**VIEWPOINT**
Yes, Sexual Harassment Still Drives Women Out of Physics
BY JULIE LIBARKIN

Editor’s note: This article is adapted from a Viewpoint commentary in Physics (physics.aps.org) accompanying a paper published in the APS journal Physical Review Physics Education Research.

You may be someone who thinks that sexual harassment is a “thing of the past” or that it’s experienced by “only a few” women. These statements don’t capture reality. As recently as 2016, a study found that sexual harassment affects the majority of women in science, technology, engineering, mathematics, and medicine (STEMM). (1) Now, a comprehensive survey of female undergraduates in physics has uncovered a similarly disturbing situation for this group of women at the start of their careers. Aycock et al. surveyed female attendees at the 2017 Conferences for Undergraduate Women in Physics (CUWiP). They found that nearly three-quarters of the roughly 500 respondents had experienced some form of sexual harassment and that these experiences correlated with a sense of not belonging in the field. This finding won’t surprise most women in STEMM, but it may shock men, who are often unaware of sexual harassment’s pervasiveness and damage.

Broadly defined, sexual harassment is unwelcome or inappropriate actions that are made on the basis of sex or gender and that create an intimidating or hostile environment. And while these actions may be motivated by the harasser’s desire to humiliate or control the victim, the harasser’s motives are irrelevant in determining whether harassment has occurred. Simply stated, sexual harassment is a matter of fact, not of intent.

The study’s findings need to be put into context. Women have made considerable progress in the last century. The result of this progress is that women now receive 10% of the physics bachelor’s degrees awarded in the United States. (2) Yet it is also the case that women are significantly underrepresented in physics graduate school and that most women who do persist in physics complete their degrees later than their male peers. The combination of these factors leads Aycock et al. to conclude that sexual harassment is a significant barrier to women’s staying and succeeding in physics.

So, what can be done to address sexual harassment in physics? The authors of the study recommend these steps: 

1. Train faculty, graduate students, and undergraduates with the goal of creating an environment in which sexual harassment is not tolerated.

2. Institute a no-tolerance policy for sexual harassment.

3. Provide a mechanism for reporting complaints.

4. Ensure that all students who report sexual harassment are treated with respect.

5. Provide resources to support the victim.

6. Identify the types of sexual harassment that occur in physics and the means by which they can be prevented.

As of yet, these recommendations have yet to be fully implemented in physics departments. But Aycock et al. are optimistic that, with the release of the study and its findings, this will change. What is important is that physicists continue to work toward creating a safe and inclusive environment for all students.

**APRIL MEETING**
News About Neutrinos: The Kavli Foundation Plenary Session
BY LEAH POFFENBERGER

April Meeting attendees gathered early on Monday morning in Denver for this year’s Kavli Foundation Plenary session to hear about recent advances in neutrino physics. The session’s three invited speakers provided an overview of the work being done to understand—and use—the elusive neutrino.

André de Gouvêa (Northwestern University) spoke about the theory behind neutrino masses, followed by Kevin Galiano (The Ohio State University), who surveyed their PhDs in May, having masses requires new ingredients to the Standard Model, since “neutrinos are evidence of physics beyond the Standard Model, since neutrinos have masses requires new ingredients to the model. However, twenty years ago, the discovery of neutrino oscillations—the variation in neutrino “flavors” as they travel, changing between tau, muon, and electron neutrinos—showed neutrino “flavors” as they travel, changing between tau, muon, and electron neutrinos—showed neutrino masses. The discovery of neutrino oscillations has had two significant implications: (1) the neutrino is not an elementary particle, (2) the Standard Model is incomplete. The existence of neutrino masses has been confirmed by experiments at accelerators, particle reactors, and cosmic ray fluxes.

As part of the Standard Model of physics, theories that predict three families of neutrinos to have a mass of zero, a parameter that fits into the known rules of the model. However, twenty years ago, the discovery of neutrino oscillations—the variation in neutrino “flavors” as they travel, changing between tau, muon, and electron neutrinos—showed neutrinos have mass, albeit very small. As de Gouvêa pointed out, non-zero neutrino mass is evidence of physics beyond the Standard Model, since neutrinos have masses requires new ingredients to the model. However, twenty years ago, the discovery of neutrino oscillations—the variation in neutrino “flavors” as they travel, changing between tau, muon, and electron neutrinos—showed neutrino masses. The discovery of neutrino oscillations has had two significant implications: (1) the neutrino is not an elementary particle, (2) the Standard Model is incomplete. The existence of neutrino masses has been confirmed by experiments at accelerators, particle reactors, and cosmic ray fluxes.

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FUNDAMENTAL UNITS

Updating Le Système International

BY ABIGAIL DOVE

On May 20, 2019, the world will officially transition to a revamped system of units, featuring new definitions for the kelvin, the ampere, the mole, and, most famously, the kilogram. Although these changes, approved in November 2018, have received a lot of attention in the scientific press, less well-known is the organization that guided this overhaul of Le Système International d’Unités (SI): The International Bureau of Weights and Measures, or BIPM (Bureau International des Poids et Mesures).

BIPM, the world’s authority for all things measurement-related, has its origins in the 1875 Metric Convention in Paris, which aimed to standardize units of measure internationally. The primary issue in 1875 was establishing universal units of mass and length, which began with the construction of official kilogram and meter prototypes.

Today the modern SI system includes a total of seven fundamental base units, including the second for unit of time, the ampere for electric current, the kelvin for thermodynamic temperature, the candela for luminous intensity, and the mole for amount of substance. These are in addition to the kilogram and the meter (plus several so-called “derived” units grounded in the base units, including coulombs, joules, volts, ohms, teslas, etc.). With 60 member states and 42 associate states and economies, BIPM promotes and advances the global comparability of results and outcomes.

May 1618: Kepler’s Discovery of Solar System Harmonics

May 27, 1618: Johannes Kepler was appointed as imperial mathematician,mathematician for the Holy Roman Emperor. The job involved nothing less than keeping track of the planet positions, which he was soon to find was beyond the scope of even the best observational astronomers.

Kepler had relied on inaccurate data gathered by Tycho Brahe near Copenhagen, where Brahe was the royal astronomer. The latter had already offered some harsh criticisms of the former offered some harsh criticisms of the latter’s work, and Kepler recognized that he needed a better system to work with.

While the treatise had its flaws, it brought Kepler to the attention of leading astronomers, including Tycho Brahe and Reimarus Ursus. Brahe and Kepler exchanged many letters, in which the former offered some harsh criticism of the young astronomer’s work, including the fact that Kepler had relied on inaccurate data gathered by Copernicus. In 1600, Kepler visited Brahe near Prague, as a new observatory was being built, and was introduced to Brahe’s assistant, Thomas Digges.

The greatest and least distances between a planet and the Sun did not follow harmonic ratios, but Kepler reasoned that the points where the planet moved fastest (“converging motion”) occurred at 6:5, 8:7, and 10:9, corresponding to a major third, minor third, and perfect fifth, respectively. In 1602, while visiting Prague, and when Brahe died, Kepler was appointed as imperial mathematician,mathematician for the Holy Roman Emperor.

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Kepler argued that the behavior of the planets was governed by a more literal music of the spheres in his 1619 treatise, Mysterium Cosmographicum, in 1596, when he was just 25. While in Graz, Kepler experienced an epiphany that opened a possibility about a geometric basis of the universe, inspired by the periodic conjunction of Saturn and Jupiter. He created a model in which each of the five Platonic solids was encased inside a sphere; if one then nested them within each other, the resulting six layers would correspond to the six known planets at the time (Mercury, Venus, Earth, Mars, Jupiter, and Saturn). He published these conclusions in his first astronomy treatise, Mysterium Cosmographicum, in 1596, when he was just 25.

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In the 1660s, Kepler’s Third Law of its orbit.” (Kepler had described from the Sun. It is typically defined describing the distance relationship matter, showing two-dimensional explained in layman’s terms how participated in the Coma cluster were moving too rapidly. While there was actually is. There are many possible candidates, from sterile neutrinos to WIMP-zillas. Rather than go through them all, Freese started with what dark matter is not. For example, it is not black holes or neutrinos. Supermassive black holes are found in the centers of galaxies but there are not enough of them to constitute the significant part of the universe that is dark matter. Neutrinos are simply too light for them to provide the mass missing from the visible universe. In computer models neutrinos cause a kind of simulated galaxy formation that does not align with current observations.

The two most likely candidates according to recent research are axions and weakly interacting massive particles (WIMPS). WIMPS are theorized to interact gravitationally but also through the weak force, meaning they could be detected through certain kinds of interactions with other particles. Freese detailed the characteristics of WIMPS and the many experiments designed to find them.

Freese described some current and future detectors for WIMPS. Among these was a DNA detector, consisting of a plate of gold with strands of DNA hanging down from it. The idea is that WIMPS passing through would sever the DNA strands where they hit. The direction could be inferred from the breaks in the strands. Another example experiment she noted was IceCube at the south pole consisting of a large array of detectors embedded in the 2 kilometer thick ice.

Freese’s discussion on the state of dark matter stimulated curiosity and many questions. The talk concluded with some astute questions from the audience.

Katherine Freese meets the audience after her public lecture on the "cosmic cocktail".

The author is a freelance writer based out of Goodland, KS.
New Results Question Controversial Dark Matter Signals

BY JESSIE CONNORS

For something that constitutes around 27% of the universe, dark matter has been hard to catch. As in past years, it was the topic of presentations and debate at the APS April meeting this year in Denver. Efforts to directly detect this strange substance have been largely fruitless, with the possible exception of the DAMA/MIBRA experiment. This detector, located beneath a mountain in Italy’s Gran Sasso Underground Laboratory, has captured a middiadic signal that the DAMA/LIBRA collaboration claims is evidence of dark matter.

Their results have been met with a steady stream of skepticism over the years. Other experiments have failed to replicate the DAMA/LIBRA results. No experiment, however, has put DAMA’s methods directly to the test, until now: Two experiments, COSINE-100 at Yangyang Underground Laboratory in South Korea and ANAIS–112 at Canfranc Underground Laboratory in Spain, are now online using sodium iodide crystals, the same material used in DAMA’s detectors. While their methods closely follow those at Gran Sasso, neither has reproduced DAMA/LIBRA’s signal.

“People have tried to come up with ideas to take away the discrepency, but no one has come up with a viable candidate for dark matter that can produce a signal in DAMA but not in the other experiments,” said Reina Maruyama, a principal investigator on the COSINE-100 experiment. “It could be that we don’t know how to think about it as theorists, or it could be that the DAMA/LIBRA experiment is wrong.”

The existence of dark matter has long been postulated, but what form it takes is still a mystery (see article on page 3). Some researchers suggest it is a widely distributed—but undetected—particle. Another camp argues that dark matter need not exist at all and that alternative theories of gravitation can explain the missing mass condurum.

Weakly interacting massive particles (WIMPs) are a popular dark matter particle candidate, and experimentalists have designed clever technologies to tease out their signatures. Thought to have formed in the early universe, these particles barely interact with the matter around them, making their detection a formidable task.

DARK MATTER CONTINUED ON PAGE 5

F Y I : S C I E N C E P O L I C Y N E W S F R O M A I P

Senate Energy Innovation Push Gains Steam

BY WILLIAM THOMAS

Efforts to promote energy innovation are taking shape in the Senate amid a swelling wave of congressional interest in climate change. Key senators have now agreed in principle that a sizeable funding increase is warranted, and several committee leaders are pushing legislation to spur new energy technologies. In March, Sen. Lamar Alexander (R-TN) proposed a “New Manhattan Project” with $1 billion in demonstration projects by 2026 and at least two additional demonstration or R&D projects by 2030 in other provisions. Murkowski and Committee Ranking Member Joe Manchin (D-WV) have introduced the Enhancing Fossil Fuel Energy Carbon Technology (EFFECT) Act and the Rare Earth Element Advanced Coal Technologies (REEACT) Act. The EFFECT Act would authorize new fossil energy technology programs at DOE and recommend increased funding for them, while the REEACT Act would back ongoing R&D related to the extraction of rare earth elements from coal and coal byproducts.

Manchin is also a sponsor of the bipartisan Utilizing Significant Technologies with Innovative Emissions with Innovative Technologies (USE IT) Act, introduced by Senate Environment and Public Works Committee Chair John Barrasso (R-WY). The bill would promote R&D on technologies to capture carbon dioxide from the atmosphere.

Alexander has often proposed such large-scale increases in Department of Energy R&D funding, going back shortly after he joined the Senate in 2003. As recently as 2016, he called for doubling the DOE Office of Science budget and paying for it by ending the wind energy production tax credit.

As articles in FYI: Science Policy News from AIP can be found at aip.org/fyi.
of a signal produced by spin-independent WIMPs, but analyses from 1.7 years of data were found to be consistent both with no modula-
tion, and with DAMA/LIBRA’s results. For a more definitive result, both groups are now collecting more data. If future results from the COSINE—100 and ANAIS—112 experiments continue to contradict DAMA/LIBRA, they may indicate weaknesses in the WIMP theory, or in current detection methods.

“A null result in COSINE—100 would close any type of loophole that theorists or experimentalists may try to come up with to explain DAMA/LIBRA’s results,” says Maruyama. “It would be more difficult to explain somebody else’s results”

While with more and more evidence stacking up against the DAMA/ LIBRA collaboration’s persistent claims of dark matter detection, the case for WIMPs as a dark matter candidate may be waning. And while experts have begun to doubt the validity of the DAMA/LIBRA results, there is no indication that DAMA/LIBRA is giving up its search for WIMPs any time soon. Yet a new idea is on the horizon: the wimp-y.

An expanding world of particles

While it’s too early to write an obituary for the WIMPs, new ideas are sparking an exciting revolution in dark matter. Theorists, experimentalists, and astrophysicists are expanding their searches. At this year’s April Meeting, 13 sessions were dedicated to the topic alone, featuring researchers across several APS membership units.

“The field of dark matter is exploding,” said Cooley. New ideas and technologies are enabling experimentalists to reach sensitivities far beyond previous dark matter searches. Experiments such as LZ at the Sanford Underground Research Facility in South Dakota and SuperCDMS at Vale Inco Mine in Ontario are searching for WIMPs using alternative experimental approaches. Researchers are getting close to the neutrino floor, where detectors have such high sensi-
tivity that incomprehensibly tiny neutrinos are detected and become background noise. Unlike DAMA/ LIBRA and COSINE, SuperCDMS employs super cold crystals to detect vibrations (measured in phonons) to probe the universe for WIMPs. The project will begin data collection in 2020, and promises to provide a valuable new perspective on the dark matter debate.

If these experiments fail to find WIMPs, light mass particles called axions may rise as the most favorable candidate, illustrating an ever-expanding range of particle possibilities. “We’re edging up to that last spot of the WIMP space, then we have this whole new uncharted territory with these light mass particles,” said Cooley, a collaborator on the SuperCDMS experiment. “We’re starting to develop a portfolio that spans multiple regions to cover a broad spectrum of dark matter candidates, and it feels to me like we could be on the verge of discov-
ering something in the next round.

Lissie Connors is a Science Communication Intern at APS.

Quantum Computing Scientists: Give Them Lemons, They’ll Make Lemonade

BY SOPHIA CHEN

At the close of 2018, U.S. quantum computing researchers got their holiday wish. Following a six-month leg-
islative process, President Trump signed the National Quantum Initiative Act into law. The law sets forth a plan to inject $1.2 billion of investment into quantum technolo-
gies. This expected infusion of cash, spread over the next five years, will fund the development of new quantum devices, building upon the existing prototype quantum computers from companies such as Google, Intel, and IBM.

Now, the hard part: developing a quantum computer capable of surpassing non-quantum technol-
ology. So far, researchers have only been able to demonstrate algorithms on their early devices that classical computers can still handle, such as simulating three-atom molecules. At this year’s APS March meeting in Boston, researchers discussed bite-size projects for the era ahead. “They’ve already come up with a new acronym: NSQI, for Noisy Intermediate–Scale Quantum Computing.

Researchers still loosely define the term, roughly describing a NSQI computer as one that doesn’t have “full-blown error correction,” says quantum algorithm researcher Kristan Temme of IBM. All existing quantum computers fall under this descriptor. “We can’t execute arbitrarily long sequences of logic gates due to hardware limita-
tions. In other words, a naively designed algorithm will result in the hardware delivering the wrong final answer.”

Imagine programming the supercomputing qubits in IBM’s computer into an initial quantum state, which each qubit corresponds to some superposition of 1 and 0. To complete some computing task, you would apply microwave pulses corresponding to a sequence of logic gates to manipulate the values of each qubit. However, errors will occur during this process, like a qubit winding up in the wrong superposition. But unlike in con-
ventional computing, which corrects errors by coding redundant data, quantum states cannot be dupli-
cated. And while experts have begun designing special quantum error correction algorithms, they have not yet successfully executed their ideas on hardware. Without error correction, the qubits end up in a final state that does not correspond to what the algorithm developer intended.

These errors arise from many different sources, says Temme. “One could be that a logic gate happens to perform badly. The best logic gates perform operations correctly at least 99.99 percent of the time, so in long algorithms, statistical errors add up. In addition, sometimes a microwave pulse will alter the value of a qubit that is not supposed to be part of an operation, a scenario known as crosstalk. On top of these errors, the qubit’s information also suffers from a short lifespan. The qubit’s quantumness, or coherence, only lasts up to about 100 microseconds.

So NSQI researchers have chosen pragmatism: to accept these flawed machines, for now. “The question is, can you still do something interest-
ing with these devices?” says Temme.

He’s betting yes. In the last couple years, Temme and his col-
leagues have published several papers on how to make the most of what they have. Their general strategy in the NSQI era is to design algorithms that take the hardware’s quirks into account. For example, Temme recommends designing algorithms that use short sequences of logic gates, known as short-
depth circuits. “Typically, you get up to a fraction of the coherence time, say 50 percent, and then you count how many gates you can fit in,” he says.

Another approach is to design a hybrid algorithm that uses both classical and quantum computations. Temme says algorithm researcher Jarrod McClean of Google. One popular algorithm with chemistry applica-
tions approximates the ground state of a molecule. “To start, the user first programs an approximation of the ground state into the qubits. The quantum computer improves the initial guess by applying a sequence of logic gates that depends on a set of parameters, analogous to weights in a neural network. Then, the state is fed to a classical computer, which then instructs the user how to tweak those weights in the quantum computer. Then, the entire process iterates in an automated process.

McClean is trying to figure out how optimize that initial guess for the ground state. Some researchers choose a random set and state of logic gates to start with, because it is more forgiving on the hardware. But this strategy can get buggy, as McClean and his colleagues reported in Nature Communications last year. Some random guesses can cause the quantum computer to get stuck and they have identified ways to avoid the logjam.

Researchers are also looking at whether NSQI computers can benefit classical machine learning algorithms. Temme’s group has uncovered some tantalizing hints, published in Nature in March, that a NSQI machine could be better at classifying certain types of data. They engineered a classical data set to contain the National Cup, the term that two qubits of a quantum computer were able to classify into two groups easily. While the classification task was simple enough for a classical computer to handle, Temme says the demonstration is a step toward the potential advantage of NSQI.

On the hardware side, researchers still can’t tell which type of qubit—superconducting
De Gouvêa proposed several possible ways the neutrino gets its tiny mass: Neutrinos interact with the Higgs boson much more weakly than quarks or leptons. But recent Higgs boson experiments that confirm Higgs boson exists that imparts mass just to neutrinos; or neutrinos get their mass from something else besides Higgs bosons. Which answer is correct is partially dependent on uncovering what particles are Dirac fermions, with distinct antiparticles like the rest of the fundamental fermions such as the Standard Model, or Majorana fermions, meaning the particles are their own antiparticles. De Gouvêa cited the need for more such lab-based experiments to be able to further understand the properties of neutrinos.

Fortunately, experiments are currently ongoing, gathering data in hopes of solving the mystery of neutrino mass. One lab-based method of determining neutrino mass—cosmology, direct measurements, and neutrinoless double beta decay—and described the status of experiments in each of these areas. Cosmological probes of astrophysical phenomena, like the cosmic microwave background and formation of galaxies, have already set some constraints on the limits on neutrino mass, and future projects, like the Euclid space telescope and the BIceCube Array, aim to directly measure neutrino mass. However, Mertens offered a caveat: A number of uncertainties may impact precision in cosmology, meaning lab experiments are still necessary.

One such lab-based method of inquiry is detection of neutrinoless double beta decay, in which two neutrinos transform into antineutrinos inside a nucleus. Only electron emission occurs (in contrast to normal beta decay) because the neutrinos annihilate each other before they can be emitted. Detecting such decays would indicate neutrinos are Majorana fermions, but since they only occur about once a year per ton of material, they require extremely low, low-background detectors, like GERDA at the Gran Sasso Laboratory in Italy. Studying the chemical reactions and the beta decay may provide a method of direct measurement of neutrino masses, and results are expected within the year from the KATRIN experiment that will provide an improved neutrino mass result. Although neutrinos aren’t well understood themselves, they do have some known properties, like electric neutrality and very long mean free paths, that make them unique cosmic messengers for studying other cosmic phenomena, according to Santander. With large enough detectors, neutrinos can be used to help determine the source of cosmic rays, which have trajectories distorted by magnetic and electric fields, and thus can’t be reliably traced to their origin.

To detect neutrinos from the cosmos, telescopes have been constructed under water or ice, such as Baikal NT-200 located in Lake Baikal, Russia, and more recently IceCube, embedded in a cubic-kilometer of a South Pole glacier. Santander shared the ingredients for neutrino astrophysics: wide sky coverage, good angular resolution, good timing resolution, and sensitivity to the flavor of neutrinos. Using this recipe for success, IceCube successfully detected a high-energy blazar emission of 250 GeV, which is an astrophysical source of neutrinos and cosmic rays in September 2017. Later, next-generation experiments, like IceCube 2, will improve sensitivity to continue using high-energy neutrinos to study the cosmos.

The April Kavli Session can be viewed on the APS YouTube channel at youtube.com/apsphysicystics.

**Rights continued from page 1**

As president of UK’s Association of Women in Mathematics and Physics, 1 am also eager to see science students thrive in the field, especially women, who only represent 28 percent of all workers in STEM careers, according to a study by the American Association of University Women. Additionally, I want to continue to push for a cultural change in STEM, encouraging more women and underrepresented minorities to consider careers in science. STEM is an exciting career choice that pays huge rewards, but for workers with a bachelor’s degree is $75,648, compared with $55,695 for non-STEM workers. This gap continues to widen, according to a Pew Research Center study.

Other students share my love of science. One student wrote about their futures as the federal funding issue once again hangs in the balance. I urge McConnell to do the right thing by using his position and power for non-STEM fields, according to a study published in September 2018, the median salary for non-STEM careers, according to a study, is $75,948, compared with $55,695 for non-STEM workers. This gap continues to widen, according to a Pew Research Center study.

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**Budget continued from page 4**

Why Science is a sure bet.

History has proved that investing in scientific research has benefited the nation in countless ways. From the large, next-generation particle collider, federally funded research has led to myriad innovations that have greatly impacted the lives of Americans.

As president of UK’s Association of Women in Mathematics and Physics, I am also eager to see science students thrive in the field, especially women, who only represent 28 percent of all workers in STEM careers, according to a study by the American Association of University Women. Additionally, I want to continue to push for a cultural change in STEM, encouraging more women and underrepresented minorities to consider careers in science. STEM is an exciting career choice that pays huge rewards, but for workers with a bachelor’s degree is $75,648, compared with $55,695 for non-STEM workers. This gap continues to widen, according to a Pew Research Center study.

Other students share my love of science. One student wrote about their futures as the federal funding issue once again hangs in the balance. I urge McConnell to do the right thing by using his position and power for non-STEM careers, according to a study published in September 2018, the median salary for non-STEM careers, according to a study, is $75,948, compared with $55,695 for non-STEM workers. This gap continues to widen, according to a Pew Research Center study.
of measurements across essentially the entire industrialized world. The activities of the BIPM are overseen by the International Committee for Weights and Measures, or CIPM (Comité International des Poids et Mesures). Effectively, CIPM is the bloc or central board of directors, and is comprised of 18 expert members, each from a different national metrology institute, to mirror the number of original signatories of the 1875 Metre Convention. Countries currently represented in CIPM include Argentina, Australia, Canada, China, France, Germany, Italy, Japan, Mexico, the Netherlands, New Zealand, Norway, Singapore, South Africa, South Korea, Switzerland, the United Kingdom, and the United States.

Chemist Willie E. May is the outgoing US representative on CIPM’s Board of Directors and President of the committee. As is traditional for the CIPM member from the US, May also served as the Director of the National Institute of Standards and Technology (NIST) under President Obama after an impressive 14 years at his alma mater, the Institute. (James Olthoff, the NIST Associate Director for Laboratory Programs was elected to CIPM membership in May, and succeeded May as the US representative on March 20.)

May has said that the ongoing update to the SI system is much more sweeping than just the redefin- ing of previously arbitrary units: it represents a comprehensive shift from a "classical" to "quantum" SI system. That is, tying metrology to the fundamental constants of physics, quantum phenomena, to fundamental constants that we lock in place for a very long time: up to centuries. In this new system the base units lose their special status (though they will still be called “base units” for the time being). On whether other aspects of SI are likely to be tweaked in the future, May noted that the new system will soon take effect intended “essentially for eternity, as far as we can comprehend,” adding, “they are constants, after all. Of course, all of the SI units we know today that all issues in the world of measure- ment science are solved with the updating of the SI system. May identified biological measurements and issues regarding reproducibility of data as some of the frontiers of measurement.

Biology is a challenging domain for measurement scientists because, unlike chemistry and physics, where quantitative measurements reign supreme, biology is a “different” kind of measurement problem (and perhaps even greater) emphasis on qualitative factors—proper- ties of proteins, nucleic acids, and cells, how they interact with one another, and the emergent func- tional properties that arise from complex networks of these compo- nents. To parse these issues, BIPM’s working group on Biometry has started new guidelines that will help determine reference for the biology of cells; nucleic acids, and proteins.

As for reproducibility, May alluded to the infamous replication crisis, pointing out that repeating and reproducing results is increas- ingly difficult in many areas of science—particularly medicine, biology, and social sciences. This is not currently an active focus area for CIPM, but the organization may eventually want to weigh in since replication is such a funda- mental aspect of measurement science. “It sounds triv- ial, but measurements drive innovation and our quality of life worldwide. Our units define the processes we use everyday and somebody has to oversee that process.”

The author is a freelance writer in Helsinki, Finland.

Behavior of a sexual nature that creates an uncomfortable or hostile environment. It comes in various forms and can apply to women or men. Three specific types were considered in the Aycock et al. study. “Sexist gender harassment” describes hostile or insulting remarks and actions based on one’s gender, such as saying women cannot do physics. By contrast, “sexual gender harass- ment” refers to sexual remarks or conduct, like commenting on the person’s looks or attire. The third form of sexual harassment is unwanted sexual attention, such as requests for sexual favors or unwanted touching.

Unfortunately, these behaviors are entrenched within societies around the world, and they persist because of pervasive mechanisms, inadequate reporting mechanisms, and the normalization of sexual violence (1). To change this culture, we need to first assess where we are. Studies in physics and other fields environments suggest that sexual harassment is common (3–5), with as many as 79% of women reporting sexual harassment experiences. Students are most likely to experi-ence harassment by their peers, but the problem is widespread for teachers, staff, and students. Sexual harassment is often pervasive and continuous: most women experience it from and before one person.

Dissertation, expensive scholar- ship, many people are unaware of the toll sexual harassment has taken on their experiences. Vendors of graduate women’s likelihood of leaving a STEM career (3). And for those women who stay, the field’s harassment costs their career, economic standing, and well-being (4). In short, unchecked harassment creates a drain on talent through lost work, lost ideas, and lost people (2).

Understanding the extent and effects of sexual harassment in physics undergraduates is essential because this is the first stage of becoming a scientist. An increase in the number of graduate women in physics has been shown to have many benefits for both women and the physics field. However, research has so far been unable to attribute their success to hard work, luck, or external percep- tions—instead of if they had experienced either sexist or sexual gender harassment. Does sexual harassment inhibit women from choosing physics as a long-term career, as these results suggest? That’s a question worth asking our students, to get a better sense of how many women who have left physics there has been little traction: only about 20% of physics degrees at all levels go to women. Aycock et al. recognize that surveys provide only one step towards assessing the damage from sexual harassment and that further study is needed to unpack their findings. For example, we need to look at the academic achievement for women who have left physics why they did so.

Sexual harassment of graduate students,“No doubt the effect of sexual harassment as an ingrained phenomenon,” where one largely attributes her or his success to luck, hard work, or preferential treatment rather than ability.

Aycock et al. found that experi-encing sexual harassment correlated to a decrease in confidence, and an exacerbated sense of the impostor phenomenon. Three- quarters (74.3%) of respondents experienced some form of sexual harassment; nearly half (42.6%) experienced multiple forms. Of the women experiencing harass- ment, 91.3% experienced sexist gender harassment, 56.2% expe- rienced sexual gender harassment, and 32.6% experienced unwanted sexual attention. The findings align with a 2016 study that demonstrated the prevalence of sexual harassment of graduate women in physics (8). Using regression models, Aycock et al. note that while sexual harassment was associated with a deteriorated sense of belonging. However, research has shown that being able to attribute their success to hard work, luck, or external percep- tions—instead of if they had experienced either sexist or sexual gender harassment.


The professor is a director of the Department of Earth and Environmental Sciences at Michigan State University.
This model allowed one to determine, given the knowledge of certain hidden parameters, the actual trajectories followed by particles. In this paper, however, Einstein is reluctant to explicitly give a realistic interpretation to it, because, as he noted before, a function living in a “many-dimensional coordinate space does not smell like something real” [8].

Einstein himself presented his paper from appearing in print [9], and in the following years, he became increasingly critical towards any further attempt of synthesizing the quantum and wave conceptions. Even when American physicist David Bohm developed his celebrated deterministic hidden variables model [3] which reproduces all the predictions of QM, Einstein maintained that this was untenable. So, despite Bohm’s model having virtually achieved the goal of Einstein’s 1927 paper, the latter wrote to Born: "Have you noticed that Bohm believes that he is able to interpret the quantum theory in deterministic terms? That way seems too cheap to me [10]."

What we learn from Einstein’s involvement in the hidden variable program is that his main concern was definitely not determinism. His early open inductive attempts, and Bohm’s consistent interpretation all retrieved determinism, however were not enough for Einstein. The fact that they all relied on a wave-function living in a configuration space, made them despicable to Einstein, in so far as they clearly did “not smell like something real.” Sacrificing a tenable form of realism was too high a price to pay for Einstein, even if determinism was so restored.

Popper put forth the view that physics is based on realism, but it is fundamentally indeterministic. In 1990, he presented his ideas on indeterminism in front of Einstein and Bohr. In discussions, Popper tried to “persuade [Einstein] to give up his determinism” [10]. Yet, later he stated: "The attribution to Einstein of the formula ‘God does not play with dice’ is a mistake. Admittedly, he was a strict determinist and that determinism was used merely instrumentally: it is unsatisfactory […]. It is […] bound, like all other deterministic theories, to interpret probabilities subjectively[ […]]. Einstein’s point of departure is ‘realistic’ rather than ‘deterministic’[ […]]."

Even Pauli maintained: Einstein does not consider the concept of ‘determinism’ to be as fundamental as it is frequently held to be (as he told me emphatically many times). […] Einstein’s point of departure is ‘realistic’ rather than ‘deterministic’[ […]]." [9].

Given Popper’s aversion towards determinism, he also did not champion Bohm’s interpretation. In the book that collects his mature views on foundations of QM, Popper indeed stated: "In spite of Bohm’s realistic and objectivist programme, his theory is unsatisfactory […] It is […] bound, like all other deterministic theories, to interpret probabilities subjectively[ […]]." [10].

In an unpublished letter, however, Bohm firmly replies to Popper that, like Einstein, his main concern was realism and that determinism was used merely instrumentally: "I certainly think that a realistic interpretation of physics is essential. […] However, I feel that you have not properly understood my own point of view, which is much less different from yours than is implied in your book. Firstly I am not wedded to determinism. It is true that I first used a deterministic version of […] quantum theory. But later, […] a paper was written, in which we assumed that the movement of the particle was a stochastic process. Clearly that is not determinism. […] The key question at issue is therefore not that of determinism vs. indeterminism. I personally do not feel addicted to determinism, but I am ready to consider deterministic proposals, […] if they offer some useful insights[11]."

In conclusion, contrarily to the standard story, neither Bohr nor Einstein were staunchly committed to determinism and they would have accepted fundamental indeterminism in exchange for realism.

The author is at Institute for Quantum Optics and Quantum Information, Austrian Academy of Science, Vienna and the Basic Research Community for Physics (BRCP).

References
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