that only increased my curiosity. It turned out Michele was picking caterpillars from the sidewalk and moving them to nearby grass. It was a very busy sidewalk. – Witold Skiba, Professor of Physics, Yale Physics Department

Sloane Physics Laboratory Turns 100: Classroom Renovations Coincide with Building's Centennial

In 1912, construction was completed for the Sloane Physics Laboratory, a new "University Laboratory" that would take the place of the two separate Yale physics buildings used since 1883. One hundred years later, the University updated its physics facilities with the renovation of all Sloane classrooms.

Until 1956, teaching in the sciences at Yale was done by the Sheffield Scientific School, an entity separate from College both in course offerings and geographic location. (Known as the "Sheff," it was originally called the Yale Scientific School at its founding in 1847.) For several departments, including Physics, this system meant some duplication of facilities. Starting in 1883, Yale had two physics laboratories: one for the Sheff plus the original Sloane Physics Laboratory, located on the no-longer-existent Library Street near Old Campus. By the beginning of the 20th century, however, these facilities were seen as crowded and outdated, and the administration began to make plans for a new University-wide physics laboratory.

After years of debate over the laboratory's proposed location, final approval for the construction of the new Sloane Physics Laboratory was given in June 1910 at an estimated cost of $365,000, roughly $9 million in today's dollars. By May 1912, "New Sloane" was ready for its formal opening. With the completion of the new lab, all the Physics Departments of the University were united in one building, and the divisions between Yale College and the Sheff were soon blurred.

The 100 years since have left the Sloane Physics building much as it was constructed, even as there have been many changes for science at Yale and the Physics Department in particular. The success of the University physics laboratory led several other departments to follow suit: "Science Hill" became populated with other labs, and by 1956, the Sheff was fully integrated into Yale College, its existence as a separate entity ended. Growth of the Physics Department has also meant its spreading across campus: rather than remaining united inside Sloane, today the department occupies three buildings, with Applied Physics occupying a fourth.

Sloane 57 before renovations…

Photo by: Claudia De Grandi

The classrooms were particularly outdated. In every classroom, seats were bolted to the floor, facing front. Modern teaching techniques involving peer collaboration, small discussion groups, or a seminar format do not fit well in such a classroom. The wooden seats in the large lecture hall, while evoking a pleasant antique grandeur, were cramped and uncomfortable for a 50-minute lecture. During one memorable prize lecture by a famous physicist, the steam pipes started banging loudly enough to stop the proceedings. (The Department Chair was well known for her imitations of the noisy heating system.)

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… and after.

Sloane Renovations *continued from page 24*

Finally, in the summer of 2012, change came again to the Sloane Physics Laboratory, with significant updates to all its classrooms. The renovations had been planned before the recession hit in 2008, which brought a few years of delay, but thanks to the Yale administration's leadership on reforming science education, as well as a generous gift from the family of a Yale alumnus, Sloane renovations were completed despite lingering financial concerns. Specifically, the STEM Teaching Transformation Committee, convened by President Richard Levin and Provost Peter Salovey in 2011, aimed to assess Yale's STEM education compared to programs at other universities and reform the science teaching and facilities of the College to help prevent the drift of prospective majors away from the sciences. To that end, Sloane Physics Laboratory's classroom renovations were part of a wider plan for improving the teaching spaces throughout Science Hill.

The changes in Sloane were noticed immediately by the returning students. The lecture halls have comfortable seats with electrical connections for laptops; seats even swivel fully in SPL 57, the smaller lecture hall, so that students can talk face-to-face. The smaller classrooms have new tables and movable seating to facilitate group work and discussions amongst students. The renovations did not come a moment too soon: as the number of physics majors at Yale continues to rise, Sloane Physics Laboratory is now a revitalized center for physics education at Yale.

A revitalized Sloane 59.

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Sloane 63 during renovations…

… and after.

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Attention All Alumni:
We want to hear from you!
Notes from the Alumni
will return in the Summer 2014 issue.
Anyone with news is invited to write to
daphne.klemme@yale.edu
to let us know what's happening.