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March Prize and Award Recipients
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APS Recognizes Cornell as Birthplace of the *Physical Review*

America's first physics-only scientific journal, the *Physical Review,* saw the light of day at Cornell University in 1893. The guiding spirit behind its birth was a member of the Cornell faculty, Edward L. Nichols, who edited it with the help of two of his colleagues, Ernest Merritt and Frederick Bedell. The journal stayed at Cornell until 1913 when it was taken over by the American Physical Society. The first issue, dated July-August 1893, listed Nichols and Merritt as editors. Bedell joined them soon thereafter. It defined itself as "A journal of experimental and theoretical physics." The first issue was 80 pages long. Volume 1 contained a mere 20 articles, spread over only 480 pages.

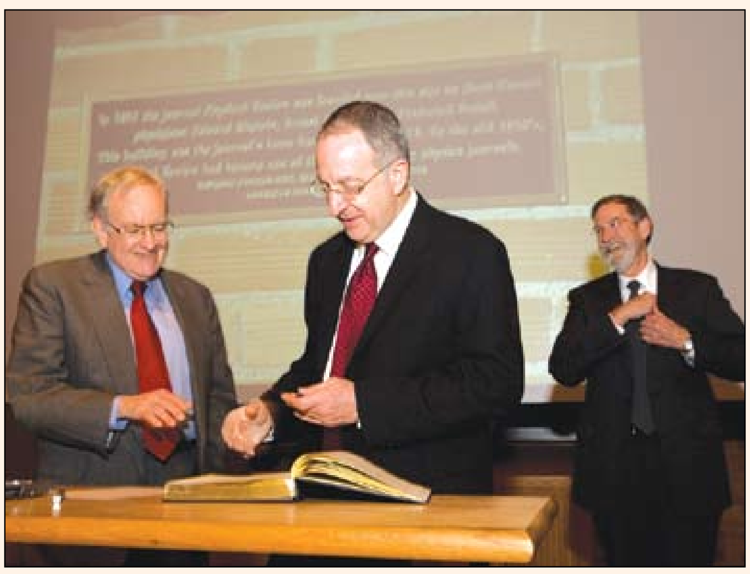

Photo by Robert Barker/Cornell University Photography

Nowadays, of course, *Phys Rev* has fissioned into five sections, A through E, each covering a broad range of physics, and has spawned two other major publications, *Physical Review Letters* and *Reviews of Modern Physics*, as well as two online-only journals. Altogether, these journals now publish upwards of 130,000 pages annually.

On March 3rd, as part of its historic sites initiative, APS presented a plaque to Cornell University to honor the founding of the *Physical Review*. In the photo, Cornell President David Skorton signs the APS Register of Historic Sites, while Historic Sites Committee Chair John Rigden (left) and APS Editor-in-Chief Gene Sprouse (right) look on.

PRL Showcases Milestone Papers

Physical Review Letters has published many important papers during its 50-year history. As part of the *Physical Review Letters* 50th anniversary, former editor-in-chief Martin Blume is compiling a series of "Milestone Letters," showcasing some significant papers from each year of the journal, starting in 1958 and continuing through 2000.

The "milestone letters" are papers that made important contributions to physics, announced significant discoveries, or started new areas of research. Many of these papers report research that resulted in Nobel prizes for their authors. The series covers a diverse range of subfields, and also gives a glimpse into the history and development of physics over the past 50 years.

Physical Review Letters started as a separate journal in 1958 as a way to quickly publish short research papers that had been published as letters to the editor in the *Physical Review*. Right from the start of the new journal, important papers were published. The two Milestone Letters for 1958 are John Bardeen's paper, "Two-Fluid Model of Superconductivity," which was a follow-up on the BCS theory of superconductivity reported in *Phys. Rev*. a year earlier, and a paper announcing the first synthesis of element 102.

The Milestone Letters series began appearing in January on the *PRL* website at http://prl.aps.org/50years/milestones, with papers from 1958. Approximately each week this year, another year's worth of Milestone letters is being posted. Previous week's entries also remain accessible.

The featured *PRL* papers can be read without a subscription by accessing them through the Milestone Letters website.

For each milestone letter, Blume has written a summary explaining the significance of the paper. These short summaries can be read and understood by students

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Macromolecular Self-Assembly a Promising Alternative to Photolithography

Macromolecular self-assembly is emerging as an alternative to conventional photolithography, a mainstay of the semiconductor industry, according to speakers at the APS March Meeting session who reported on the latest research in this area. As photolithography edges closer to fundamental physical limits, physicists are looking to create microchips and data storage devices from novel materials such as organic molecules and polymers.

Photolithography is a powerful technique for etching surfaces with light and designing such patterned structures as microprocessors. However, the technique is limited by the wavelength of light used, and the current state-of-the-art can only precisely etch details on a scale of 30 nanometers or larger. In contrast, macromolecular self-assembly uses polymer building blocks–which self-assemble with very little energy–to construct nanoscale patterned surfaces with great precision.

Paul Nealey and his colleagues at the University of Wisconsin are investigating techniques to integrate self-assembling block-copolymers into the lithographic process,

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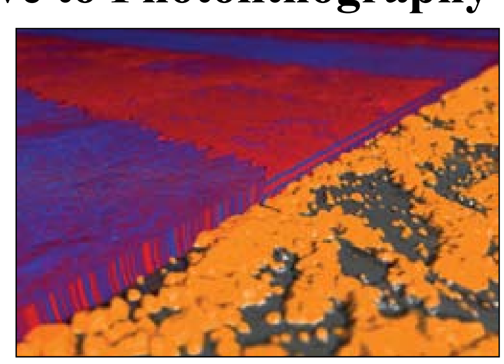

A novel technique for controlling the orientation of nanostructures (red and blue) is to use disordered, roughened substrates. Silica nanoparticles (orange), cast onto silicon substrates (grey), create "tunable" substrates which can control self-assembly, despite inherent disorder.

Photo provided by NIST

Diamond Sparkles in Quantum Computing

Diamond has the potential to be a useful component for quantum information processing systems, according to several speakers at a March Meeting session.

Scientists can now grow high quality synthetic diamonds. Diamond has high thermal conductivity and is an electrical insulator. It has a type of impurity called an N-V center, in which a nitrogen atom takes the place of one carbon atom in the diamond, and a vacancy takes the place of a neighboring carbon. An unpaired electron circulates around the nitrogen-vacancy center. This electron can be excited or polarized by a laser. When excited, the electron emits a single photon as it falls back to a lower energy state. The electron can be put into a quantum superposition where it has both spin up and spin down, so it could potentially be used as a qubit, a quantum bit that is both 0 and 1 at the same time that would form the basis of a quantum computer.

Furthermore, these impurities in diamond can be created and manipulated at room temperature, unlike other potential quantum computing systems, and NV-center qubits are long-lived.

Ronald Hanson, now at the Kavli Institute of Nanoscience Delft, previously of UC Santa Barbara,

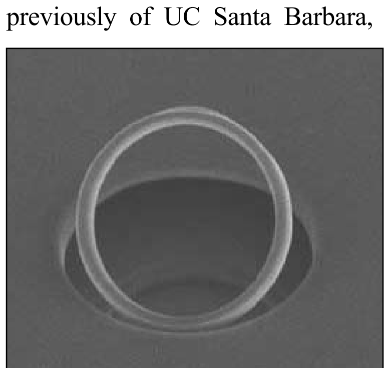

Photo courtesy of Steven Prawer, University of Melbourne

reported the achievement of electron spin resonance, analogous to nuclear magnetic resonance at the March Meeting. He and colleagues flip the spin of an electron in an NV center, and then watch as it loses its polarization through interactions with nearby nitrogen impurities. They can tune the interactions with the nitrogen atoms (called a "spin bath") by adjusting an external magnetic field. The researchers also reported the results in *Science Online* March 13.

In another step towards diamond-based quantum computing, Mikhail Lukin of Harvard has been able to detect the spin of a single carbon-13 nucleus in a diamond by its effect on the electron spins in nearby NV centers. Carbon-13, which makes up about 1% of diamond, is magnetic, while carbon-12 atoms have no net spin. Detecting and controlling single nuclear spins is challenging, but Lukin has been able to detect the weak magnetic fields of single carbon-13 atoms with nanometer resolution. The method could be useful for extremely precise magnetic resonance imaging.

Lukin's group has also made qubits using the NV-center-carbon 13 interaction. Such qubits have up to one second long coherence times

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March Meeting Session Addresses Climate Change

Speakers in a March Meeting session devoted to climate change described how physics methods can be applied to study this important issue.

One usually doesn't find climate science at a physics meeting, session chair John Wettlaufer of Yale University said in a press conference on the topic. Physicists have a unique perspective that is relevant to the study of climate, he said. Several scientists reported their latest results and described how physics methods can be used to study climate.

For instance, Annalisa Bracco of Georgia Tech has used simulations to study turbulence. Ocean and atmospheric flows have large Reynolds numbers and low viscosity, but most climate models, which have limited resolution, use viscosity higher than is found in nature, she pointed out. Bracco used simulations to explore how large-scale circulation depends on Reynolds number. The simulations, which required three years of computation, could result in better climate modeling, she reported.

A statistical physics approach can give insight into climate change while avoiding time-consuming numerical simulations, according to Brad Marston of Brown University. Weather is the moment to moment fluctuations; climate is the big picture we're trying to understand, he said. While we can't predict the weather more than a few days in the future, a statistical approach can provide better understanding of climate, Marston said. His approach is similar to describing the behavior of a gas by looking at statistical properties such as temperature rather than tracking the individual molecules that make up the gas. "Statistical physics teaches us to focus on important variables and not get caught up in details," he said. Marston believes his approach can lead to a better understanding of processes relevant to climate change without the need for complicated numerical simulations that require years of supercomputing time. Numerical simulations may reproduce known effects, but may not give real

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Members in the Media

"It turns out babies seem to cry for no reason at all."

***Dan Sisan**, Georgetown University, on finding that little scientific research had been done on infant crying,* Chicago Tribune, *March 24, 2008*

"The future for students is bleak if their only vision is to become a professor. This year's budget cuts alone may not be enough to convince someone [to leave physics] but it will definitely influence people on the cusp of a decision."

***Gary White**, Society for Physics Students, on physics students leaving for other fields,* Boston Globe, *March 10, 2008*

"It was a nice experience, but it also convinced me I was not cut out to do that sort of thing."

***Eric Cornell**, University of Colorado, on his travels to China and attempt to learn Chinese,* La Crosse *(Wisconsin)* Tribune, *March 31, 2008*

"Our research shows that what is true in power networks is also true in biological networks. Inflicting a small amount of damage can control what otherwise would be much more significant damage."

***Adilson Motter**, Northwestern University,* Chicago Tribune, *March 31, 2008*

"We were working not only on nanoscience, but on a nanobudget."

***Eric Mazur**, Harvard University, on making tiny glass fibers to guide light,* The Huntsville Times, *March 30, 2008*

"I understand clearly as a freshman in Congress you don't get to steer the bus."

***Bill Foster**, former Fermilab physicist recently elected to Congress,* Scientific American, *April 1, 2008*

"Having spent £25m to build it, it would seem crazy not to operate it."

***Peter Weightman**, University of Liverpool, on Alice, an LHC detector that may fall victim to funding cuts, BBC News online, April 3, 2008*

"Cramer was such a wonderful person. I'd like to see someone replace him who is just like that."

***David Maker**, Photon Research Associates, who is running for Bud Cramer's seat in Congress (Alabama, 5th district),* The Huntsville Times, *April 3, 2008*

Physics Rebounds in Post-Katrina New Orleans

By Richard Harth

Physicists who descended from far and wide on New Orleans for the March Meeting caught a glimpse of the city in the process of tentative renewal. It was also an opportunity to meet with colleagues in the New Orleans physics community and see how they were faring since the August 2005 hurricane.

Three years ago, Katrina made landfall as a strong category 3 hurricane, sufficient to breach the levee system and inundate 80% of the city. Physicists in New Orleans faced unusual challenges both in the immediate aftermath and following their eventual return.

All universities were shut down for many months, lost email capacity, and saw faculty and students scattered to parts unknown. Since the calamity, a combination of luck, geography and the particular nature of each institution have played a role in the degree of recovery.

Without question, the biggest success story has been Tulane University. All physics faculty have now returned, and the department today is undergoing something of a renaissance. While the university was closed, many physicists, (along with their families and research groups), were graciously welcomed at institutions across the US. The ensuing collaborations proved a silver lining for both physicists and their students.

Ulrike Diebold, a physicist in surface science, was invited with her group to New Jersey and participated in stimulating collaborations at Rutgers University. John Perdew, a theorist, evacuated to Houston, where he immediately contacted former collaborator Gustavo Scuseria, a theoretical chemist at Rice University, who offered office space and computers.

Fleeing Katrina, Wayne Reed, a polymer physicist, landed for a time in the Ozark wilderness. But like fellow Tulane faculty, he caught a lucky break. A colleague at University of Massachusetts at Amherst invited Reed and his sizeable research group to UMass, which boasts one of the finest polymer science departments in the world.

As Lev Kaplan, a Tulane quantum chaos theorist said, "I think I speak for all of us when I say we are very grateful to departments all over the country who invited us and our students."

Tulane physics chair Jim McGuire also praised the initiative shown by his university, which continued to pay salaries to faculty and teaching assistants during their absence.

Physicists at other institutions in

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This Month in Physics History

May 1801: Thomas Young's double slit experiment

The debate over whether light is a wave or a particle goes back many centuries. In the 17th century, Isaac Newton believed light was composed of a stream of corpuscles. At that time, a few scientists, most notably Dutch physicist and astronomer Christiaan Huygens, thought light was a wave vibrating in some sort of ether.

There was evidence for both pictures. For instance, sound, known then to be a wave, can travel through crooked pipes and around corners, while light cannot, and this fact was taken as evidence for the corpuscular theory of light. But phenomena such as refraction were difficult to explain with the corpuscular theory. Newton had to invoke an inexplicable force that changed the velocity of light in water. Newton was also intrigued and puzzled by colored fringes in soap films, but stuck to the corpuscular theory despite its difficulties.

Photo courtesy of AIP

Thomas Young

Newton was so greatly revered as a scientist that it was nearly impossible for anyone to dispute his theory. In 1801 Thomas Young presented a serious challenge to Newton's ideas on the nature of light.

Young was a true polymath, with interests ranging from physics to Egyptology. He was born in 1773 in Milverton, in southwest England, into a large Quaker family. He was a prodigy as a child, learning to read by age two, and teaching himself Latin at age six.

He began studying medicine in 1792, and was elected to the Royal Society in 1794. He was also interested in pure science. In 1801 Young was appointed to a lectureship at the recently-formed Royal Institution in London, where he gave a series of lectures on a variety of topics.

As part of his medical studies, Young had dissected an ox eye in order to figure out how the eye focuses on objects at different distances. He also proposed a theory of color vision. In addition, he was fascinated by languages, and he completed a dissertation on the human voice in which he came up with a 47 letter alphabet that covered all human sounds. His studies of the eye and ear led naturally to his interest in studying sound and light.

Young had first read Newton's *Opticks* in 1790 at age 17, and had admired Newton's work. By 1800 Young saw some problems with Newton's corpuscular theory. For instance, he noticed that at interfaces such as that between air and water, some light is reflected and some is refracted, but the corpuscular theory can't easily explain why that happens. The corpuscular theory also has trouble explaining why different colors of light are refracted to different degrees, Young noted.

Sound was known to be a compression wave in air; Young thought light might be similar. He noticed that when two waves of sound cross, they interfere with each other, producing beats. While he didn't immediately look for the optical equivalent of beats, he began to realize that light might exhibit interference phenomena as well.

In May of 1801, while pondering some of Newton's experiments, Young came up with the basic idea for the now-famous double-slit experiment to demonstrate the interference of light waves. The demonstration would provide solid evidence that light was a wave, not a particle.

In the first version of the experiment, Young actually didn't use two slits, but rather a single thin card. He covered a window with a piece of paper with a tiny hole in it. A thin beam of light passed through the hole. He held the card in the light beam, splitting the beam in two. Light passing on one side of the card interfered with light from the other side of the card to create fringes, which Young observed on the opposite wall.

Young also used his data to calculate the wavelengths of different colors of light, coming very close to modern values.

In November 1801 Young presented his paper, titled "On the theory of light and color" to the Royal Society. In that lecture, he described interference of light waves and the slit experiment. He also presented an analogy with sound waves and with water waves, and even developed a demonstration wave tank to show interference patterns in water.

Despite Young's convincing experiment, people didn't want to believe Newton was wrong. "Much as I venerate the name of Newton, I am not therefore obliged to believe that he was infallible," Young wrote in response to one critic. Disappointed at the response to his research on light, Young decided to focus on medicine, though he was never very successful as a physician. He did do some further work in physics, and in 1807, Young published some of his lectures, including the double-slit version of the interference experiment.

Before he died in May 1829, Young contributed to deciphering the Rosetta stone, and wrote many articles for the *Encyclopedia Britannica* on an incredible range of subjects, including Bridge, Carpentry, Chromatics, Egypt, Languages, Tides, and Weights and Measures.

The basic double-slit setup Young proposed has since been used not only to show that light acts like a wave, but also to demonstrate that electrons can act like waves and create interference patterns. Since the development of quantum mechanics, physicists know that light is both particle and wave, not simply one or the other.

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Washington Dispatch

A bimonthly update from the APS Office of Public Affairs

ISSUE: Science Research Budgets

The House and Senate completed work on their FY09 Budget Resolutions. The Senate voted to spend $30.5 billion on the Function 250, which is the General Science Function and includes the National Science Foundation (NSF), programs at the National Aeronautics and Space Administration (NASA) except for aviation programs, and general science programs at the Department of Energy (DOE). The Senate number is approximately $1 billion above the President's request. The House figure for Function 250 is $29.9 billion. But the increases for science are predicated on a total Federal Budget bottom line figure of approximately $1.01 trillion in both the House and Senate versions, which is about $22 billion above the total presidential request. The difference sets up a scenario similar to FY08, which resulted in a stalemate.

The last Washington Dispatch (http://www.aps.org/publications/apsnews/200803/washintondispatch.cfm) noted that the budgets for NSF, NIST, and the DOE Office of Science ended up significantly lower than the levels approved by Congress earlier in the year and authorized in the America COMPETES Act. The APS Washington Office has worked to mobilize the Society's membership to lobby members of Congress and Congressional leadership to include $510M ($180 million for NSF, $30 million for NIST Core, and $300 million for the DOE Office of Science) for science in the FY08 Supplemental Appropriations Bill. More than 7,000 APS members have already responded to the call using the APS website to communicate to Congress or signing letters at the APS March and April Meetings. The Washington Office urges APS members who haven't yet written to do so at the APS Write Congress site (http://www.congressweb.com/cweb4/index.cfm?orgcode=apspa&hotissue=77).

To track the progress of the appropriations bills and the emergency supplemental bill, visit http://www.aaas.org/spp/rd/approp08.htm or go to http://www.aps.org/policy/issues/research-funding/index.cfm.

ISSUE: Nuclear Forensics

The APS Panel on Public Affairs, in cooperation with the American Association for the Advancement of Science (AAAS) Center for Science Technology and Security Policy, issued an unclassified report that reviews the US nuclear forensics program. The report provides a summary of the techniques and capabilities and identifies five areas for improvement. The report was summarized in *APS News* in the April Back Page, and can be downloaded from the APS website: http://www.aps.org/policy/reports/popa-reports/index.cfm.

The Washington Post published a story in its February 17th Sunday edition regarding the conclusions of the APS/AAAS nuclear forensics report. *The Post* also ran an op-ed on March 25th by Jay Davis, a member of the APS/AAAS study group that developed the forensics report. This report was covered by more than 200 additional media outlets including the Associated Press, *New Scientist*, and *Scientific American*.

ISSUE: Campaign Education Project

The American Physical Society, in cooperation with 10 science and engineering organizations, is hosting a "Campaign School" on May 10th to be held in Washington DC. The purpose of the event is to educate members of the participating organizations on running for state and local elected office. For more information and to register, go to the event's website at www.elections.sefora.org.

If you have any questions, please contact Francis Slakey at slakeyf@georgetown.edu.

ISSUE: Nuclear Policy Project

The APS, in cooperation with AAAS and the Center for Strategic and International Studies, is engaged in an examination of US Nuclear Weapons Policy. The Project has three tracks: Technical Issues (chaired by Mike Cornwall), International Issues (chaired by former Congressman Jim Leach), and Military Issues (chaired by Frank Miller). After workshops on each track, there will be an integration workshop (chaired by John Hamre) to synthesize the results into a set of options and conclusions. Each workshop will have the strong participation of physicists working in the relevant issue areas. A final report is scheduled to be completed in mid-September.

ISSUE: Washington Office Media Update

The *Chicago-Tribune* published an op-ed by Kevin Pitts, a Fermilab scientist, on April 2. The piece detailed the damage done to science since last year's omnibus bill and advocated for a $510 million supplemental bill to fix the situation.

Log on to the APS Public Affairs webpage (http://www.aps.org/public_affairs) for more information.

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New Orleans were often less fortunate than their Tulane colleagues. Many faculty at the University of New Orleans, including Greg Seab, departmental chair, had their homes destroyed.

Ashok Puri, also at UNO, lost his house and was then defrauded of $30,000 dollars by crooked contractors who vanished into thin air. Puri was most concerned, however, for his son, who was preparing for university entrance exams when the hurricane struck. (Fortunately, despite the disruption, the student was admitted to Cornell.)

The management response at UNO has come in for criticism by a number of physics faculty. In the opinion of some, the administration took advantage of the catastrophe to engage in restructuring efforts, which included furloughing a number of physics professors, some of whom were tenured. The impact on departmental morale has been palpable, according to some.

Xavier University, which took on six to seven feet of water in virtually every building on campus, has also had a difficult time getting back on its feet, as Physics chair Murty Akundi made clear in a special APS session, Learning From Katrina. A number of senior physics faculty have left Xavier in Katrina's aftermath, forcing Akurti to rebuild the department—a significant challenge. Funding shortfalls continue to undermine physics efforts at both Xavier and UNO.

As with other New Orleanians, physicists struggling after Katrina proved that necessity is the mother of invention. Although many were highly critical of administrative and state bureaucracy, all gave the nationwide academic community high marks for ingenuity and exceptional generosity. Many professional relationships forged as a result of the storm continue to prosper.

The city's physics community seemed invigorated by the lively March Meeting. While many visitors to the city stayed close to the Convention Center, some ventured into the city's vibrant French Quarter, a short walk from the meeting site. This tended to give a skewed impression of recovery in the city, which remains in a sorry state in areas like Lakeview and the Lower Ninth Ward. Nevertheless, even physicists most severely affected by the storm and its aftermath expressed hope that their departments are finally getting back on their feet and will begin again to flourish.

Economic Models for Stock Markets Should Incorporate "Outlier" Events

So-called "outliers," which are rare events in trading on the New York Stock Exchange (NYSE), actually occur in regular patterns, and thus should be incorporated into economic theories, which to date have dismissed them as "anomalies," according to Eugene Stanley of Boston University.

Stanley spoke at the APS March Meeting in New Orleans about his efforts to uncover whether there are underlying unifying principles–the equivalent of physical laws–that dominate financial markets.

"Classic economic theories not only fail for a few outliers, but there occur similar outliers of every possible size," he said. "So ignoring them is not a responsible option." Stanley has recently completed analysis of 200 million transactions on the NYSE over a two-year period–significantly more data than has been available for similar analysis previously.

Econophysics emerged in the mid-1990s when several physicists–including Stanley–decided to apply the tools of statistical mechanics to the complex problems posed by financial markets. Huge amounts of financial data suddenly become available at that time, and there were an increasing number of PhD physicists finding work on Wall Street as financial analysts.

Many different physics models have been applied to financial systems, including percolation models, diffusion theory, models with self-organizing criticality of complexity, models developed for earthquake prediction, even chaotic models originally developed to study cardiac arrest. Fractal analyses of cardiac rhythms suggest that healthy people have complex cardiac behavior, compared to the rhythms of the unhealthy. Researchers at Brigham Young University are looking into whether similar complexity might be an indication of a healthy company.

Stanley uses a spin glass model to describe stock market fluctuations. The stock market is a complex system made of up many individual units (traders) who interact and make decisions based on the relative strengths of those interactions. The stronger the interaction –the more trustworthy a trader deems a colleague–the more influence that interaction has. But the strength of those interactions can change with time, if for example, a trader loses confidence in a colleague.

Of course, no financial model is likely to ever enable analysts to predict a specific event in the stock market, any more than one can precisely pinpoint the time, location, and severity of an earthquake. One of the prevailing economic theories is the random walk hypothesis for stock market prices holds that prices can't be predicted due to the lack of correlation between past and present prices. Just because a stock rises one day, there is no guarantee it will rise again the next.

Stanley was unequivocal about this, calling the stock market "a very complex system and probably insoluble," emphasizing, "There is absolutely no way anyone has been, or will be able to predict the future." However, better models that take outlier events into account can help investors better manage risk.

INTERNATIONAL News

...from the APS Office of International Affairs

"To speak for those who can't"

By Khaled A. Sallam

Since the 1970s when it began as a subcommittee of the APS Panel on Public Affairs, the Committee on International Freedom of Scientists (CIFS) has advocated on behalf of scientists whose rights have been violated. CIFS monitors the human rights of scientists–not merely physicists–throughout the world, including the United States, and works to assist those in need. Scientists worldwide face injustices every day. While we may not be able to bring positive resolution to every injustice that occurs, the scientific community can still have a positive influence through its defense of our fellow scientists' rights.

Where the Scientific Community's Support is Needed

CIFS has followed with great anguish the violence that has engulfed Iraq since 2003. Most disturbing, however, is that our colleagues—Iraqi academics, scientists—are being deliberately targeted. Hundreds of academics have been killed or injured, and others have been kidnapped or have disappeared. Still more are fleeing the country to prevent falling victims themselves.

At Baghdad University alone, eighty professors have been killed since the war began, according to an article in *The Washington Post* on 27 January 2008. From other reports in the media, we know that those from Baghdad University who have been murdered include the president of the University (July 2003), two deans (December 2007 and January 2008), and the head of the chemical engineering department (June 2007), to name just a few. The Arabic news network *Aljazeera* reported that those who have been killed include most of the scientists who participated in the Iraqi nuclear program or collaborated with Iraqi military industries as well as those with rare scientific expertise.

Photo from *Aljazeera* (10/20/07)

A black sign morning the death of a university professor in Iraq

No one can pinpoint the reason why these academics were killed. Yet, due to this violence and atmosphere of fear, Iraq is losing one of its most valuable and irreplaceable resources: its scientific and intellectual personnel who are critical to the intellectual and educational survival and to the building of a stable and democratic Iraq.

In 2006, the International Council for Science (ICSU) issued a statement expressing its support for the Iraqi scientific community and condemning the torture and killing of Iraqi scientists (see http://tinyurl.com/36l4q3). ICSU's Committee on Freedom and Responsibility in the Conduct of Science subsequently published a letter in the journal *Nature* (Vol. 444, pp 422, 23 November, 2006) urging the international scientific community to unite to identify ways in which to end the violence against Iraqi scientists. CIFS has called on Iraqi and US authorities to secure the urgent protection of educators, academics, and scientists in Iraq. CIFS encourages APS members to do the same by writing to your Senator and/or your favorite presidential candidate and asking him/her to put pressure on the Iraqi authorities and coalition forces. Your efforts will help the remaining Iraqi scientists to resume their lives without fear and continue training the next generation of Iraqi scientists and leaders.

Where the Scientific Community's Support Has Helped

In August 2007, student protests occurred at the University of Dhaka and Rajshahi University in Bangladesh. Several professors tried to serve as mediators between student protestors and police. As a result, twelve professors, including three physicists, were arrested and put in jail. Their detentions and the reported violations of their rights were brought

TO SPEAK continued on page 4

Letters

Referees Can Be Ignorant, Arrogant

Regarding the front page article (*APS News*, March 2008) on "outstanding referees," the APS editorial office should try to exclude ignorant, arrogant referees that tend to dislike, not comprehend, and reject, sometimes with venom, any new concept in physics.

As Cornelius Lanczos wrote: "How fortunate that someone of the calibre of Planck was editor of *Annalen der Physik* (in 1905)–Today none of these papers would see the light of day." Lanczos is, from my experience, absolutely correct.

Howard D. Greyber
San Jose, CA

Germany's Chancellor Holds Physics PhD

Concerning the thoughtful Back Page essay by Rep. Ehlers [*APS News*, February 2008], it might of interest to note that the current chancellor of Germany, Angela Merkel, holds a doctorate in physics and had worked in the field until re-unification led her to enter politics. One clearly notes her scientific background in a number of her policies, but this does not mean that there is a golden age of science in Germany. On a more cautionary note, one should recall the former leader of the German social democrats, Oskar Lafontaine (M.S. in physics), who as minister of finance could not face up to the numbers telling him that there was no money for the many "presents" he wanted to make, and thus resigned leaving his government in trouble (resulting in a lost first year of the new social-democrat+greens government in 1998). Similarly, in the US the most highly placed PhD in physics that comes to my mind was Admiral Poindexter, who was at the heart of the Iran-Contra scandal in the Reagan administration. I sometimes fear that our ability to model the world can lead to a cognitive dissonance such that people end up being treated like numbers, too–a danger any scientist should be aware of when entering the political arena.

Christian Schoen
Stuttgart, Germany

Education Courses Don't Help

I would like to add some data to the debate on the relative importance of training in "how to teach" versus knowledge of the subject. I am a retired physics professor here. For years we have been fighting with the school of education about the requirements for teaching certification. The state of Indiana gave them authority to make rules for certification, and for years they have been requiring 60 credits of education courses. Compare this with about 40 physics credits, which a physics major takes (out of 120 total in 4 years)! Recently, under lots of pressure, they relaxed the rules, so that a science graduate can get a teaching certificate by taking education courses full time for one year, including summer! (The so-called fast track, 30 education credits!) During that year, it is almost impossible to take a job. Very few of our students are willing to put up with this. Such a system has worked only when the student wanted to be a high school teacher from the first day in college and started taking education courses right away. It is hard to believe that, by taking some education theory courses, a bad physics teacher would suddenly become a good one. I came to know about one case recently where a biology major, who had barely taken two physics courses, was assigned physics teaching. This person had difficulty with inclined planes!

Also, I am surprised at the letter from Rick Moyer in the January *APS News*, which asserts that "...in most schools that there are too few students taking physics to justify full-time physics teachers." But an article in the February 2006 *Physics Today* by Jack Hehn and Michael Neuschatz showed that "fully one-third of recent high-school graduates have taken physics." A suburban school, with which I am familiar, has about 600-700 students (out of a total of 3500) taking physics courses each semester. Quite a few of these are in AP classes. A student responded to my question about the reason for taking physics with "Physics looks good on my transcript! Competition for getting into good colleges is very stiff!"

But whatever the reason for taking physics, we have to provide good physics teachers in high schools. At least around here (and perhaps in the whole Midwest) there is a shortage of qualified high school physics teachers. In spite of this, it is unlikely that Prof. Ketterle (Zero Gravity, *APS News*, November 2007), with his current qualifications, would be hired by Indiana high schools!!

Kashyap Vasavada
Indianapolis IN

TO SPEAK continued from page 3

to CIFS's attention by the American Society of Plant Biologists via the Science and Human Rights Program of the AAAS. CIFS wrote to Bangladeshi officials to express concern for the rights of the detained individuals. Happily, by January 2008, five professors had been acquitted and released from jail. The seven others were found guilty of inciting student unrest, but were subsequently pardoned.

One of the physicists who had been detained wrote that he was grateful for CIFS's support and the concern expressed by the scientific community on his and the other detainees' behalf. Even when a letter from CIFS does not reach a high-level government official, it still accomplishes other important things such as letting the imprisoned know that they are not forgotten or getting them better treatment by prison guards. And above all, it reminds the rights abusers that the world is paying attention. Calling attention to injustices can have an impact even if we cannot single-handedly stop human rights abuses from occurring or continuing.

Concerning the Bangladeshi case, Juan C. Gallardo, Chair of CIFS in 2007, said "This is a small victory in the general struggle for respect of human rights, indeed, but of utmost importance to the 12 academics and tens of students acquitted and/or pardoned." Of course, CIFS by itself cannot take credit for the release of all the faculty and students. Only through the prompt and combined action of several scientific associations and human rights organizations can CIFS be successful. Gallardo added that "The AAAS Science and Human Rights Coalition may be the right approach at this junction." (The Coalition is an alliance of human rights groups in the scientific community that is being established through the auspices of the AAAS.) In the past, Gallardo was on the other end of the story when he was one of the cases in which the APS intervened, in the 1970s in Argentina. As a former Chair of CIFS, he believes that "it is our moral responsibility to speak for those who can't."

To fulfill its mission and to uphold the American Physical Society's support for the Universal Declaration of Human Rights, CIFS needs every APS member to help defend the human rights of our persecuted colleagues. If you learn that a colleague has been subjected to human rights violations, please bring it to CIFS' attention. CIFS can help either directly or through its partners in the scientific community. More information is available on the CIFS web site: www.aps.org/about/governance/committees/cifs/index.cfm .

Ed. Note: *Khaled A. Sallam is an Assistant Professor of Mechanical and Aerospace Engineering at Oklahoma State University, and a member of CIFS.*

"Mixed Reality" States Explore Link Between Real and Virtual Worlds

A University of Illinois physicist has built a system that explores the connection between the real and virtual worlds by linking a mechanical pendulum to its virtual twin. It is the first real/virtual physics experiment, and could help clarify the influence that virtual communities exert on the real world, and vice versa. For instance, the experiment could help us understand how the economies of online games such as Second Life could affect real economies.

According to UI physics professor Alfred Hubler, his latest experiment is an example of a "mixed reality" state where there is no clear boundary between the real system and the virtual system: "The line blurs between what's real and what isn't."

At the APS March Meeting, Hubler reported on a recent experiment that he believes supports the existence of mixed reality states. He used a standard mechanical pendulum coupled with a virtual pendulum programmed to follow the well-known equations of motion. He and his colleagues sent data about the real pendulum to the virtual one, while sending information about the virtual pendulum to a motor that influenced the motion of the real pendulum. They found that when the two pendulums were of different lengths, they remained in a "dual reality state" in which their motion was uncorrelated, and thus not synchronized.

They also discovered that when the pendulum lengths were similar, they reached a critical transition point and became correlated. "They suddenly noticed each other, synchronized their motions, and danced together indefinitely," said Hubler. He compared it to a phase transition: the critical temperature/pressure point wherein matter moves from one state (gas) to another (liquid). In this case, the "phase transition" occurs when the boundary between reality and virtual reality disappears.

This is the "mixed reality" state, where a real pendulum and a virtual pendulum move together as one. The trick is real-time feedback. Scientists have coupled mechanical pendulums with springs to create correlated motion, but without the staggering computational speed now achievable, coupling pendulums with a virtual system simply hadn't been possible. "Computers are now fast enough that we can detect the position of the real pendulum, compute the dynamics of the virtual pendulum, and compute appropriate feedback to the real pendulum, all in real time," said Hubler.

As flight simulations, immersive VR, and online virtual games and worlds become increasingly accurate in their depictions of the real world, Hubler believes such "mixed reality" states will become more common. He thinks his lab-induced mixed reality states could be used to better understand real complex systems with a large number of parameters, by coupling a real system to a virtual one until their constant interactions result in a mixed reality state–for instance, modeling neurons by coupling a real neuron with a virtual one.

Instantaneous interaction is a critical requirement and while Hubler has shown that we can manage this in the lab with real and virtual pendulums, expanding that to an entire virtual world will require even faster computers, as well as far better probes and actuators and other supporting device technologies. Future generations of Second Life and other online games could become very exciting indeed, and almost indistinguishable from "reality."

zero gravity

The Lighter Side of Science

Practical Corollaries To Heisenberg's Uncertainty Principle

By Dale Dobson

The Cocktail Corollary: No personal opinion may be freely expressed until a preliminary assessment of the listeners' related opinions has been completed.

The Sartorial Corollary: The fashion value of any wardrobe-related purchase cannot be measured by its originator.

The Trailer Corollary: A motion picture's true qualities cannot be measured until a ticket has been purchased, at which point opinion of the film will exist in an indeterminate state until the credits roll or the instrumentation leaves the theatre.

The Flirtation Corollary: No flirtatious comment or salacious remark may be unambiguously stated before the receptiveness of its target has been confirmed.

First Vacation Corollary: The binary state of an iron, burner, space heater or other potentially inflammatory electric device cannot be determined without returning home after merging onto the freeway.

Second Vacation Corollary: The arrival of a body in motion cannot be accelerated by repeated measurement.

The Piscean Corollary: Any inaccuracy in estimation regarding the size of any sport fish will be magnified by the number and frequency of conversational references.

The Spiritual Corollary: Evidence for any deity's existence will be recognized in direct proportion to the observer's degree of belief in said deity.

The Nostalgia Corollary: No element of pop culture may be accurately measured until sufficient time has passed to document statistical significance in relative decay rates of lovabiliate and suckium.

The Fermentation Corollary: All known corollaries may be modified in an alcohol-enriched environment.

Dale Dobson writes, animates and acts in the metropolitan Detroit area, and occasionally gets around to updating http://www.daledobson.com. This article originally appeared in the Science Creative Quarterly.

Quants and the Conquest of The Street Called Wall

By Alaina G. Levine

***Editor's Note**: This is the sixth in a series of articles profiling people trained in physics who have gone on to make their mark in a variety of careers. The first article appeared in the April 2007* APS News*. The articles are archived online at http://www.aps.org/publications/apsnews/features/profiles.cfm .*

In the song, Mo Money, Mo Problems, rapper The Notorious B.I.G. postulated that "the more money we come across, the more problems we see." And though this is certainly a concern for all of us, it is even more so for physicists who work on Wall Street. Except for them, the "problems" they encounter are less sociological and more mathematical in nature, and thus are most certainly welcomed.

The dashing physics- and mathematics-educated pros who work for financial firms are called Quants. Very simply, they seek to solve the fundamental problem that has plagued Man since the dawn of time: how do we get "mo' money"? Not surprisingly, Quants have the skills and ingenuity to examine complex financial problems and design models to solve them, as well as analyze and reduce risk in securities trading. But what is shocking is how long it took firms on The Street to recognize and appreciate the contribution physicists can make as Quants within their organizations.

In fact, in the late 1970s and early 1980s when Quants began making a marked presence in financial firms, the term "Quant" was not endearing. "Back then we practitioners of quantitative finance didn't refer to ourselves as quants," said Emanuel Derman who is the Head of Risk Management for Prisma Capital Partners and directs Columbia University's financial engineering program. "That's what 'real businesspeople'–traders, investments bankers, salespeople–called us, somewhat pejoratively."


Emanuel Derman

Derman, who wrote a book entitled "My Life as a Quant", defines a Quant as "someone who works on quantitative finance," which is simply "the application of mathematics/physics modeling techniques to the evaluation and trading of financial securities." The field is also called financial engineering.


Andrew Davidson

Much of the work that Quants perform involves optimization problems, stochastic processes, econometric analysis of data, partial differential equations (including Monte Carlo methods), as well as other advanced mathematics, says Andrew Davidson, a Quant whose focus is in mortgage-backed securities. He serves as President of his own firm, Andrew Davidson & Co., Inc., which provides advice and analytics for fixed income investment management. His company works in an area called "Credit Modeling", which essentially involves predicting defaults and foreclosures.

Today, Quants are considered prized members of their organizations. Derman suggests that the shift in how they are perceived was instigated by three events over the last two decades: 1) all the securities that people trade got much more complicated; 2) the people who trade simple securities became more sophisticated about how they trade them (especially as more exchanges were done electronically); and 3) as a few firms began significantly employing quantitative techniques to their exchange work resulting in profits (and incidentally and coincidentally losses) in the billions of dollars, people took notice of the influence Quants have over the market.

So what specific skills do physicists bring to Wall Street? "Physicists and engineers [are] jacks-of-all-trades, simultaneously skilled mathematicians, modelers, and computer programmers who [pride] themselves on their ability to adapt to new fields and put their knowledge into practice," wrote Derman.

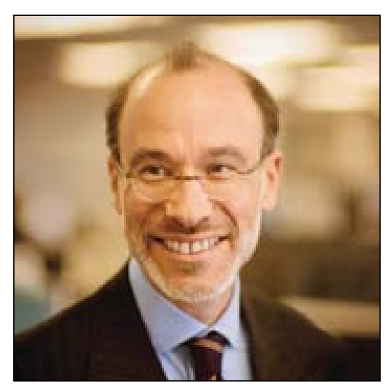
Although Davidson has a physics degree from Harvard and leads a team of Quants, he still doesn't consider himself one. Yet, he does acknowledge that his work in mortgage-backed securities has been quantish and greatly influenced by his physics education. He wrote in the book, "How I Became a Quant," "Little did I know [in college] that the diffusion equations and probability operators that I was studying then would prove useful later in life."

Indeed, quantitative finance is calculation-heavy, and as Davidson explains, requires a great degree of rigorous analysis. It also requires you to jump from problem to problem and adapt quickly to new circumstances, which are driven by market conditions and affect the math problem at hand.

Ron Kahn, whom along with Derman is described as an über Quant by Davidson, is the Global Head of Advanced Equity Strategies for Barclays Global Investors. His particular focus is in Asset Management. He has a PhD from Harvard and says his physics training absolutely comes in handy. He recalls that as he made his transition from cosmologist to Quant, he thought to himself, "Evidently physics was excellent training for finance. I didn't know the difference between a stock and a bond, but the idea of applying rigorous scientific analysis to investing sounded intuitively appealing."

His decision to enter finance was motivated by recognition of his own skills and characteristics and a need for job security and excitement. Looking back, he says, "in many ways, I was much better suited for [finance] problems [than those in physics]…In physics, you work on a problem for many years, not knowing if you're making progress or not…you wander in the dark a long ways." But as a Quant, Kahn likes having smaller problems that require quicker solutions. He finds satisfaction in this unique return on investment as well as the constant human feedback you get in the industry, he says.

Davidson chose his path based on a belief shared by many physics-educated professionals in non-traditional careers: "In college it became clear to me that I wasn't going to be a star [in physics]." It wasn't difficult for him to figure out what subjects he could be a star in. He did a self-skill inventory and realized that not only was he good in physics and math, but he also excelled in business, and in particular had an interest in international business and financial mathematics. This epiphany led him to pursue an MBA. His first job after business school was in the treasurer's department at Exxon, a position he called "a dream come true".


Ron Kahn

Derman, whose PhD in theoretical particle physics is from Columbia, worked for Bell Labs for five years before making the leap. "I liked being in physics because people value what you do," he says, but at Bell Labs in the 1980s, he encountered a very "corporate" and political machine that did not interest him.

Through contacts he was able to get a job in the Financial Strategies Group at Goldman, Sachs, & Co., which immediately appealed to him. "The stuff was interesting and [people] were interested in it, and it didn't matter who you were, it mattered if you could do something," he says. "You didn't have to be a manager or boss people around to be valuable [contrary to Bell Labs]". Furthermore, it was informal–"there was a flat management structure, so you could talk to anybody if you needed it."

Today Quants are seen as extremely strategic to the success of the companies that employ them. Their models determine what moves traders make and can destine the rise and fall of countless bank accounts. Quants "have become much more powerful than before," quoth the Quant Kahn, as "scientific investing", or utilizing a scientific approach to decision-making, "has become more compelling to large numbers of investors."

To become a Quant, Kahn recommends learning as much as you can about the industry and talking to a lot of people. But according to Derman, "it's harder now [to enter quantitative analysis than years ago] because when I went in, there wasn't much preparatory education you could get."

Whereas physicists of yesteryear could learn on the job, today many financial firms look for something more than a predilection towards particles. "You are expected to know something now [about Wall Street firms and their business]," says Derman, and in fact, there are now scores of financial engineering master's programs offered at universities around the country (including the one that Derman administers at Columbia).

Years ago, Derman, Davidson, and Kahn took a divergent path from physics and hedged their bets to become Quants. They dreamed of merging their scientific know-how with an interest in unique problem-solving and a desire to influence world economics. Their assets now include exceptional experience in various areas of quantitative finance and sought-after skills in market analysis and model-building. And all of them are still bullish over their decision to trade the bonds of physics for the securities of The Street called Wall.

Alaina G. Levine can be reached through her website at www.alaina-levine.com.

Quotes taken from personal interviews as well as the following:

Derman, Emanuel, "Finance by the Numbers", *The Wall Street Journal*, August 22, 2007.

Derman, Emanuel. *My Life as a Quant: Reflections on Physics and Finance*. Hoboken, NJ: Wiley, 2004.

Lindsey, Richard R. and Schachter, Barry. *How I Became a Quant: Insights from 25 of Wall Street's Elite*. Hoboken, NJ: John Wiley & Sons, Inc., 2007.

Workshop Opens Door to Energy Research

Materials research and nanoscience have the potential to help solve the world's energy problems. More than 80 graduate students and postdocs attended the APS energy workshop held in New Orleans on Sunday March 9, before the March Meeting, to learn about opportunities for research. Presenters described a wide variety of areas where physics research can contribute to the energy problem, including photovoltaics, hydrogen, fuel cells, thermoelectrics, and solid state lighting.

Organized by APS and funded by the Department of Energy, the workshop was aimed at students who were not studying energy topics, but who showed enthusiasm about becoming involved with energy research.

While there is no discipline called "energy," there is a lot of interdisciplinary work that needs to be done to solve our energy problems, said George Crabtree of Argonne National Laboratory in an overview of the workshop.

Clean energy is desperately needed. Right now only one percent of urban dwellers in China breathe air that is considered safe by European Union standards, Crabtree pointed out. Oil will eventually run out; while there are various estimates about when oil will peak, scientists generally agree that it will happen by the middle of the century, said Crabtree. Demand for energy is growing rapidly. The world now uses more than 10 terawatts of energy, and twice that amount will be needed by about 2050, according to projections, said Crabtree. "The truth is that no one knows where that energy is going to come from," said Crabtree. "There is no single solution to this energy challenge."

Solar energy can provide part of the solution. The amount of energy reaching Earth in just 1.5 days of sunlight is about the same as the amount of energy in three trillion barrels of oil, said Sara Kurtz of the National Renewable Energy Laboratory, who talked about "today's photovoltaics."

In recent years, photovoltaics have become commercially viable, and the industry is growing rapidly. "More silicon is used in solar cells than in the integrated circuit industry," Kurtz said. We're just getting into a range where solar energy is actually cheaper than conventional electricity, she said. There is plenty of room for improvement. For instance, nanomaterials could make better antireflective coatings for solar cells, or could be used to minimize gridlines that carry electricity away from the cells but block light coming in. Many different materials can potentially be used for solar cells. "If you can make a p-n junction out of it, chances are you can make a solar cell," she said. Efficiency gains could also come from multi-junction cells, which use more than one p-n junction to capture light with a range

WORKSHOP continued on page 7

March Meeting Prize and Award Recipients

Photo by Pat Garin

Front row (l to r): Jun Akimitsu, Robert C. Haddon, Karin Rabe, Arthur F. Hebard, Julia M. Phillips, Mildred Dresselhaus, Zeev V. Vardeny, Joseph Orenstein, Steven Block, Bryce R. Gadway. Back row (l to r): David P. Landau, H. Eugene Stanley, Mitchell Feigenbaum, Kenneth S. Schweizer, Gary S. Grest, Tin-Lun Ho, Gordon Baym, Christopher Pethick, Kari Dalnoki-Veress, Bjorn Wannberg.

Sessions Cover "Designer Viruses", Spread of Global Disease

Researchers continue to make progress in the emerging field of physical virology, according to speakers at a March Meeting session in New Orleans. The session was chaired by Bogdan Dragnea of Indiana University in Bloomington, one of a growing number of researchers interested in the physics of viral protein cages (capsids), which self-assemble to contain nucleic acid (RNA or DNA). The first Gordon Conference on physical virology will be held in February 2009.

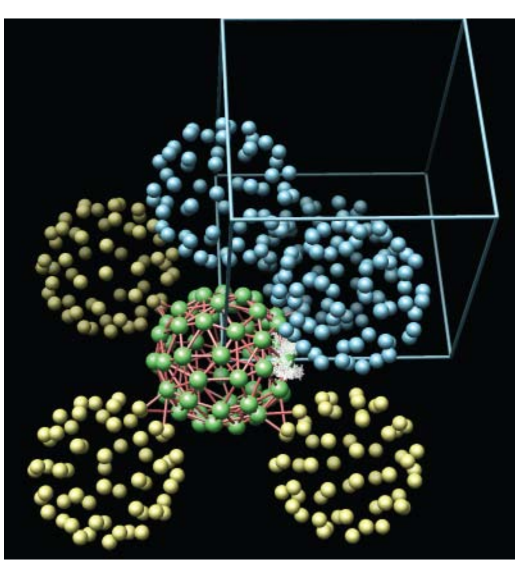
Dragnea has constructed artificial viruses by embedding negatively charged gold nanoparticles inside viral capsids by exploiting their attraction to the positively charged proteins lining the capsids. This mimics the interaction between "anionic genetic contents" (RNA and DNA) and those same positively charged proteins in real viruses. He has also encased fluorescent quantum dots of cadmium selenide crystals in a shell of zinc sulfide, which he then used to track how long it took for a particular virus to travel across a cell membrane.

The March Meeting session featured new research using cowpea chlorotic mottle virus (CCMV) that specifically infects the cowpea plant, more commonly known as the black-eyed pea. According to UCLA's Charles Knobler, CCMV is a favorite choice for physical virologists because it is so evolutionarily well-designed for self-assembly that one can literally break the viruses into their constituent parts–purified viral RNA and capsid proteins–mix them together in vitro in a solution at just the right pH and ionic strength, and the mixture will spontaneously assemble into infectious particles.

Knobler is investigating what determines the size of a virus, which he believes to be a combination of polymer length and capsid size. Furthermore, he has found that it is possible to manipulate the length of protein building blocks in the CCMV and the size of the capsid in such a way as to use virus proteins to make nonbiological particles that not only contain foreign molecules, but also that conform to a specific intended structure, such as multishell structures, tubes and sheets.

Adam Zlotnick and his colleagues at the University of Oklahoma Health Sciences Center can manipulate the CCMV coat protein in such a way as to redirect its self-assembly to produce tubular structures. A major focus of Zlotnick's lab is to understand the biophysics of virus capsid assembly.

"Capsid assembly and disassembly are salient events in the virus lifecycle, yet they are poorly understood and have not been exploited in developing antiviral therapeutics," he said. Viral capsids serve to contain and protect the viral nucleic acid, and may also serve as a delivery mechanism and as a metabolic compartment. The CCMV is a spherical virus, so its capsid is assembled from multiples of 60 protein subunits, arranged into a soccer-ball shape ("icosahedral symmetry").



"Knowing the structure of a virus gives us a snapshot, but add the knowledge about the kinetic process of assembly, and we have a much more complete picture" of how a virus works, according to Zlotnick, who has devised dynamic models of the self-assembly process that match well with experimental observations, "Experimentally, we have found that capsids are based on a network of extremely weak interactions," he said. Far from being static structures, viruses are "very dynamic molecule machines."

Because the interactions are weak, it is possible to interrupt the assembly process to generate tubular structures in addition to spheres–or even keep the virus from forming completely in the first place. The fact that it's possible to disrupt and manipulate the process bodes well for the bottom-up production of manmade nanostructures via self-assembly for any number of applications, including the development of new antiviral drugs.

Another March Meeting session focused on panic reactions and the spread of global disease. Researchers from the Max Planck Institute for Dynamics and Self-Organization recognized that human beings will "change their dispersal characteristics" in response to local infections to avoid becoming infected themselves. The researchers found that "the individual rationale of avoiding an epidemic wave... actually facilitates epidemic spread"–at least in one of their models. A more fully developed dynamical model showed the same effect, but also "an increased extinction probability of the epidemic as a function of increasing dispersal response."

It is difficult to model the dynamics of epidemics because there are so many unpredictable variables. Scientists would like to have a clearer picture of human mobility patterns–preferably one that can be universally applied. Researchers at Northeastern University and Notre Dame University have analyzed cell phone usage to demonstrate that human mobility can be described by the same universal pattern, regardless of what our individual travel habits may be.

These patterns could be useful in urban planning, traffic forecasting, and of course, the spread of diseases and viruses. The latter would include the possibility of cell phone software viruses, in which malevolent code could be transmitted either via text messaging or through Bluetooth connections between devices. Each transmission pathway would require different countermeasures, since text message viruses, like email, would spread through social networks rather than the physical location of the actual cell phones, whereas a Bluetooth-specific virus would spread among cell phones in close proximity.

March Meeting Briefs: Buckyballs, Optical Lattices, and Subwavelength Imaging

Buckyballs can be made from elements other than carbon, forming a variety of potentially useful structures. Lai-Sheng Wang of Washington State University has produced hollow sphere-shaped cages made from gold and tin atoms. Wang's group formed a variety of gold structures, ranging from 2-dimensional structures with 4 to 12 atoms to pyramids made of 20 gold atoms. In between, gold clusters with 16 to 18 atoms formed hollow cages. Wang's group created the clusters using pulsed laser vaporization, in which a laser vaporizes atoms off a solid gold target. The vaporized atoms condense into clusters of various sizes, as small as a few atoms, which are then sorted by size. Wang used photoelectron spectroscopy to look at the structures of the clusters.

The researchers have also been able to insert other atoms into the hollow centers of the cages, changing the electronic, magnetic, and catalytic properties of the structures.

The gold cages, first produced a couple of years ago, were the first metal buckyball-like structures produced. More recently, Wang reported at the March Meeting that he has produced stable tin icosahedral structures, which he calls "stannashperene." He has inserted various transition metal elements into these cages as well. While it is too early to develop any specific applications, these structures have interesting properties, and could be potential building blocks for new materials, Wang said in a press conference at the March Meeting.

In a step towards quantum computing and other applications, David Weiss of Penn State reported that he and colleagues have demonstrated a new 3D optical lattice in which they have trapped and manipulated 250 atoms for potential use as qubits.

Optical lattices use a set of crossed laser beams to create an array of sites where atoms can be trapped in potential wells. The researchers load a small trap with cesium atoms, then turn on the lasers. The lattice starts with about six atoms per site; after laser cooling, each site in the lattice is left with either one or zero atoms. The spacing between atoms in their lattice is about 5 microns, which gives enough space between atoms that they can address individual atoms and manipulate the states of individual atoms with lasers. The researchers have imaged 250 individual neutral atoms in this array, and are working on filling in all the vacancies in the lattice. The method could be scaled up to create arrays with thousands of atoms.

They hope to use the trapped atoms as qubits. "They are really isolated perfect quantum systems," said Weiss. He has proposed a way to use the optical lattice to execute single or two qubit gates for quantum computation. While there are many potential routes to quantum computing, said Weiss, one advantage of neutral atoms in these traps is that they have very weak interactions with the outside world. Optical lattices have other uses as well, Weiss pointed out. "The hottest use for optical lattices is to simulate condensed matter systems," he said.

Images with subwavelength resolution have been transmitted farther than ever. Pavel Belov of Queen Mary University of London described his record-setting subwavelength transmission of light at the March Meeting. Imaging details smaller than half the wavelength of the light used to create the image has been a fundamental problem, but in the past few years scientists have been able to get around the classical diffraction limit with metamaterials, which have generated a lot of excitement lately in applications such as superlenses and cloaking. It's a nice concept, but applications need improvement, Belov said. One problem is that although these materials can be used to create subwavelength images, these metamaterials materials can't transmit an image very far.

Belov and colleagues used a new approach, using an array of parallel metal rods to channel light. The setup is similar in operation to a bundle of waveguides. They were able to reach about 1/20 wavelength resolution, and transmitted an image a distance of more than 3 wavelengths. So far, their experiments have used microwaves, but in simulations, their setup worked with wavelengths up to 30Thz, and in theory they believe it could work up to 100 THz. Belov suggested the technique could have applications, for example, in improving MRI resolution.

PRL continued from page 1

and non-specialists. Some of the papers themselves are difficult to read. Blume points to Roy Kerr's 1963 paper describing what is now known as the Kerr metric, which he says people in the field did read, understand and build upon, despite the "impenetrable mathematics."

In the summaries, Blume also points out some interesting facts and stories related to some of the papers. For instance, the most-cited particle physics paper, Steven Weinberg's 1967 paper, "A Model of Leptons," wasn't cited in the first year after its publication and was only cited twice in the following two years.

Selecting the milestone letters and writing the short summaries requires a lot of research, says Blume. Since he can't possibly read every single *PRL* paper published each year, Blume begins the selection process by looking through lists of the most cited and most downloaded papers for each year.

Some years have more than one *PRL* paper that led to a Nobel Prize, and all years have plenty of significant papers to choose from. "There's an overabundance," says Blume. "It shows how important *Physical Review Letters* has been."

ANNOUNCEMENTS

Still Time to Enter the FABULOUS APS News Caption Contest!!!

See www.aps.org/publications/apsnews/200804/zero-gravity.cfm

Now Appearing in RMP: Recently Posted Reviews and Colloquia

You will find the following in the online edition of *Reviews of Modern Physics* at **http://rmp.aps.org**

Half-metallic ferromagnets: From band structure to many-body effects

M.I. Katsnelson, V. Yu. Irkhin, L. Chioncel, A.I. Lichtenstein and R.A. de Groot

Ferromagnetism, which spontaneously spin-polarizes the conduction electrons, offers a fascinating possibility: a material can be a semiconductor for one spin projection, and a metal for the other. This review gives an overview of this class of materials, their electronic structure, and their transport and thermodynamic properties.

ALTERNATIVE continued from page 1

with the goal of achieving sub-15 nanometer resolution while retaining such essential lithographic benefits as pattern perfection and high-volume manufacturing.

NIST's Alamgir Karim has developed what he believes could be a robust, high-throughput nanomanufacturing technique for self-assembling block copolymers. It employs two-dimensional physical and chemical patterns (templates lined with troughs separated by crests) that can direct, in three dimensions, the orientation of "block copolymers." Block copolymers are materials consisting of a long chain of one type of building block strongly bonded to a chain consisting of another type of monomer.

Karim uses a temporal zone (cold-hot-cold) annealing of block copolymer films. Computer simulations demonstrated that when a heated zone sweeps across the template, the polymer molecules that have been deposited on the template self-assemble into well-aligned, almost defect-free lines. Using this technique, the block copolymers can form arrays of tiny dots that, in turn, could be used as the basis for electric components capable of cramming 1000 gigabytes of memory into a device the size of a pack of gum.

A major challenge in realizing the potential of polymer nanotechnology is controlling the self-assembly process. Karim and his NIST colleagues have developed techniques for accurately measuring thin film polymetric nanostructures in 3D, drawing on tomographic small-angle scattering methods. For instance, they combine many 2D neutron scattering images into a single composite imaging pattern that reveals the thin film's 3D internal structure, thus enabling them to determine if the nanoscale polymer structures are in the correct positions and free of defects.

Being able to measure these nanoscale structures is just part of the challenge; one still needs to control molecular function with nanometer-scale precision. To that end, Christopher Ober of Cornell University reported on his use of block copolymers to deliver chemical functions to the near-surface region with precise control of surface functionality. His team has found that by using block copolymers alone and in combination, it is possible to tailor not just surface properties, but also the mechanical behavior of the polymer surface region.

In an intriguing twist, NIST scientist Kevin Yeager discovered that deliberately roughening his templates with a sprinkling of nanoparticle silica forces block copolymers into a perpendicular standing position relative to the template–a critical feature for nanotech applications. The internal structure remains disordered using this technique, but it could prove to be a useful, inexpensive way to achieve those vertical structures for applications that require just the surface to be smooth.

For Daniel Savin of the University of Vermont, investigating the process of self-assembly is less about lithography and electronics and more about biological interactions. For instance, nature uses the same building blocks (amino acids) embedded in block copolymers to self-assemble proteins. He is interested in mimicking nature's process, incorporating biological elements into directed self-assembly of block copolymers to form large-order structures that can respond to different solution conditions.

At the March Meeting, Savin described how he uses polypeptide-based polymers that are "tunable" and have potential applications as viscosity modifiers and gels for application in cosmetic products such as shampoos, as well as for liquid crystals. The bulk properties of these materials depend on the morphology of these polymers, which can be finely tuned by altering the acidity or the temperature of the solution.

Elsewhere on the self-assembly research front, scientists at Brookhaven National Laboratory have developed a new method for controlling the self-assembly of nanometer and micrometer-sized particles based on designed DNA shells that coat a particle's surface. According to Dmytro Nykypanchuk, who described this work at the meeting, the method is unique because it employs two types of DNA attached to the particles' surfaces. The first forms a double helix, while the second is non-complementary, neutral DNA that provides a repulsive force. This enables the scientists to regulate the size of particle clusters and the speed of self-assembly with greater precision.

In subsequent experiments, the Brookhaven scientists used the attractive forces between complementary strands of DNA to create 3D, ordered crystalline structures of nanoparticles with unique properties such as enhanced magnetism and improved catalytic activity. They also added "thermal processing," heating the DNA-linked particles, then cooling them back down to room temperature, thereby allowing the nanoparticles to unbind, reshuffle, and find more stable binding arrangements.

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of wavelengths, and from concentrators that focus sunlight onto the solar cell. NASA already uses very high efficiency (about 40%) multi-junction cells to power the Mars rovers, but those solar cells are extremely expensive. "We're trying to bring that down to Earth," Kurtz said.

Some gains could come from the "third generation" of solar cells, according to Arthur Nozik of the National Renewable Energy Laboratory. The first generation solar cells were made from single crystal or polycrystalline silicon. The second generation includes amorphous silicon, thin film silicon, organic semiconductors, and some other materials. The third generation, said Nozik, which could be based on quantum dots or other nanostructures, will have very high efficiency and low cost, but to reach that point, "we need some major breakthroughs," said Nozik.

Hydrogen could be another significant element of the future energy mix. Mildred Dresselhaus of MIT pointed out that hydrogen is abundant, and combustion of hydrogen yields only water. Challenges remain in producing hydrogen in sufficient quantities, storing it, and utilizing it efficiently. For the next decade or so, hydrogen will primarily be produced using fossil fuels, but in the future hydrogen could be produced from renewable sources, Dresselhaus said. "New materials and nanoscience discoveries are necessary to get from where we are to where we have to go," she said.

In some cases, centuries old technologies can be made dramatically better using nanoscience. Debra Rolison of the Naval Research Laboratory pointed out that batteries, first developed over two hundred years ago, haven't changed much in their basic design. "There's no Moore's law for battery science," she said. Nanotechnology could bring about new developments. For instance, some materials that aren't useful in macroscopic form for energy-storage could be useful for batteries in nanostructured forms. "An old material that you would never have used as a battery is now a battery," she said. She also highlighted the potential advantages of disordered materials. "Order and periodicity are overrated," she said. Progress is already being made, she said, giving an example of some new, high-capacity lithium ion batteries for plug-in electric and hybrid vehicles that have recently been developed using nanotechnology.

Solid state lighting is also making great strides. In the United States, 22% of electricity is used for lighting, yet standard incandescent lights are only 5% efficient, and fluorescents only about 20% efficient. Light emitting diodes (LEDs), on the other hand, are small and versatile, and have the potential for 50% efficiency. Solid state lighting is already a $40 billion industry worldwide. Single color LEDs are already in widespread use in applications such as automobile taillights and traffic signals. Replacing red traffic lights with LEDs saves $1000 per year per intersection, said Jerry Simmons of Sandia National Laboratory. Developing LEDs for general purpose lighting is somewhat more challenging–cost is still an issue, as is producing a white light that people find acceptable–but scientists and engineers are making rapid progress. Simmons pointed out several areas where research could contribute to improving solid state lighting.

GM staff research scientist Jihui Yang made a presentation on new thermoelectric technologies that would utilize the heat from a car's exhaust pipe to power electric devices in the car. GM hopes to have a working prototype using this technology in just two years, which they claim will have a three to four percent fuel economy improvement. If every GM model car had such a device, that would save three to four million gallons of gas a year. In fact, GM engineers are shooting for 10% fuel economy improvement.

Thermoelectric energy faces challenges in terms of needing increased compactness, efficient and lightweight materials, and efficiency. GM is seeking to employ recently graduated engineers and physicists to work on these problems. Thermoelectric technology may be used in various other heat-waste systems such as power plants, aircrafts, trains, heavy-duty trucks, cars and buses, and fuel cells.

A panel discussion with representatives of funding agencies, industry, and national laboratories provided the students with some advice on how to find research opportunities in energy areas. While many postdoc positions seek someone with previous experience in energy research, Phil Price of Lawrence Berkeley National Laboratory said he had made a transition from atomic physics to energy and environmental research, and that a physics background can be useful.

One student at the workshop, Christina Hagemann of the University of New Mexico, studies dark energy detection, but says she would like to get involved with energy research after she graduates. She and other attendees Mark Wilson of Penn State and John Gregoire of Cornell appreciated the opportunity to find out more about the physics of energy research. "My experience with this stuff is pretty much the Discovery Channel," says Hagemann, "It's great to hear from the experts what the challenges are." The graduate students agreed that the workshop was a chance to learn more about the primary questions being asked by researchers in the field of energy efficiency, and perhaps a way to relate their own research to the field of energy efficiency.

Calla Cofield contributed to this article.

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insight into why things happen, he said.

Daniel Rothman of MIT reported on his model of the rates at which microbes consume organic matter in soil and sediment, converting organic carbon to carbon dioxide. Many processes are involved, and these processes happen at rates that are "disordered"–some are fast, most are slower. Overall, Rothman's model predicts that the rate of decay of organic matter and production of CO_2 decreases with age. His results compare well with measurements, he said. Similar considerations could be applied to other aspects of the carbon cycle, such as the decay of leaves to carbon dioxide. The work could lead to better understanding of the carbon cycle and predictions of atmospheric carbon dioxide levels, he said.

Soil moisture and vegetation are also significant factors in climate. Antonello Provenzale (ISAC-CNR, Torino, Italy) reported on a simple box model used to study the relationship between vegetation and summer droughts. Soil moisture and vegetation cover at the end of spring and beginning of summer are important in determining the probability of a severe dry season, the researchers found. Droughts are more likely if there is less than a minimal vegetation cover. Also, a fixed vegetation cover, such as in cultivated areas, is more likely to lead to drought than a dynamic natural vegetation cover that can respond to prevailing soil moisture conditions.

Stephen Griffies of NOAA discussed the physical process and numerical issues involved in ocean modeling, but said that there are many processes that may be relevant to ocean flows and the larger climate issues, and scientists still need to figure out what factors matter most. "A lot of the tools are at the art stage rather than the science stage," he said.

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at room temperature, which is unprecedented for solid state qubits, he said. Lukin also believes he can link up several of these qubits in a small register for quantum information processing.

Charles Santori of Hewlett Packard described an all-optical method of manipulating spins in diamond. His goal is to create a photonic network in diamond for quantum information processing applications. His approach uses an array of microcavities and microphotonic waveguides; there is no need for an external magnetic field. This optical approach to manipulating spins in diamond is a step towards building networks of linked qubits to create a working quantum computer, he said.

Steve Prawer of the University of Melbourne showed off a picture of the world's smallest diamond ring. At just 300 nanometers in cross-section diameter, and about 5 micrometers across, it could be used as a potential element of a quantum computing scheme. The tiny ring, carved from single crystal synthetic diamond, could be useful for producing and detecting single photons. The photons can be used as qubits in a quantum computer. Single photons are also needed in applications such as secure quantum communication schemes. This is just one small step, but Prawer believes diamond quantum information processing devices are on a path to commercialization. "I think we can look forward to actual devices coming out in the next few years," he said.

The Back Page

Peer Review at the Physical Review

By Reinhardt Schuhmann

We editors often say, and also often hear, that the great strength of *Physical Review* and *Physical Review Letters* lies in the extensive peer review that submitted manuscripts receive. This widely held view is a natural topic for our discussion surrounding the 50th anniversary of *PRL*. The issue is particularly relevant because recently both *Physical Review* and *PRL* have taken steps that have increased the number of papers that are returned to authors *without* external review. These steps were a response to the relentless increase in submissions and to a generally held view that average manuscript quality has decreased. Another important goal was to address the ever increasing burden on reviewers, the source of our journals' strength. Thus in recent years more papers are reviewed only by the editors, and it is of interest to examine these issues in historical context.

The Physical Review was conceived in 1893 as a more egalitarian publication than was usual for the time. One can guess as to why. Perhaps it was a reflection of the 19th century American inclination to redefine class. Perhaps it came about because the journal was initially located at Cornell, a relatively new, and quite progressive, institution that admitted women as well as men. (Incidentally, Ezra Cornell, a self-made millionaire of humble beginnings, was an embodiment of the changing social strata of the time.) More prosaically, *The Physical Review* may have embraced an egalitarian model for the simple reason that it was natural to do so amongst late 19th century US physicists because there were few of wide fame. In any case, we know that at least a few submissions were sent by the editors to external reviewers as early as 1901. Other papers were reviewed by the editors, eventually with assistance from an Editorial Board that was in place by 1913, when APS assumed responsibility for *The Physical Review*. As was common practice at scientific journals around the turn of the last century, most papers were published or rejected without extensive review. Decisions about what to publish and what not to publish were to a large extent made solely by the editors.

We know that by the 1930's peer review at the journal was more established. Ledger pages from the time contain the same basic information that we now store in our computer: date of receipt, date sent to a reviewer, date returned, date published or rejected. From these we see that many papers were sent out for expert evaluation, but also that in many cases the expert assigned to a manuscript was the Editor, John Tate. We also learn that many papers had no referee assigned to them, and that some of these were accepted and some were rejected. Thus during this period peer review was growing, and making a larger contribution, but decisions were still often made by the editors alone.

This situation apparently continued for many years. In the early 1960's, when the APS journals were located at Brookhaven National Laboratory, Editor Simon Pasternack would obtain local input from physicists who worked at the lab. A memo in use at the time clearly allows for rejection of a paper without formal peer review. One of its options was "It should be refereed," indicating that the contrary possibility was also viable.

So far this discussion has been about *The Physical Review*. The history at *Physical Review Letters* is somewhat different. First, one must consider the basis for *PRL*, the Letters to the Editor section of *The Physical Review*, which first appeared in 1929. From 1929 through the first half of 1958 it included a disclaimer from the editors: "The board of editors does not hold itself responsible for the opinions expressed by the correspondents." This statement carries the implication that Letters to the Editor were not reviewed. This is supported by the fact that no Letters to the Editor appear in the ledger entries mentioned above. It is also clear that not all submissions to the Letters to the Editor section were published: By the 1950's, the section had grown to such an extent that the Editor, now Sam Goudsmit, took steps to reduce their numbers, which of course means that he turned away some Letters to the Editor without external review. So, manuscripts that appeared as Letters to the Editor were chosen entirely by the Editor.

It is interesting to note that the primary motivation for the Letters to the Editor section was speed of publication. The description of the section offered "prompt publication ... of important discoveries in physics." The absence of review was a strategy aimed at minimizing delay. The growth in Letters to the Editor mentioned above likely occurred because of an increasing association of "prompt" and "important" in the community. The idea that important work was published quickly began to be turned around: work that was published quickly was important, apparently, by definition. Goudsmit indicated his understanding of this logical reversal by noting in the 1 May 1958 announcement of the upcoming birth of *PRL*, "Such a fast-publishing journal may become very popular with authors and could soon grow beyond reasonable bounds."

Photo by David Tomanek

When *PRL* began, it initially followed the practice established for Letters to the Editor. In an editorial in the first issue of *PRL*, Editor Goudsmit states that "most of the decisions for acceptance...will have to be made in the Editor's office." Naturally this means that decisions *against* acceptance were to be made there also. This original intent quickly shifted, however, as *PRL* grew, and a few months later, 1 August 1958, Editor Goudsmit wrote that the journal was "obliged to send to referees many of the submitted Letters to ascertain whether their contents require rapid publication." Consultation with single referees grew through the sixties, and in the early seventies a shift to simultaneous consultation of two referees took place.

Once again, the motivation for these changes was speed of publication. The editors found themselves overwhelmed by the number of submissions, and in order to move things along found it necessary to distribute the decision-making process among some referees, initially one at a time. Consulting a single referee did not always work, however, because sometimes referees did not respond. Thus the use of two referees was initially a means to insure that at least one report appeared. Because Letters were seen by authors as important and prestigious, however, a tendency arose to conclude that all papers must have two referees. This point of view is often expressed by authors today, in particular if there is only one, and he or she opposes publication. It is not, in fact, a policy requirement of *PRL* today. While in practice most Letters are reviewed by more than a single referee, it has always been well within standard practice for an editor to make a decision on the basis of a single report.

There is a somewhat ironic aspect to the increased inclusion of anonymous review as a means to insure prompt publication. Our statistics consistently show that time with referees represents about half of the time required to review a manuscript, with the other half divided roughly equally between authors and editors. Publication today is somewhat different than it was many decades ago, because it is now possible, e.g., via the ArXiv, to distribute results immediately, without peer review. The steady increase in submissions to *PRL* shows that promptness is no longer as large a consideration for contributors, although naturally authors still want a quick decision, especially a favorable one. For better or worse, some journals are viewed as more important than others, and publication at the highest possible level is preferred. It seems that journal importance is thought to prove individual manuscript importance, although in general the range published by all journals is very broad.

Three other points are of interest in the context of level of review and speed of publication. Beginning in July 1964 and continuing into the 1970's, *PRL* submissions that covered high-energy physics experiments were accepted without review, if they met certain simple criteria, including a cover letter from a senior administrator at the home institution. The basis for this was the fact that high energy experimental groups had many members, and were few in number, which led to many (unwarranted) accusations of unfair referee behavior. Authors felt that any potential referees who were not coauthors were fierce competitors, so unbiased review was not possible, and this policy was an attempt to reduce acrimonious exchanges by immediate publication. It was always applied at the discretion of the Editors, and it has been decades since any paper was accepted in this way.

On the other hand, in March 1969, faced with continued growth and with financial pressure, Editors Goudsmit and George Trigg wrote that while "in the past, most borderline cases, when referees' opinions differed, were decided in favor of the author," they "could no longer afford that luxury." Finally, in the late 1980's, in response to a flood of submissions relating to high temperature superconductors, the journals established a temporary advisory board, to make quick decisions about submittals on this topic. This board acted similarly to the 1913 Editorial Board mentioned above, making quick recommendations to the editors either for or against publication. The three events demonstrate that in some cases during these years decisions were made largely by the editors, sometimes without extensive review.

So, what can we conclude from this? Certainly we can say that throughout its history, the editors of *The Physical Review* and *Physical Review Letters* have made decisions about publication using some referee advice. We may also state that referee input has grown over the years. Further, we see that the editors have adjusted their reaction to, and usage of, input from referees for cause, e.g., to control growth of published pages. We find it reassuring to revisit the considerable precedent for our recent efforts to turn away some submittals without external review.

The proof of the pudding, however, is in the eating, and it is also reassuring to note the considerable evidence that these efforts have been successful. Certainly the roughly 20% of submittals to *PRL* that now do not go out for review has reduced the burden on our pool of referees. In addition, our early decisions have allowed manuscripts to find homes in more appropriate journals without undue delay. They have also sometimes inspired authors to take another look at their manuscript, and improve it, occasionally to the extent that the manuscript becomes appropriate for one of our journals. Finally, early decisions have had no obvious impact on the quality of the published journals, and have not diminished interest among authors in publishing in them. Overall, early decisions have proven themselves to be beneficial, will continue, and should probably increase.

This does not mean that we intend to abandon peer review, which we still believe to be essential to the success of the APS journals. Most submitted manuscripts will continue to be reviewed. Input from referees is invaluable to us as editors, especially when it provides a substantive basis for any assessment, because it provides essential information to help us choose what to print. We also will keep in mind the fact that referee effort is a finite resource, and will work to apply peer review judiciously, so as not to overburden referees.

Referee reports also help authors, because they lead to improved manuscripts. It is not possible to keep precise statistics for "manuscript improvement," since it is inherently subjective. What one person views as significant change another might view as a minor clarification. It is fair to say, though, that most submitted manuscripts undergo revision in response to referee reports, and that a substantial number of those are changed significantly for the better, both in terms of presentation and in their substance. Many papers submitted to *PRL* eventually appear in another journal, either one of the sections of *The Physical Review* or elsewhere, and the revisions are valuable there as well.

Finally, peer review is useful to the entire community, because manuscripts that are both more readable and more rigorous do a better job of communicating results to readers. Peer review is and will remain an essential element of the APS mission "to advance and diffuse the knowledge of physics."

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