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Nobel Chemistry Committee Cites Feynman's 1959 APS Talk
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2016 Nobel Prize in Physics

By Rachel Gaal

This year's Nobel Prize for physics was awarded on October 4, with one half to David J. Thouless of the University of Washington, Seattle, and the other half to both F. Duncan M. Haldane of Princeton University and J. Michael Kosterlitz of Brown University. The committee's official citation reads, "For theoretical discoveries of topological phase transitions and topological phases of matter."

In the early 1970s and 1980s, these three physicists explained phenomena in quantum states of matter, such as the quantum Hall effect and superfluid phase transitions, using the mathematical concepts of topology. They correctly predicted transitions in these unusual phases of matter. Moreover, their success has sparked an array of research with topological materials, which could be used in future quantum computers or in new generations of electronics and superconductors.

The collaboration of Kosterlitz and Thouless in the 1970s sought to challenge the theory that ordered phases and phase transitions could not occur in thin layers. With topology as a tool, they demonstrated that superfluidity can indeed exist in a thin layer as a result of a transition between topologically distinct phases of matter. Now recognized as a fundamental mechanism in condensed matter physics, topological phases have been identified in 1D materials, like chains of atoms, thin layers of matter (2D), and some 3D materials.

The applications of topology extended into Thouless's and Haldane's work in the 1980s, when they employed these concepts to unravel the magnetic properties of low-dimensional materials. Haldane studied magnetic atomic chains, and discovered that their topo-

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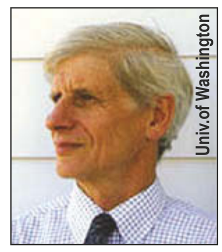
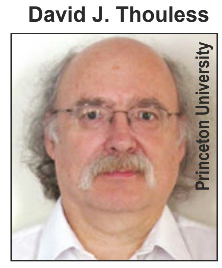


David J. Thouless



F. Duncan M. Haldane

J. Michael Kosterlitz

From Quarks to Cosmos in the Nation's Capital: 2017 APS April Meeting

By Rachel Gaal

Calling all physicists — it's time to get ready to travel to Washington, D.C! The 2017 APS April Meeting will be held January 28 - 31, 2017, at the Marriott Wardman Park Hotel. The April Meeting (held next year in January to avoid the exploding cost of hotel rooms during the spring cherry blossom viewing season) will host exciting talks about quirky quarks, the vast cosmos, and much in between.

Expecting over 1,500 attendees, the organizers will welcome 130 invited speakers and offer three plenary sessions that cover topics of particle physics, astrophysics, nuclear physics, and gravitational physics.

Government and political figures will speak on the theme of "Science Policy in the 21st Century" at Saturday's plenary session. John Holdren, Director of the U.S. Office of Science and Technology Policy, and Cherry Murray, Director of the Office of Science, U.S. Department of Energy, will discuss the changing role of science within policymaking and their roles as physicists in the government. Rush Holt Jr., CEO of the American Association for the Advancement of Science (AAAS) will discuss the importance of promoting science among policymakers. Congressman Bill Foster, representing the 11th District of Illinois, will also join in the session to discuss his experience as a "physicist on the hill" and as a U.S. representative.

The Kavli Foundation special plenary session, scheduled for Monday, will feature talks from Barbara Jacak of Lawrence Berkeley National Laboratory

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Q&A with Sabine Hossenfelder: Consultant for Armchair Physicists

By Sophia Chen

When funding for her quantum gravity research started to look spotty, Sabine Hossenfelder came up with an unusual solution to pay the bills. First, Hossenfelder, a research fellow at the Frankfurt Institute for Advanced Studies in Germany and well-known physics blogger, wondered, "What is all this knowledge in quantum gravity good for?"

And then she thought about all those armchair physicists out there, the ones who cook up their own theories of everything and proclaim in Internet comments that they can prove Einstein wrong. She posted an offer to act as a physics consultant on Facebook and on her blog: for 50 U.S. Dollars, she would spend 20 minutes on Skype answering your questions and setting you straight on your pet theory. If you were open to it, she'd also suggest concepts to learn and papers to read. The clients have rolled in: Since starting the service a year ago, Hossenfelder has expanded the operation to include five more physicists.

In addition to quantum gravity research and this consulting service, Hossenfelder writes prolifically about physics in her blog for non-technical audiences, *Backreaction*, and in publications like *Forbes* and *Aeon*. She spoke with *APS News* last month about her experiences counseling physics enthusiasts. This interview has been edited for length and clarity.

Sabine Hossenfelder

I can sort of relate to your experience. When I was studying physics in grad school, we'd get emails from random people pushing their pet theories on us. But we'd delete them and laugh it off. Why'd you decide to engage with them?

I admire their drive a lot. These people have spent a lot of time on their theories, and they really want to understand [the physics] and contribute. They love the science. They're not people I like to ignore.

Has anyone come up with anything publishable?

Not yet. I've only offered this service for a little over a year, and you know, nobody can immediately publish when they first start studying physics. But before this service existed, people were already asking me about their theories, and one person actually did publish a paper.

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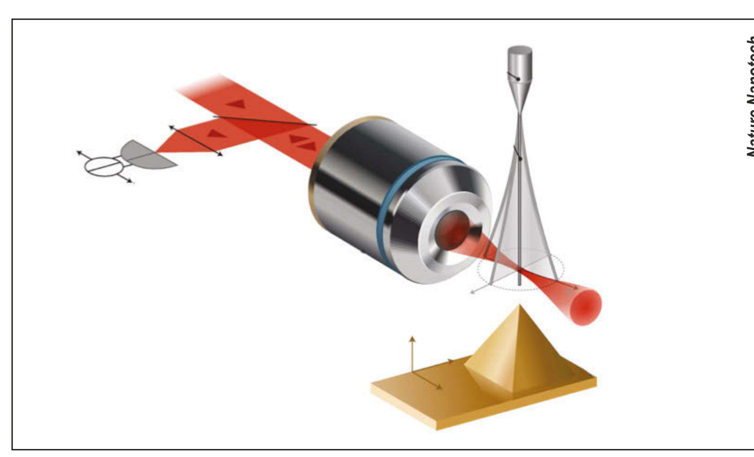
Research News: Editors' Choice

physics.aps.org

A Monthly Recap of Papers Selected by the Physics Editors

Atomic Force Microscopy Maps Vector Field in 2D

Two independent groups have developed atomic force microscopy (AFM) schemes that can measure vectorial force fields in two dimensions. AFM can image the surface of a sample with atomic resolution by recording the force exerted by a sample on the tip of an oscillating cantilever. Conventional setups, in which the cantilever motion is limited to one dimension, probe only the projection of the force along a specific direction. Mercier de Lépinay et al. and Rossi et al. replaced the cantilever tip with a nanowire, which follows the surface forces like the needle of a record player. Both setups, which are described in *Nature Nanotechnology* (doi:10.1038/nnano.2016.193, 10.1038/nnano.2016.189), use optomechanical readout techniques, in which laser light monitors displacements of the nanowire. The two-dimensional force field of the sample surface can then be extracted by measuring the effect of the field on two orthogonal oscillation modes of the wire. Mercier de Lépinay et al. used the setup to map the force field produced by a sharp tip, while Rossi et al. imaged a patterned semiconductor surface. A vectorial AFM will be useful in a wide range of applications, including the characterization of the anisotropy of chemical bonds and the measurement of the directional nature of Casimir forces.



Researchers have successfully mapped the vector force from a surface in two dimensions by using a nanowire as the probe in an atomic force microscope.

Atoms Mimic Antiferromagnetism

New experiments with cold atoms demonstrate magnetic correlations that could help explain high-temperature superconductivity. The observed correlations support a condensed-matter model that assumes electrons in a crystal hop between lattice sites, while also avoiding each other because of repulsive interactions. When the electron density is at a certain level, this so-called Fermi-Hubbard model predicts the material will exhibit antiferromagnetic ordering, in which magnetic moments — or spins — of the electrons align in an alternating (up/down) pattern. Testing this prediction is difficult in solids, but cold atoms offer a way to simulate the basic elements of the Fermi-Hubbard model within a controllable platform. Three separate groups—Parsons et al., Boll et al., and Cheuk et al.—have placed cold atoms in optical lattices and utilized site-resolved imaging to measure the number of atoms, as well as their spin, at each site in the lattice. The results, reported in the journal *Science* (doi: 10.1126/science.aag1430, 10.1126/science.aag1635, 10.1126/science.aag3349), showed that neighboring atoms typically had opposite spins, as expected for antiferromagnetic ordering. The experiments also showed evidence of longer-range correlations (between more distant neighbors), which could play a role in generating high-temperature superconductivity in antiferromagnetic materials.

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Inside the Beltway

An Election to Remember: Sex, Lies, and Videotape

By Michael S. Lubell, APS Director of Public Affairs

If you're sick of seeing and hearing the presidential candidates duke it out over their indiscretions and worse, you've got plenty of company. But as a physicist, I am even more disturbed by the way evidence has taken a back seat to the diatribe — or in the case of Donald Trump, the Tweet — of the moment. The presidential debates, which have drawn record TV audiences, make a compelling case that facts no longer play the vital role they once did.

In years past, the debates were informed, albeit sometimes heated, discussions of the weighty issues facing the country. They were forums in which competing visions and political philosophies were on display. And if a candidate strayed too far from a question, it was the job of the moderator to intervene and get the dialogue back on track.

Should a candidate utter something patently false, the moderator was expected to challenge the speaker. That happened most famously in 1976 when President Gerald Ford said, "There is no Soviet domination of Eastern Europe, and there never will be under a Ford administration." Max Frankel of the *New York Times* was moderating the debate and interrupted, "Did I understand you to say, sir, the Russians are not using Eastern Europe as their own sphere of influence and occupying most of the countries there and making sure with their troops that it is a Communist zone?"

Ford tried to recover from his factual error but only succeeded in digging himself an even deeper hole. His miscue, which Frankel highlighted, might well have cost Ford the election.

Scroll forward 40 years, and ponder what we have witnessed in this year's high-stakes verbal jousting. Donald Trump wins the fairytale contest hands down, but Hillary Clinton has also suffered from the Pinocchio syndrome, although on a far smaller scale.

More troubling, moderators — and journalists more generally — have largely failed to hold the candidates' feet to the fire. The truth-stretching or, less decorously, lying has become so common that it has birthed a new cottage industry — fact-checking. Evidenced-based arguments have become a vanishing expectation.

The post-debate TV analysis used to revolve around spin room dissection. But this year, it has become a gotcha forum for underscoring how the candidates — particularly Trump — have been able to twist factual threads into whole cloth lies and get away with it.

The visceral response of an ill-informed public has been to paint both candidates with a broad brush of untrustworthiness. Dishonesty might have been the big story of the 2016 election, but in early October, the *Washington Post* posted a lewd videotape of Donald Trump from 2005. An *Access Hollywood* hot mic caught him bragging about his sexually aggressive exploits with language so crude it would make Kim Kardashian blush.

Trump's excuse: "This was locker-room banter, a private conversation that took place many years ago." There's nothing like sex and videotape to get the fact-checking juices really flowing. Within days almost a dozen women surfaced, going on the record saying that Trump's locker room banter was far more than banter. None of that dislodged Trump's core supporters, who, polls showed, remained fixated on Hillary Clinton's 33,000 emails that disappeared from the private server she had used when she was Secretary of State.

Which finally leads me to the issue of polling and some of the bizarre results that illustrate lack of scientific rigor. Let's start with the easiest one: open online voting that showed Trump thrashing Clinton in the second debate. In that instance, the sample was self-selected. It wasn't really a poll, even though Trump and Fox News' Sean Hannity claimed it was.

But what about the *Los Angeles Times* / University of Southern California tracking poll that consistently showed Trump significantly over-performing relative to other surveys? Trump and his supporters cited it repeatedly.

I did a little digging and found that Nate Cohn of the *New York Times* had beaten me to it. His October 16, 2016 "Upshot" analysis is a gem and worth a read for

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This Month in Physics History

November 7, 1940: Collapse of the Tacoma Narrows Bridge

When the Tacoma Narrows Bridge over Puget Sound in the state of Washington famously collapsed on November 7, 1940, it was captured on film for posterity. The footage became the basis for a textbook example of resonance, which is a standard topic in high school physics. But that classic explanation is incorrect.

Initial designs for the bridge by engineer Clark Eldridge were for a typical suspension bridge with 25-foot-high trusses under the road to stiffen the bridge and keep it from swaying too much. But the $11 million proposed design was costly. Engineer Leon Moisseiff — who consulted on the Golden Gate Bridge in San Francisco — countered with a novel and aesthetically pleasing design that replaced the trusses with 8-foot-high plate girders, lowering the construction costs to $8 million but providing much less resistance to bending and twisting.

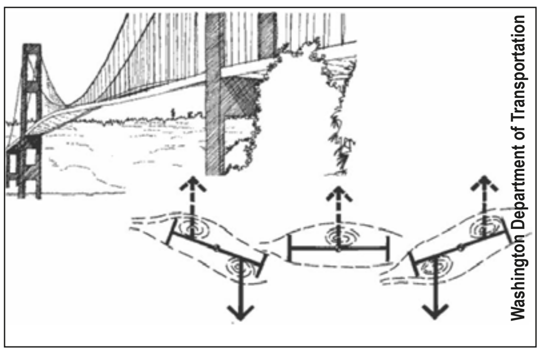
Moisseiff and his New York City colleague, Frederick Lienhard, argued that the main cables would be sufficiently stiff to absorb enough static wind pressure to stabilize the structure, because the aerodynamic forces acting on the bridge would push it only sideways, rather than up and down. Their argument was based upon deflection theory, which was developed by Austrian civil engineers.

That cheaper, slimmer, and more elegant design won out, and construction began on September 27, 1938. There were problems even while the bridge was still being constructed, with the deck moving up and down vertically significantly in even moderately windy conditions. It prompted construction workers to dub the bridge "Galloping Gertie," inspired by a popular saloon song. When the bridge opened on July 1, 1940, the public experienced the vibrations firsthand.

Several attempts were made to reduce the bouncing: tie-down cables anchoring the plate girders to 50-ton concrete blocks (the cables soon snapped); the addition of inclined cable stays connecting the main cables to the middle of the deck; and hydraulic buffers to dampen the main span's longitudinal motion. None had much of a dampening effect. So the Washington Toll Bridge Authority brought in a University of Washington engineering professor named Frederick Farquharson to conduct wind tunnel studies in hopes of finding a solution.

Galloping Gertie had been surprisingly well-behaved throughout October, despite being blasted by 50 mph winds. But Farquharson noticed that occasionally his models would show a twisting motion, and later told reporters, "We watched it and said that if that sort of motion ever occurred on the real bridge, it would be the end of the bridge."

Farquharson was standing on the Tacoma Narrows Bridge on the morning of November 7, and noted that problematic twisting motion of the bridge — rather than the typical bouncing — with growing alarm. Half an hour earlier, officials had closed it to traffic, but *Tacoma News Tribune* reporter Leonard Coatsworth had made it onto the bridge just before then; but when he was halfway across, an especially big bounce toppled his car onto its side. He jumped out and managed to crawl, bruised and bleeding, on his hands and knees to the safety of the towers, as six lamp posts snapped off and the steel coverings on the cables produced a metallic wail. The big steel cables snapped around 11 a.m., followed by a rumbling roar as 600 feet of the roadway crumbled into the water below. Finally, the entire center span cracked, leaving just the two towers standing.



The collapse of the Tacoma Narrows Bridge was driven by wind-generated vortices that reinforced the twisting motion of the bridge deck until it failed.

The days that followed revealed a struggle to explain why the bridge collapsed. A *New York Times* article attributed it to the phenomenon of resonance: "Time successive taps correctly and soon the pendulum swings with its maximum amplitude. So with this bridge." And when educator Franklin Miller distributed the footage of the collapse for classroom use in 1962, one of the captions erroneously mentioned "resonance vibration" as the cause. (The footage itself also proved to be misleading, thanks to errors converting the early film reels into other formats with different frames-per-second rates.)

That explanation stuck for decades, even though the Federal Works Administration concluded that resonance was an "improbable" explanation. Farquharson confirmed as much in his own report a decade later. The true culprit was the twisting motion he had observed both in his early models and on bridge itself the day of the collapse.

For more detail, below is a section from the State of Washington Department of Transportation (DOT) undated online report [1] on the cause of the Tacoma Narrows Bridge collapse:

Why Did Galloping Gertie Collapse?

... The primary explanation of Galloping Gertie's failure is described as "torsional flutter." It will help to break this complicated series of events into several stages.

Here is a summary of the key points in the explanation.

1. In general, the 1940 Narrows Bridge had relatively little resistance to torsional (twisting)

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Education & Diversity Update

October Woman Physicist of the Month

Jedidah Isler

Dr. Jedidah Isler studies the physics of particle jets emanating from supermassive black holes at the centers of massive galaxies called blazars. Dr. Isler's current research uses simultaneous infrared, optical, and gamma-ray observations to better understand the physics of these blazar jets by constraining the time-resolved spectral variability. She received her B.S. in physics from Norfolk State University, her M.A. in physics from Fisk University, M.S. in physics and Ph.D. in astronomy from Yale University. She is also the founder of #VanguardSTEM and host of the monthly web series "Vanguard: Conversations with Women of Color in STEM."

Nominate the next Woman Physicist of the Month at aps.org/programs/women/scholarships/month/

Phys21: Preparing Physics Students for 21st Century Careers

A new report provides information about the skills and knowledge that employers of physicists are seeking, and describes ways in which physics departments can help students acquire those skills and that knowledge.

Learn more at compadre.org/JTUPP

Join the Conversation in the Women in Physics and Minorities in Physics LinkedIn Groups

Get updates about career development opportunities, jobs, conferences, and articles related to women and minorities in physics. Post your own opportunities, "like" the work of others, or start a discussion about what else you'd like to see in the women and minority physics community!

Join Women in Physics at linkedin.com/groups/313547
Join Minorities in Physics at linkedin.com/groups/3959050/

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(LBL), Cora Dvorkin of Harvard University, and S. James Gates of the University of Maryland, discussing their work in "Quarks to the Cosmos." Jacak will discuss her role as director of the Nuclear Science Division at LBL, and as a leading member of the collaboration that built and operates the PHENIX detector at Brookhaven National Laboratory. Dvorkin will also discuss her experience as a Hubble Fellow at the Harvard-Smithsonian Center for Astrophysics at Harvard, prior to her current position as assistant professor in Harvard's Department of Physics. Gates's work in supersymmetry, supergravity, and superstring theory will also expand on the meeting's main theme of "from quarks to the cosmos."

Black holes will be discussed in Tuesday's plenary session, featuring Laura Cadonati of Georgia Tech, Chung-Pei Ma of University of California, Berkeley, and Andrew Strominger of Harvard University. The session will feature recent results on gravitational waves from LIGO and particle astrophysics.

A number of APS units will participate in this year's April Meeting. Scientific sessions and presentations will be hosted by the APS Divisions of Astrophysics; Computational Physics; Nuclear Physics; Gravitational Physics; Particles and Fields; and Physics of Beams.

APS Topical Groups involved include Few-Body Systems; Hadronic Physics; Instrument and Measurement Science; Physics Education Research; and Precision Measurement and Fundamental Constants.

Among other events and exhibits, undergraduates can get a leg up on their graduate school aspirations by attending "Lunch with the Grads," which will feature a panel discussion on what to expect as they pursue an advanced degree. They can also attend Sunday's undergraduate breakfast, which will include a career workshop and award ceremony.

APS authors and referees can attend a tutorial by editorial office staff on Sunday to get a step-by-step walk-through on how to appropriately submit their research and what to expect during peer review. They can also stop by the "APS Meet the Journal Editors" preceding the tutorial to speak with the editors of the journals. The prize and awards ceremonial session will be held after the editorial meet and greet.

Attendees will be able to sharpen their communication chops at a career-skills workshop focused on "Achieving Your Goals Through Effective Communications." They also can try setting U.S. research funding priorities at a special event on Monday titled "How Would YOU Decide the Federal Budget?"

Many society meetups will be held during and before this year's meeting: the annual pre-meeting APS April "Tweetup" will be held on Friday, where Twitter fanatics can connect and coordinate their social media appearances during the meeting. A roundtable on Sunday will focus on improving the climate in physics for LGBT+ physicists, preceding the National Society of Black Physicists and National Society of Hispanic Physicists meetup.

Only one poster session will be held at the 2017 APS April Meeting, on Saturday evening preceding the welcome reception. Since the meeting itself is hosted earlier than previous years, the post-deadline abstract submission is open until 5:00 p.m. on November 11, 2016 for those who wish to present at a poster session on a space available basis. Don't wait to submit, and we hope to see you there!

Ig Nobels 2016: The comical science that makes you think

By Rachel Gaal

Above: Nobel Laureate Dudley Herschbach presents the 2016 Ig Nobel Prize in Physics to Susanne Akesson of Sweden for work "discovering why white-haired horses are the most horsefly-proof horses, and for discovering why dragonflies are fatally attracted to black tombstones."

At left: Audience members throw paper airplanes at the stage during the 26th First Annual Ig Nobel Prize ceremony at Harvard University in Cambridge, Massachusetts, September 22, 2016.

Dressed in old wedding gowns, lab coats, or more likely their daily work attire, a crowd showed up with ridiculous amounts of paper, and it wasn't for note-taking. Scores of scientists were anticipating the countdown to launch paper airplanes at various human targets and keen to kick off the 26th First Annual Ig Nobel Prize ceremony in Cambridge, Massachusetts. Each prizewinner was celebrated for producing research that "makes people laugh, then think."

This year, an astounding 10 Ig Nobel Prize winners traveled to the ceremony at their own expense to shake the hands of a group of genuine, genuinely bemused Nobel Laureates who presented the prizes. Among the distinguished guests was 2005 physics Nobel Laureate Roy Glauber. For almost two decades, Glauber has humbly swept paper airplanes from Harvard's historic Sander's Theater stage.

The physics Ig Nobel went to a team of eight physicists (and one biologist) for their work on how polarized light affects random farm animals. Gábor Horváth, Miklós Blahó, György Kriska, Ramón Hegedüs, Balázs Gerics, Róbert Farkas, Susanne Åkesson, Péter Malik, and Hansruedi Wildermuth won for "discovering why white-haired horses are the most horsefly-proof horses, and for discovering why dragonflies are fatally attracted to black tombstones."

"I feel very honored to represent my team of nine people, and it's been really exciting because I'm the biologist," said Åkesson in her 30-second explanation. "The rest are mainly in physics. We found you would rather be a white horse than a black one, if you like to avoid being bitten by horseflies … but in fact you can dress in either stripes like a zebra or, like myself, in a dotted coat … which will also help you".

Ushered toward stage left by opera singers in grandfather clocks (this year's theme was "time"), she was left to treasure her new timekeeping trophy: a giant clock with plastic hourglasses for hands, and its numbers replaced with the letters, "I-G-N-O-B-E-L-P-R-I-Z-E". Each winner was bestowed this same priceless trophy.

The winning team's bizarre experiments, carried out in the vast farm valleys and graveyards in Hungary, looked at polarized light caused by reflection, whether off of an animal's fur, or the surfaces of black polished tombstones. They found the darker the surface, the more polarized the light. And little bugs (in particular horseflies and dragonflies) take a keen liking to surfaces that reflect horizontally polarized light, similarly to the way they are attracted to reflective surfaces of water. It was noted that the dark-coated horses were targeted around the neck, backside, and hindquarters in their standing posture, usually due to the sun-light's angle of incidence. And tombstones that were black in color reflected highly and horizontally polarized light. This is bad news for any dragonflies that decide to lay their eggs on these attractive tombstones — the group saw that the bugs were fatally dragged away from their water-filled habitats, unable to relocate back to their homes.

Also awarded were a psychology prize to Japanese scientists, "for investigating whether things look different when you bend over and view them between your legs," and a chemistry prize presented to Volkswagen, "for solving the problem of excessive automobile pollution emissions by automatically, electromechanically producing fewer emissions whenever the cars are being tested." No one showed up to claim that prize.

To learn more about the Ig Nobels and to watch the timely festivities of this year's ceremony, go to: improbable.com/ig/2016/

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logical properties revealed themselves at their ends, considerably simplifying investigation of these chains. Thouless and colleagues described theoretically what is now known as the quantum Hall effect — when the electrical conductance in thin layers changes in step values that are exact integer multiples of e^2/h. These precise steps are related to the concepts in topology in which objects are categorized by integer values.

"These theoretical discoveries illustrate in a very nice way the interplay between physics and mathematics, [where] theoretical physics is at the crossroad," commented Thors Hans Hannson, a member of the Nobel Committee for Physics, in an interview to the press after the announcement. "The Quantum Hall Effect became the starting point for David Thouless's [achievement], and he explained the experiments with these topological invariances. In Duncan Haldane's case ... he predicted effects of experiments performed 25 years later."

Their predictions proved to have an unexpected impact; the majority of these laureates' work went beyond considering a material's symmetry properties, in a way that was unheard of at the time of their initial research.

"It started out as a toy model demonstration, and then I realized it was a very good model," explained Haldane at the Nobel Committee's press conference. "We stumbled upon this, playing with the mathematics of the model … and like most discoveries, you stumble onto them. You don't realize the full implication until other people start thinking it's true and they realize the big picture."

Almost half of physics Nobel prizes in the past decade were awarded for research in condensed matter physics, and the field itself is rapidly growing — in part due to the theories set forth by the three new laureates.

"The 2016 Nobel Prize in Physics this year honors three researchers who have cracked a crucial part of this problem, explaining electronic and magnetic highly correlated states in two dimensions," said APS President-Elect Laura Greene. "These solutions are clever and inspiring, and have laid the foundation to today's exploding field of topological matter — as indicated by the growing number of papers in this area taking up an ever larger fraction of the condensed matter community."

Thouless, Haldane, and Kosterlitz are all members and fellows of APS. Thouless and Kosterlitz both received the 2000 Lars Onsager Prize for their work with topological phase transitions. Haldane was the recipient of the 1993 Oliver E. Buckley Condensed Matter Physics Prize for his own contributions to low dimensional quantum systems. Both Haldane and Kosterlitz are scheduled to speak at the 2017 APS March Meeting in New Orleans.

Related Information

See the Focus article "Topological Phases of Matter" in *Physics*: physics.aps.org/articles/v9/116

Profiles in Versatility

String Theorist Turns to Science Policy

By Katherine Kornei

The Cold War loomed large in Edwin Lyman's experience as a physics graduate student in the 1980s. "[Ronald] Reagan's Strategic Defense Initiative Program was getting into full swing then," Lyman remembers, "and there was a lot of attention focused on the responsibility of scientists, particularly physicists, who engage in programs that might have moral implications." When the time came for Lyman to select a thesis topic, he chose string theory and high energy particle theory, a decision partly intended to minimize any potential military applications of his work.

As Lyman neared the end of his Ph.D. studies at Cornell, he became increasingly involved in discussions with other physics students and faculty about the social repercussions of defense work. When the native New Yorker graduated in 1992, he accepted a postdoctoral position focused on science and security policy at the Center for Energy and Environmental Studies (now the Science and Global Security Program) at Princeton University. "I had become convinced that engaging in policy might be a better use of my resources," he says.

Lyman's postdoctoral work involved determining what to do with the significant stockpiles of plutonium left over from the recently ended Cold War. "One option [for disposing of the plutonium] that was being pushed very hard by the Department of Energy (DOE) and other countries was to use that material as a fuel for nuclear power plants," he says. However, Lyman and his colleagues at Princeton recognized several of the issues with using plutonium in nuclear power plants — it's more expensive than a conventional fuel like enriched uranium, and it has to be safeguarded and protected to stringent standards.

The researchers decided to instead focus on turning the plutonium into a stable waste form that could be safely buried underground. "We were looking at essentially vitrifying the plutonium — that is, mixing it with radioactive waste and glass-forming materials," Lyman says. "Some Russian scientists were claiming that plutonium had very low solubility in such glasses. However, I concluded that the plutonium solubility was strongly dependent on the glass composition and that the Russian results were probably outliers." DOE later came to a similar conclusion and briefly considered plutonium vitrification before canceling the program because of the cost.

In 1995, at the conclusion of his postdoctoral work, Lyman moved to Washington, D.C. and accepted a job at the Nuclear Control Institute (NCI), an organization devoted

Edwin Lyman

to discouraging the commercial production and use of nuclear weapons-grade materials. "We promoted the conversion of highly enriched uranium-fueled research and test reactors so that they could use low-enriched uranium, which is not directly weapon-usable," Lyman says. "We [also] worked to prevent the Nuclear Regulatory Commission from weakening requirements for protecting nuclear plants from terrorist attacks, which took on greater urgency after 9/11."

After the NCI lost its primary funder, the W. Alton Jones Foundation, in 2001, Lyman accepted the position of president and attempted to secure enough funding to keep the organization going. He was unable to obtain sufficient funding, but he learned that a job opportunity had opened up at

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The Beginning of Nanotechnology at the 1959 APS Meeting

By Katherine Kornei

"It was the best of times, it was the worst of times ..." The classic lines that open *A Tale of Two Cities* by Charles Dickens, rendered in a minuscule type size, netted Tom Newman $1,000 and a letter from Richard Feynman.

In the last few days of 1959, several hundred physicists gathered for "Winter Meeting in the West" of the American Physical Society. Feynman, then a professor of theoretical physics at Caltech, was among the attendees, and he delivered an after-dinner lecture at the nearby Huntington-Sheraton Hotel entitled "There's Plenty of Room at the Bottom."

The banquet speech would prove prescient. Feynman's lecture is widely accepted as spurring the field of nanotechnology, and the Nobel Prize Committee lauded it as "visionary" when they awarded the 2016 Nobel Prize in Chemistry to researchers who assembled tiny motors made of molecules.

"I want to talk about … the problem of manipulating and controlling things on a small scale," Feynman said early in his lecture. He went on to discuss information storage, suggesting that the 120,000 volumes in the Caltech library might, within 10 years, "be kept on just one library card." Feynman also talked about miniaturizing computers and creating perfect copies of molecules based on spins. "It is a staggeringly small world that is below," he emphasized.

Tom Newman used an electron beam to etch the opening of Dickens' *Tale of Two Cities* onto a 200 x 200 micron square of plastic and won the Feynman challenge.

Feynman concluded his lecture by presenting two challenges to his audience. The first challenge, associated with a cash prize of $1000, was to miniaturize a page of text by 1/25,000 in linear scale so that it was readable with an electron microscope. The second challenge, also worth $1,000, was to build a functioning electric motor within a 1/64-inch cube. "I do not expect that such prizes will have to wait very long for claimants," Feynman prophesied.

Indeed, one of Feynman's prizes was claimed within a year by William McLellan. The Caltech graduate presented Feynman with a working motor far smaller than a pinhead. However, Feynman's other challenge of miniaturizing text remained unsolved for decades. When *Engineering & Science*, Caltech's quarterly magazine, covered McLellan's achievement it humorously noted that "[since offering the prizes] Feynman has been married, bought a house and, what with one thing and other, hasn't got another spare $1,000."

In 1985, Tom Newman was a graduate student at Stanford University in the electrical engineering department. His Ph.D. thesis work — which involved making very small lattices to observe quantum effects — was nearly complete. "My advisor encouraged me to finish up and not get too distracted by side projects," Newman remembered.

At the same time, another student in Newman's research group read a transcript of "There's Plenty of Room at the Bottom." Ken Polasko suggested to Newman that he attempt Feynman's remaining challenge. "The lab I was working in … had all of the optics necessary for making a high-resolution [printer]," Newman acknowledged. "[And my advisor, R. Fabian Pease] had a real passion for lithography."

When Pease was away at a conference on the east coast, Newman seized his opportunity to investigate Feynman's challenge. "I decided to give it a big push for two days while he was gone. During that time, I was able to come up with the basis for how to do it," Newman said. He made rough calculations of the necessary resolution and the size of the letters required, and he looked over his bookshelf. "I had [*A Tale of Two Cities*]; it was a nicely bound copy. When I pulled it out, it seemed like a nice text," Newman said.

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forces. That was because it had such a large depth-to-width ratio, 1 to 72. Gertie's long, narrow, and shallow stiffening girder made the structure extremely flexible.

2. On the morning of November 7, 1940 shortly after 10 a.m., a critical event occurred. The cable band at mid-span on the north cable slipped [and slid along the bridge]. This allowed the cable to separate into two unequal segments. That contributed to the change from vertical (up-and-down) to torsional (twisting) movement of the bridge deck.

3. Also contributing to the torsional motion of the bridge deck was "vortex shedding." In brief, vortex shedding occurred in the Narrows Bridge as follows:

[a] Wind separated as it struck the side of Galloping Gertie's deck, the 8-foot solid plate girder. A small amount twisting occurred in the bridge deck, because even steel is elastic and changes form under high stress.

[b] The twisting bridge deck caused the wind flow separation to increase. This formed a vortex, or swirling wind force, which further lifted and twisted the deck.

[c] The deck structure resisted this lifting and twisting. It had a natural tendency to return to its previous position. As it returned, its speed and direction matched the lifting force. In other words, it moved "in phase" with the vortex. Then, the wind reinforced that motion. This produced a "lock-on" event.

4. But the external force of the wind alone was not sufficient to cause the severe twisting that led the Narrows Bridge to fail.

5. Now the deck movement went into "torsional flutter." "Torsional flutter" is a complex mechanism. "Flutter" is a self-induced harmonic vibration pattern. This instability can grow to very large vibrations.

When the bridge movement changed from vertical to torsional oscillation, the structure absorbed more wind energy. The bridge deck's twisting motion began to control the wind vortex so the two were synchronized. The structure's twisting movements became self-generating. In other words, the forces acting on the bridge were no longer caused by wind. The bridge deck's own motion produced the forces. Engineers call this "self-excited" motion.

It was critical that the two types of instability, vortex shedding and torsional flutter, both occurred at relatively low wind speeds. Usually, vortex shedding occurs at relatively low wind speeds, like 25 to 35 mph, and torsional flutter at high wind speeds, like 100 mph. Because of Gertie's design, and relatively weak resistance to torsional forces, from the vortex shedding instability the bridge went right into "torsional flutter."

Now the bridge was beyond its natural ability to "damp out" the motion. Once the twisting movements began, they controlled the vortex forces. The torsional motion began small and built upon its own self-induced energy.

In other words, Galloping Gertie's twisting induced more twisting, then greater and greater twisting. This increased beyond the bridge structure strength to resist. Failure resulted.

19th century bridge designers had learned painful lessons from numerous bridge collapses, but 20th-century designers did not heed them. Again, quoting the Washington State DOT report [2]:

First Investigations-Partial Answers to "Why"

Early suspension-bridge failures resulted from light spans with very flexible decks that were vulnerable to wind (aerodynamic) forces. In the late 19th century engineers moved toward very stiff and heavy suspension bridges. John Roebling consciously designed the 1883 Brooklyn Bridge so that it would be stable against the stresses of wind. In the early 20th century, however, says David P. Billington, Roebling's "historical perspective seemed to have been replaced by a visual preference unrelated to structural engineering.

Just four months after Galloping Gertie failed, a professor of civil engineering at Columbia University, J. K. Finch, published an article in Engineering News-Record *that summarized over a century of suspension bridge failures. Finch declared, 'These long-forgotten difficulties with early suspension bridges clearly show that while to modern engineers, the gyrations of the Tacoma bridge constituted something entirely new and strange, they were not new — they had simply been forgotten.' ... An entire generation of suspension-bridge designer-engineers forgot the lessons of the 19th century. The last major suspension-bridge failure had happened five decades earlier, when the Niagara-Clifton Bridge fell in 1889. And, in the 1930s, aerodynamic forces were not well understood at all.*

Aftermath

The remains of the original Tacoma Narrows Bridge deck are still on the bottom of Puget Sound, forming an artificial reef, and its side spans were melted down for steel during World War II. Eventually state authorities approved a replacement bridge, completed in 1950 and dubbed 'Sturdy Gertie.' This time the design used 33-foot trusses to stiffen the bridge, as well as wind grates and hydraulic shock absorbers. A second bridge was added in 2007.

1. Washington State Department of Transportation, *Tacoma Narrows Bridge: Lessons from the Failure of a Great Machine*, Why Did Galloping Gertie Collapse? Available at wsdot.wa.gov/TNBhistory/Machine/machine3.htm#6
2. ibid., First Investigations-Partial Answers to "Why."

Further Reading:

Billah, K. and Scanlan, R. "Resonance, Tacoma Narrows Bridge Failure, and Undergraduate Physics Textbooks," *American Journal of Physics* 59 (1991): 118–124.

Green, D. and Unruh, W. G. "The Failure of the Tacoma Bridge: A physical model," *American Journal of Physics* 74 (2006): 706.

Olson, Donald W.; Wolf, Steven F.; Hook, Joseph M. (2015) "The Tacoma Narrows Bridge collapse on film and video," *Physics Today* 68 (11): 64–65.

Pasternak, Alex. "The Strangest, Most Spectacular Bridge Collapse (And How We Got It Wrong)," *Motherboard*, December 2015.

RESEARCH continued from page 1

Neutrons Spiral into a Hologram

Holography isn't just for photons anymore. Researchers now report their success in using neutrons to make holograms, which record patterns of interference between two coherent beams. Sarenac et al. describe in *Optics Express* (doi: 10.1364/OE.24.022528) a neutron holography experiment employing a neutron interferometer that is based on the same principles used in optical holography. Here, a neutron enters the interferometer and is separated into two paths by a beam splitter, generating reference and object beams. The object beam is altered with a spatially varying phase after passing through a test object called a spiral-phase plate (a device that imparts helicity), while the reference beam, as in optical holography, is unaltered. The two beams combine at another beam splitter, and the output beams from this are sent to an imaging detector and an integrating counter. Built up from many single-neutron events, the resulting hologram was then reconstructed into a simulated image to generate different intensity profiles of the phase plate. This unique neutron holography setup may offer a new method for characterizing the coherence of neutron beams.

Borrowing Higgs Physics to Heat Up Inflation

New theoretical work shows how to arrive at a proper theory of warm inflation from first principles. Warm inflation, which involves warm, rather than cold, cosmic temperatures, is a simpler variant of the widely accepted view of the explosive growth of the early Universe. Bastero-Gil et al. report in *Physical Review Letters* (doi: 10.1103/PhysRevLett.117.151301) their derivation of a compelling model of warm inflation by borrowing a trick from Higgs boson theories. The Higgs, which gives other particles their mass, is a Nambu-Goldstone boson — a particle that arises from a broken symmetry. The key particle in inflation is, naturally enough, the inflaton, and when the authors assume it to be a Nambu-Goldstone boson, they conclude that inflatons can exist in a warm thermal bath despite the rapid cooling effects of inflationary expansion. Previous models of warm inflation have required an absurdly high number of coupled fields, but the new theory only requires four additional fields. Moreover, the authors present observational predictions about cosmic microwave background radiation resulting from warm inflation and show that these are in agreement with recent results from the *Planck* satellite. (For more, see the Synopsis "Little Higgs Gives Warm Inflaton a Hand" in *Physics*.)

Oxygen Nuclei Lie Near a Quantum Phase Transition

Using state-of-the-art computer simulations, researchers have discovered that some light nuclei can exist near a quantum phase transition between a liquid-like collection of neutrons and protons and a clumpier state involving clusters of alpha particles. Everyday phase transitions like boiling water are thermally provoked, but quantum phase transitions are driven by quantum fluctuations even at zero temperature. Such transitions may play an important role in determining how subatomic particles are arranged in a nucleus. In a paper in *Physical Review Letters* (doi: 10.1103/PhysRevLett.117.132501), Elhatisari et al. report their results of using a lattice Monte Carlo method to tackle effective-field-theory calculations of oxygen-16 and other light nuclei. By exploring a wider range of nucleon interactions than previous studies, they found that, indeed, the nuclei are close to a transition between a so-called Fermi-liquid configuration and a state with alpha clustering. The results are encouraging for looking at quantum phase transitions in carbon nuclei, which harbor Hoyle states — excited states of carbon characterized by clusters of alpha particles. Such states are thought to be essential to life, as they directly influence stellar production of carbon in the universe. (For more, see the Viewpoint "Uncovering a Quantum Phase Transition in Nuclei" in *Physics*, physics.aps.org/articles/v9/106)

Questions for 2016 U.S. Presidential Candidates

APS works on behalf of its members, and the physics community at large, to inform policy leaders about the importance of physics and research funding. In September 2016, APS reached out to both the Democratic and Republican presidential campaigns. Both candidates were sent five questions on topics of interest to the physics community. As *APS News* went to press, APS has received a response from the Clinton Campaign. Read the answers at aps.org/policy/analysis/prescandidates.cfm

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the Union of Concerned Scientists (UCS). The independent scientists and policy leaders at UCS focus on combating global warming, ensuring stringent regulations of nuclear power, and stopping the spread of nuclear weapons, many of the same issues that Lyman had supported at NCI.

Lyman joined UCS in 2003 as a senior scientist, a role he still holds. His work involves a mix of research, writing, and public speaking, and he has described his role as "a nuclear safety watchdog. … to ensure that U.S. nuclear reactors are adequately safe from accidents and secure from terrorist attacks." Lyman often testifies before Congress on matters related to nuclear energy, and he served as an expert analyst after the 2011 Tōhoku earthquake and tsunami in Japan crippled the Fukushima Daiichi nuclear power plant.

On March 11, 2011, a magnitude 9.0 earthquake triggered tsunami waves that swamped Fukushima Daiichi, an aging power plant built on the coast in Fukushima prefecture. The plant suffered a complete loss of primary and backup power — a worst-case scenario known as a "station blackout" — and workers were unable to pump sufficient cooling water over the plant's nuclear fuel rods to keep them safely below 1500°F, the approximate temperature at which they start to disintegrate. In three reactors, the fuel rods boiled away their protective water baths and began to melt through their confinement vessels, releasing harmful radioactive materials into the environment.

As the disaster in Japan unfolded, Lyman and his colleagues worked around the clock in Washington, D.C. to provide expert analysis about potential radiation leaks and the structural integrity of the reactor buildings. "We put out some early analysis … at that time, I think I was one of the only commentators to predict that there would be meltdowns and hydrogen explosions," he says. "The media interest was astronomical, like nothing we'd seen before."

A team from the International Atomic Energy Agency surveys the damaged nuclear reactor in Fukushima, Japan.

When Lyman provided testimony to the Senate Committee on Environment and Public Works on March 16, 2011 about the situation in Japan, he was asked whether a meltdown could also occur in the United States. His comments were sobering: "We have plants that are just as old, and we have had a station blackout. We have a regulatory system that is not clearly superior to that of the Japanese. We have had extreme weather events that exceeded our expectations and defeated our emergency planning measure[s], [such as] Hurricane Katrina."

In 2014, Lyman and his colleagues at UCS published a book entitled *Fukushima: The Story of a Nuclear Disaster*. The book highlights the events that preceded the meltdowns at Fukushima Daiichi and argues that the regulations and safety protocols governing nuclear power plants in both Japan and the United States are not stringent enough. "Nuclear energy is hard. It's hard to engineer, and it's hard to go from a paper study to a functioning, reliable, operating plant," Lyman cautions.

Lyman's role as a communicator and spokesman of science continues to be a challenge. "[There has been a] shift away from fact-based reasoning and the substitute of social media volume for actual facts," he says. "In physics, there are plenty of controversies, but things do get settled with information. That doesn't always happen in public policy," he says. "[But] I do believe that persistence will pay off and facts and good analysis will ultimately prevail."

Katherine Kornei is a freelance science writer in Portland, Oregon.

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It was a minor thing, a new way of looking at a known phenomenon in special relativity. But he worked it through and got it published, and that was really encouraging.

What's a typical email exchange like?

They'll say, "Hello, my name is so-and-so, and I've been working for ten years on this theory of, insert something, and I have a problem with something. Can I talk to you?" Sometimes they'll send me twenty, thirty pages about their theories. I'll write back yes or no, and if it's outside of my expertise, I might refer them to someone on my team.

Then, we'll talk over Skype. They'll have images in mind and use concepts they've heard of but don't exactly understand. If they use equations, they use very few, and they are typically the wrong ones. They might use the equations you learn in high school, which you can't use to construct a fundamental theory. I have to explain that if you want to deal with these topics, you need to know what a Hamiltonian is, what a quasiparticle is, et cetera, and you need to learn how to compute them. And I often have to tell them that they're not offering anything new.

Are you straightforward with them about that?

Yeah. Some of them get pretty offended, I think. A lot of people, strangely enough, also find it outrageous that I ask for payment, because certainly I must be interested in their great theory, and I'm just like, no, I'm not that interested.

Do you enjoy reading the theories?

To tell you the truth, I don't read them because I don't have the time. It's not the point of the service. I'm there to answer questions to help them meet a high scientific standard. So I tell them, if you want my opinion, you'll have to talk to me. Some of the people on my team will read the theories, though, and they charge a rate per word.

Do you think the large demand for these services means that the academic system is failing somewhere?

It's not the academic system; it's a problem with science communication. These people are interested in topics like quantum gravity and foundations of quantum mechanics. But all they have is popular science writing on one side and textbooks on the other. If you start with popular science, it's very difficult to get to the other side. Physicists do it through ten years of education. I don't think you can shortcut those ten years, but I'm trying to bridge that gap a little.

You've written that journalists make science seem too easy and can mislead readers to interpret their analogies too literally. How can science communicators improve on that?

It's difficult. Popular science articles have to cater to a diverse audience. They often end up targeting the least common denominator and become wishy-washy nuggets that don't tell you much. I see nothing wrong with this, though. Many readers just want to be inspired or to have something to talk about.

But some readers want more, and they're the ones who get it badly wrong. One big misunderstanding is about the importance of mathematics in theoretical physics. I find this very badly communicated in popular science. Because they don't have the experience, they seem to think mathematics is optional and is something physicists do to offend other people.

One way you can improve on this without scaring people away is to provide layers of explanation. You can have a fluffy article that also includes options for the reader to choose different levels of detail. For example, you can imagine clicking a button for additional information. It's not impossible, but someone has to do it, and there's no money and no interface for it right now.

What do you think is the responsibility of garden-variety physicists to communicate their work?

They definitely need to communicate their work within the community. But when it comes to communicating with the public, I don't think scientists generally have an obligation to do this. Not every scientist is skilled at it, and I don't see the point of forcing them to do it.

But a current problem facing scientists who are good at science communication is that they don't get any benefits from it. You get points for teaching, for research, and for leadership positions, but public outreach isn't really good for anything. Well, actually — you'll get emails from people who want to share their theories with you. That's what it's good for.

Sophia Chen is a freelance science writer based in Tucson, Arizona.

In Recognition of the 2016 APS Fellows

Each year, no more than one half of one percent of American Physical Society members are elected Fellow. APS Fellows have been recognized by their peers for their outstanding contributions to physics, including original research and publication, innovative applications to science and technology, exceptional teaching and outreach, or esteemed leadership and service to the Society. Here are the newly elected 2016 Fellows, listed by the unit who recommended their nomination for election to the APS Council of Representatives. For more information, visit https://www.aps.org/programs/honors/fellowships/

APS General Category
Paul Johnson

Division of Astrophysics
Rachel Bean
Nicole Bell
Daniel Chung
Stéphane Coutu
Megan Donahue
Hume A. Feldman
Paolo Gondolo
Ann Hornschemeier
Brian Keating
Richard L. Kelley
Adrian Lee
Miguel Mostafá
Hiranya Peiris
Clement Pryke

Division of Atomic, Molecular & Optical Physics
Nigel Badnell
Christopher T. Chantler
Matthew Davis
Nirit Dudovich
Peter Engels
George N. Gibson
Jack Harris
Hui Hu
John Kitching
Robert Lucchese
Thomas Pfeifer
Jean-Michel Raimond
Cindy Regal
Marc Simon
Wim Ubachs
Martin Zwierlein

Division of Biological Physics
Aaron Dinner
Robert Endres
Kalina Hristova
Ilya Nemenman
Keir C. Neuman
Sean Sun
Jay X. Tang
Massimo Vergassola
Mingming Wu
Edward Yu

Division of Chemical Physics
Eric R. Bittner
Vladimir Chernyak
Frédéric Merkt
David H. Parker
Mary T. Rodgers
Charles A. Schmuttenmaer
Xue-Bin Wang
Jianzhong Wu

Division of Computational Physics
Simon Catterall
Laura Gagliardi
Joel D. Kress
Angelos Michaelides
Brian W. O'Shea
Humberto Terrones
Maria-Roser Valentí
Matthieu Verstraete

Division of Condensed Matter Physics
Alexander G. Abanov
Ian Appelbaum
Richard D. Averitt
Antonio Bianconi
Donglai Feng
Gregory A. Fiete
Ilya Gruzberg
Vitalyi Gusev
Krzysztof Kempa
Young-June Kim
Kimitoshi Kono
Andreas Kreyssig
Nina Markovic
Satoshi Okamoto
Natalia Perkins
Marek Potemski
Sven Rogge
Leonid Rokhinson
Emanuel Tutuc
Xingjiang Zhou
Jian-Xin Zhu

Division of Fluid Dynamics
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Ahmed Ghoniem
Sascha Hilgenfeldt
Eric Lauga
Laurent Limat
Beverley J. McKeon
Martin Oberlack
Demetrios T. Papageorgiou
Sergio Pirozzoli
Mike Reeks
Jason Reese
Zvi Rusak
Spencer Sherwin
Bruce R. Sutherland
John Tsamopoulos
Alexander L. Yarin
Roberto Zenit

Division of Gravitational Physics
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Jiri Bicak
Valery V. Frolov
Michael Landry
Eva Silverstein
Ulrich Sperhake
Robin T. Stebbins
Michele Vallisneri

Division of Laser Science
Harry Atwater
Igal Brener
Tobias Kippenberg
Greg Salamo
Feng Wang
Gary Wiederrecht
Richard W. Ziolkowski

Division of Materials Physics
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Kyeongjae Cho
Hongyou Fan
Anderson Janotti
Ezekiel Johnston-Halperin
Mercouri Kanatzidis
Ho Nyung Lee
Jianwei "John" Miao
Ganpati Ramanath
Athena S. Sefat
Jonathan E. Spanier
Haiyan Wang
James A. Warren
Qikun Xue
Judith C. Yang

Division of Nuclear Physics
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Adam Bernstein
Gabor David
Axel Drees
Dieter Frekers
Robert Grzywacz
Jamal Jalilian-Marian
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Peter Petreczky
Andreas Piepke
George H. Rawitscher
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Alan Wuosmaa
Steven W. Yates

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Aaron Dominguez
Patrick Fox
Christopher Hill
Andreas Karch
Karol Lang
Scott M. Oser
J. Michael Roney
Pierre Savard
Peter N. Shanahan
Sunil V. Somalwar
Daniel Whiteson
Stéphane Willocq
Kathryn Zurek

Division of Physics of Beams
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Division of Plasma Physics
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Anthony Murphy
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Hiroshi Yamada
Hartmut Zohm

Division of Polymer Physics
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Junhan Cho
Marcus Cicerone
Yossef Elabd
Sinan Keten
Guruswamy Kumaraswamy
Ricardo Ruiz

Forum on Education
Stephen Padalino
Monica Plisch
Timothy J. Stelzer
John Stewart

Forum on History of Physics
Kathryn M. Olesko

Forum on Industrial & Applied Physics
Edward Adler
Robert G.W. Brown
Michael S. Gordon
Muhammad M. Hussain
Subramanian Iyer
Steven Lambert
François Léonard
Mathias B. Steiner
Handong Sun
Peide "Peter" Ye

Forum on International Physics
Giorgio Apollinari
Sergio Bertolucci
Christine Darve
Günther Dissertori
Sandro Scandolo
Noboru Takeuchi

Forum on Outreach and Engaging the Public
Steven Goldfarb
Ágnes Mócsy
Rebecca Thompson

Forum on Physics and Society
Hugh Kendrick
Micah Lowenthal
Keivan Stassun
James E. Trebes

Topical Group on Few-Body Systems
William Detmold
Kalman Varga

Topical Group on Hadronic Physics
Peter Bosted
Maarten F. Golterman

Topical Group on Instrument and Measurement Science
L. Douglas Bell
Vladimir Glebov
James H. Werner

Topical Group on Magnetism
Laura Heyderman
Laura H. Lewis
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Igor Zutic

Topical Group on Physics Education Research
Charles Henderson

Topical Group on Plasma Astrophysics
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Topical Group on Precision Measurement & Fundamental Constants
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Topical Group on Quantum Information
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Ivan Smalyukh
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Topical Group on Statistical & Nonlinear Physics
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Felix M. Izrailev
Mason Porter
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Robin Selinger
Jeffrey Urbach

On September 17, 2016, the APS Board of Directors approved the following two statements:

HEU Reactor Conversion

The Board of the American Physical Society supports the crucial need to reduce, with the goal of ultimately eliminating, the use of highly enriched uranium (HEU) to fuel civilian research reactors as called for by the National Academies of Sciences, Engineering, and Medicine in its 2016 report *Reducing the Use of Highly Enriched Uranium in Civilian Research Reactors*. Since HEU can be readily used to construct nuclear weapons, minimizing it as a fuel in civilian reactors is an important step toward reducing proliferation risks in the United States and throughout the world.

The Lincoln Project: Excellence and Access in Public Higher Education

The American Physical Society Board of Directors commends the American Academy of Sciences for its report on public research universities, *Recommitting to Lincoln's Vision: An Educational Compact for the 21st Century.* The report, co-chaired by Robert Birgeneau and Mary Sue Coleman, provides a sobering account of the decline in public research university support — a drop of 34 percent nationwide in just the last decade — and its implications for America's future. The report contains a set of thoughtful recommendations for (1) public research universities, (2) state government, (3) the federal government and (4) the private sector that are worthy of serious consideration. The American Physical Society Board recognizes that public research universities represent only one segment of the public higher education establishment and urges concerted study by scholarly and educational organizations of the broader problems of public higher education support.

For more information on these and other Board Statements, please visit **aps.org/policy/statements/executive.cfm**

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anyone who worries about statistics and biased data.

In brief, according to Cohn, the *LA Times*/USC poll used the same panel of 3,000 voters repeatedly in its frequent surveys. That's OK for tracking purposes. But the pollsters segmented the panel with granularity so fine that weighted results were vulnerable to significant errors.

One particularly egregious example led Trump not only to claim he was leading in national polls but also to claim he was capturing a sizable fraction of African American voters.

Here's what Cohn uncovered: "There is a 19-year-old black man in Illinois who … is sure he is going to vote for Donald J. Trump … . In some polls, he's weighted as much as 30 times more than the average respondent and as much as 300 times more than the least-weighted respondent. Alone, he has been enough to put Mr. Trump in double digits of support among black voters."

Nate Cohn is a fact-checker. So, too are Nate Silver of *fivethirtyeight.com* and the dozen or so women who disputed Trump's lame locker room excuse for lecherous conceit. This year, it's clear all of us, especially scientists, need to be fact-checkers.

Donald Trump's response to a question from moderator Chris Wallace in the final debate underscores that necessity. Trump twice said he would not accept the election results because he believed they were rigged. But the deluge of polls this year — virtually all predicting a Clinton victory — can conclusively negate Trump's treacherous allegation of massive voter fraud, provided they are scientifically accurate.

ANNOUNCEMENTS

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Fortunately, Pease was enthusiastic about Newman's pursuits, and the two men begin to repurpose their lab's existing equipment. "The pattern generator that we had produced a square dot matrix of 512 x 512 pixels," Newman explained. He determined how to convert a typed-in string of letters readable by humans into a string of bits readable by the pattern generator. Pease and Newman then used the pattern generator to scan a beam of electrons over a thin layer of poly(methyl methacrylate). When the electrons impacted the poly(methyl methacrylate), they broke bonds within the material's organic molecules and rendered that area more soluble to a developer solution. "The developer solution eats away the area that's been exposed," explained Newman.

Newman and Pease printed the first page of *A Tale of Two Cities* on a 200 × 200 micron square of poly(methyl methacrylate). The text occupied an area just under six microns on a side, which made it challenging to find on the square. "I learned after the first time [of going to the microscope] to bring a map on a piece of paper," said Newman. At this scale, the entire *Encyclopedia Britannica* could be printed on the head of a pin.

On October 12, 1985, Newman and Pease sent a telegram to Feynman at Caltech. The short message read: "Please advise if prize has been collected for reducing a page of text 25 thousand-fold to be readable in an electron microscope."

"We had decided not to even bother him until we were certain that we could meet the spirit of the challenge," Newman explained.

Just a few weeks later, Newman was in the lab when a telephone call came through. "Someone said they were transferring a call to me from Professor Feynman. I was a little nervous taking the call," said Newman.

"The first thing Feynman said was something like 'Hey Newman, what are you guys doing up there?'," Newman recounted. Feynman went on to say that the prize had not been claimed and that he was interested in seeing what Newman and Pease had produced.

On November 5, Newman mailed an envelope to Pasadena containing photos of his printing taken using a transmission electron microscope. "I didn't have high hopes at that point that Feynman would agree that we met [the challenge]," said Newman. "The image is kind of rough, and you're seeing the resolution limit of this process."

But Feynman was satisfied and considered his challenge solved, 26 years after it was first posed. Within a couple of weeks, Newman received a congratulatory letter from the physicist and a check for $1000. "It was a welcome amount of money," Newman recalled. "I was thinking of getting a Macintosh computer. They had just come out and I was really fascinated by them."

Newman defended his thesis in December, 1985, and his work would stand as a proof of concept that text could be substantially compressed. "Maybe I didn't plan it this way, but there is some value in having people recognize this text," said Newman. "The fact that they knew that first line — or at least the first part of the first line — probably helped a bit in terms of interpreting what I had done."

Since graduating from Stanford, Newman has worked in the field of lithography. His job responsibilities have spanned engineering, project management, and marketing.

He never kept in touch with Feynman, however. "Maybe I was a bit reticent to contact the great man," he said.

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The Back Page

New terrorism reveals new physics

By Neil Johnson

It is ten years since I wrote a Back Page article "The Mother (Nature) of All Wars?" which pointed to a connection between the physics of complex systems and human conflict including terrorism (*APS News*, November 2006). A lot of things have changed in the world since then, one of which is the expansion of the Internet to 3.5 billion users — that's nearly 1 out of 2 of the world's population. An immediate impact of this Internet expansion has been an increase in availability of information about individual violent events related to conflicts and terrorism at the daily level.

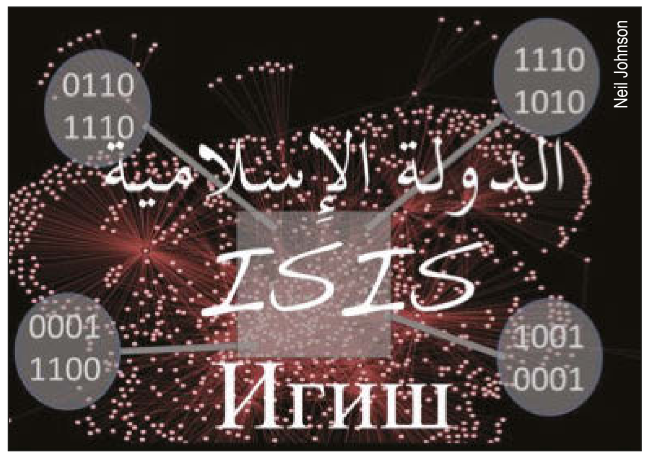
This has enabled a thorough testing of the conjecture reported in that 2006 article, that modern conflicts including terrorism follow an approximate power-law distribution for the severity of events, with a universal exponent near 2.5. That approximate "2.5 law of war" has now been confirmed using new databases from multiple recent and pre-existing conflicts including insurgencies, as well as updated terrorism databases [1]. Also thanks to Internet reporting, a power-law trend has been identified in the timing of attacks in conflicts that is interpreted as a non-Markovian stochastic walk between a Red Queen (i.e., small but agile state opponent) and a Blue King (i.e., large but more sluggish state). This mechanism represents a dynamical generalization of the Red Queen hypothesis [2] from evolution. Also, the availability of Google maps has led to better understanding of how casualty data should be collected — in particular, it led to the unraveling of "main street bias" in casualty data collected from epidemiological surveys during the most recent Iraq war. In that study [3], a network model from physics was used to identify the likely source of bias as being due to clustering along major thoroughfares owing to surveys being concentrated there.

But the impact of the Internet on human conflict goes much further than a convenient reporting outlet for daily events. As shown by the world's ongoing experience with ISIS (the so-called Islamic State), it can serve an extremist entity as a primary tool for recruiting, organizing, and inspiring attacks across the globe. Yet this also means that there are likely digital footprints available to researchers for developing a dynamical model of such collective human extremism. As a result, much work has focused on data from Twitter to identify influential online individuals. However, such "single particle" approaches have met with only limited success, in part because removing #1 from any extremist network automatically leads to #2 becoming #1, #3 becoming #2 etc.

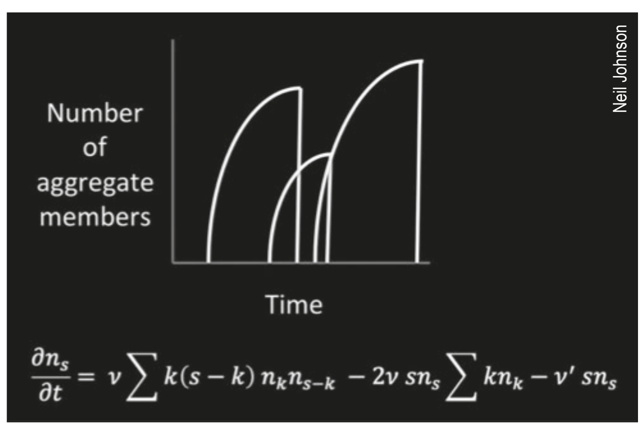
The limited success of individual-based approaches makes sense from a physics perspective, since it is akin to attempting a single-particle approach to understand many-body phenomena such as the fractional quantum Hall effect and superconductivity. Instead, we know from physics that the power behind such collective phenomena lies in the correlations between *aggregates* of particles, not single-particle behavior. And it turns out that the same is true for online extremism, with social media groups playing the role of collective quasiparticles.

Social media groups are now a big feature of networking websites, since they allow individuals — including any of us — to get together virtually and share information, opinions, etc. Supporters of ISIS around the world do the same. But instead of, for example, sharing more mundane news or ideas concerning a social event or sports team, they exchange operational information concerning ISIS. Their discussions frequently included details of fundraising for potential fighters who wanted to travel to Syria or transferring funds for fighters already there. They also share details about survival skills, such as how to use cellphones and the Internet without being detected by security services, and how to prevent or repel a drone attack or evade certain types of drones. The information and narratives shared by these online groups may ultimately inspire some of its followers to carry out terrorist acts — including lone wolf actors, who may have no prior history of extremism, no formal cell membership, and no direct links to leadership.

Setting out to study the many-body dynamics of pro-ISIS online support, we found that Facebook rapidly shuts down such pro-ISIS groups. However, its overseas competitors can be slower to act, probably because doing so would require significant amounts of resources and time. The most important among these is VKontakte (www.vk.com) which has more than 350 million users spread across the world, but which is physically based in the politically sensitive area of Central Europe near ISIS' major area of operations.



Online pro-ISIS aggregates are made up of interacting individuals.



The graph shows an example of the aggregate size (i.e., number of members of an online group or community) as time increases, for three example aggregates. Below the graph is the equation that correctly describes these aggregate dynamics within a mean-field approximation.

Our study of VKontakte between January 1 and August 31, 2015 uncovered an ultrafast ecology of 196 pro-ISIS aggregates [4] (i.e., online groups and communities) that share operational information and propaganda, involving 108,086 individual followers. Although these aggregates are typically shut down by online moderators within a few weeks of being created, their members would simply go on to form another aggregate or join an existing aggregate that was still evading shutdown. The high-resolution aspect of our data also meant that this study moved beyond the current focus of the network science field on identifying community structure in time-aggregated networks. Instead, we can see followers' behavior in real time down to a timescale on the order of seconds. It also moves the understanding of human dynamics beyond the current focus on quasi-static links related to family or long-term friends, toward operationally-relevant dynamical interactions.

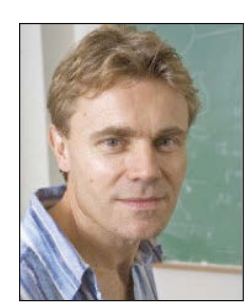
The evolution of this aggregate ecosystem follows a rather precise mathematical form similar to fragmentation-coalescence processes in physics (e.g., polymers). But unlike physical or chemical systems where individual units might break off or the aggregate might break into a few pieces, the fragmentation is now like a shattering process reflecting the sudden moderator shutdown of an aggregate. Most importantly, this is *exactly the same* coalescence-fragmentation process that had been conjectured for real-world conflicts in the original Back Page article of 2006 but had never been observed directly. Solving the mean-field equation yields an approximate power-law with exponent 2.5, exactly as observed from the empirical data for the online aggregate average sizes and also for the distribution of casualties from previous conflicts and terrorism. So taking the size of an aggregate in the real world as indicating its potential impact in an event, and hence the number of casualties that it would generate, then this same process of collective human aggregation describes quantitatively both online and offline extremist behavior — it is just that online it becomes turbocharged thanks to the Internet making it faster and with now potentially global reach.

We also identified new evolutionary adaptations that these pro-ISIS aggregates have managed to find. Some may go invisible for a while, and also occasionally reincarnate, appearing at a later date with a different identity and yet managing to retain most of their members. So just as Darwin predicted what happens in biological evolution, pro-ISIS support has adapted to exploit features afforded by its new online environment (i.e., social media website) in order to survive longer.

The practical consequences are many-fold. Identification of the coalescence-fragmentation mechanism suggests that anti-ISIS agencies can step in and break up small aggregates before they develop into larger, potentially powerful ones. If anti-ISIS agencies aren't active enough in their countermeasures, pro-ISIS support will quickly grow from a number of smaller aggregates into one super-aggregate. Also, if aggregate shutdown rates drop below a certain critical value [5], any piece of pro-ISIS material will then be able to spread globally across the Internet — ultimately leading to an Internet arms race. Finally, the birthrate of these aggregates escalates in a particular way ahead of real-world mass onslaught, just as clusters of correlations begin to proliferate ahead of a phase transition in a physical system — except this is now a dynamical phase transition in time. The important role of these aggregates also ties in nicely with earlier work on guilds in the massively parallel online game World of Warcraft [6].

Furthermore, it means that instead of having to sift through millions of Internet users and track specific individuals through controversial profiling techniques, an anti-ISIS agency can usefully shift its focus toward open-source information to follow the relatively small number of aggregates in order to gauge what is happening in terms of hard-core global ISIS support. But perhaps most importantly in light of the massacre in Orlando and bombings in New York, this coalescence-fragmentation mechanism of online support means that any online lone-wolf actor will truly be alone for only short periods of time. Since individuals with serious interest in ISIS online tend to coalesce into these aggregate groups, any such lone wolf was likely either recently in an aggregate or will soon be in one. By knowing the groups and hence narratives to which such individuals have been exposed in the past, it might ultimately be possible to predict the type of event that they become capable of perpetrating.

As for the future, even if pro-ISIS support moves onto the dark net where open access is not possible, or if a new entity beyond ISIS emerges, these many-body findings should still apply, since they appear to capture a basic process of human collective behavior. Independent of cause, we can assume that the same types of many-body coalescence-fragmentation phenomena will arise.



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References:

1. J. C. Bohorquez et al., "Common ecology quantifies human insurgency," *Nature* 462, 911 (2009); N. F. Johnson et al., "Simple mathematical law benchmarks human confrontations," *Scientific Reports* 3, 3463 (2013).
2. N. F. Johnson et al., "Pattern in Escalations in Insurgent and Terrorist Activity," *Science* 333, 81 (2011).
3. J. P. Onnela et al., "Sampling bias due to structural heterogeneity and limited internal diffusion," *Europhysics Letters* 85, 28001 (2009); N. F. Johnson et al., "Bias in Epidemiological Studies of Conflict Mortality," *Journal of Peace Research* 45, 653 (2008).
4. N. F. Johnson et al., "New online ecology of adversarial aggregates," *Science* 352, 1459 (2016).
5. Z. Zhao et al., "Effect of social group dynamics on contagion," *Physical Review E* 81, 056107 (2010); "Anomalously slow attrition times for asymmetric populations with internal group dynamics", *Physical Review Letters* 103, 148701 (2009).
6. N. F. Johnson et al., "Human group formation in online guilds and offline gangs driven by a common team," *Physical Review E* 79, 066117 (2009).