Better Biological Imaging with Nuclear Physics

BY LEAH POFFENBERGER

Physics has long been a contributor to medical imaging, dating back to the discovery of x-rays in 1895. And thanks to nuclear medicine, physics continues to play a role in improving how we can see inside the human body.

Paul Lecoq (CERN) and Andrew Weisemberger (Thomas Jefferson National Accelerator Laboratory) presented new ideas for detectors in medical imaging at the 2019 APS April Meeting, as part of the first session sponsored by the APS Topical Group on Medical Physics (GOMED). Lecoq proposed a method of increasing positron emission tomography (PET) scan sensitivity by improving timing resolution, and Weisemberger discussed a number of projects at Jefferson Lab exploring new uses for radioisotopic imaging.

Imaging with radioactive nuclear isotopes is a valuable diagnostic tool, able to detect cancer and investigate organ function. These isotopes, radioactive versions of compounds involved in metabolic processes, are injected into the body and concentrate in tumors or organs of interest. PET scans measure gamma ray photons that are produced when positrons emitted by the isotope collide and annihilate electrons in tissue. Because the compounds are chosen to bind to specific biomolecules, the bright 511 gamma ray images indicate biological activity.

Lecoq is on a quest to further improve PET scanners as part of a team at CERN developing technology that would increase scan sensitivity by a factor of 200. A
From April 25 to 27, physics and chemistry faculty came together for a workshop aimed at improving career mentoring for students in the physical sciences. APS, the American Chemical Society (ACS), and the Research Corporation for Science Advancement (RCSA)’s Cottrell Scholars Collaborative joined forces for the event, hosted at the American Center for Physics (ACP) in College Park, Maryland. The Career and Occupational Mentoring for the Professional Advancement of Science Students (COMPASS) Faculty Workshop paired up 30 early to mid-career faculty members from institutions around the country. In 10 sessions over three days, attendees received guidance on career mentoring, promoting professional development, and changing departmental culture at their respective institutions.

Crystal Bailey, APS Head of Career Programs, spoke at the first session about the importance of being an effective career mentor. She emphasized the need for mentors to consider industry options when guiding students towards future careers. Physics education researcher and Rutgers University professor Geraldine Cochrane presented on culturally-aware mentoring to address equity and inclusion within the physical sciences.

Other speakers and the participating Cottrell Scholars at the COMPASS workshop (sites.trinity.edu/compass/2019-workshop/) challenged attendees to research the current professional development opportunities available to their students and concepts to improve these programs at their respective universities.

APS and ACS provided logistics support to the conference by finding expert speakers, while APS hosted the workshop at ACP and funding came from RCSA. The workshop was an effort organized by the Cottrell Scholar Collaborative, a program instituted by RCSA for early career faculty members in chemistry, physics, and astronomy to promote innovation in teaching at a university level.

He received the 1982 Nobel Prize in physics for this work, with the deceptively simple citation, “for his theory for critical phenomena in connection with phase transitions.”

He applied a similar approach to his work on the relatively new discipline of quantum field theory, which was plagued by mathematical infinities at the time. His new technique resolved these issues. His ideas were also crucial to the development of quantum chromodynamics, notably his concept of lattice gauge theory, imaging space as an interconnected lattice of bars, in which every intersection represents a point in space-time. According to Paul Ginsparg, who was mentored by Wilson at Cornell, Wilson was far ahead of his physics colleagues when it came to computing and networks, largely out of frustration. “After inventing lattice gauge theory in 1974, he found he didn’t have adequate computing power to solve the theory numerically, so he wanted easy ways to use large numbers of parallel processors,” Ginsparg wrote in a memoir. Wilson was involved with the building of five national supercomputing supercenters by the National Science Foundation. In 1985, Cornell named him as director for its new Center for Theory and Simulation in Science and Engineering (now known as the Cornell Theory Center).

Later in his career, he and Alison moved to Ohio State University, where she had been hired to run its supercomputer center. (Wilson joked that he was the “spousal hire.”) There, he turned his efforts toward improving education. He was an early champion of the “active involvement” approach to physics teaching, which he called “something as simple as ice melting or water boiling but worrying about publish or perish.”

Wilson’s experience with the renormalization group as a graduate student ended up having a profound influence on his work with phase transitions and critical points. The variation of the fundamental properties of particles and forces depended on the scale over which they were measured, and Wilson realized that this scaling was also crucial for phase transitions. He showed that it was possible to divide the problem up into many smaller, simpler pieces, making it possible to describe was happening at the critical point of a system one scale at a time.

Wilson continued on page 3
John Hopfield and Eli Yablonovitch Named Benjamin Franklin Medalists

BY DAVID VOSS

Named Benjamin Franklin Medalists John Hopfield and Eli Yablonovitch have Ken Wilson to thank for this will break down and be replaced will continue working at arbitrarily of Wilson’s passing. “We don’t now regard nearly every quantum associated with lymphoma. 29 In addition, he has made a number of key contributions in solar cell and semiconductor laser research. He obtained his Bachelor in solid-state physics at Cornell University in 1954 and his PhD in 1958. He joined Bell Labs after completing his doctoral work, and while there, his attention turned to biology. In the 1970s he worked on error correction in genetics, and in the 1980s began researching neural networks and storage of memory in the brain. Hopfield served as President of APS in 2006. His medallion citation reads “For applied concepts of theoretical physics to provide new insights on important biological questions in various areas, including brain science and genetics, with significant impact on machine learning, an area of computer science.” Yablonovitch, professor of electrical engineering at Berkeley, is widely known for his work in optics and lasers. He obtained his Bachelor of Science from Mccill University in Montreal in 1967 and his PhD at Harvard in 1971. While at Bell Laboratories in the 1970s, he was a pioneer in the field of photonic crystal nanostructured materials that exhibit photonic bandgaps. In addition, he has made a number of key contributions in solar cell and semiconductor laser research.

WILSON CONTINUED FROM PAGE 2

died on Jun 15, 2013, just one week after turning 75, from complications associated with lymphoma. Wilson’s great legacy is that we now regard nearly every quantum associated with lymphoma, sometimes in response to laser light. Caltech physicist John Preskill wrote when news broke of Wilson’s passing. “We don’t dare to dream that the theory will continue working at arbitrarily short distances. At some stage it will break down and be replaced by a more fundamental description. More than anyone else, we have Ken Wilson to thank for this indispensable wisdom. Few ideas have changed physics so much.”

Further Reading:
Wilson, K. (1971) “Renormalization Group and Critical Phenomena II: Phase-Space Cell Analysis of the tiny robots inside the body is still a challenge, since the robots are powered by light. One way is to use more than a millimeter deep in tissue, they lose their power source. As a result, Miskin and his colleagues are working on alternative methods of powering the robots, such as magnetic fields.

Figuring out how to control these tiny robots inside the body is still a challenge, since the robots are powered by light. One way is to use more than a millimeter deep in tissue, they lose their power source. As a result, Miskin and his colleagues are working on alternative methods of powering the robots, such as magnetic fields. These robots could have other uses outside of biology too: Miskin is also interested in seeing how these robots could be used in conjunction with chemistry and material growth. Another of his colleagues is working on ways to use these tiny robots to scrub out poisons from lithium ion batteries to extend battery life.

The big advantage here is that they’re manufacturable and they’re cheap, they’re like a chemical, said Miskin. “And then you can start to treat them that way and really push the edge of the envelope.”

Future facilities will include KAGRA (Kamioka Gravitational Wave Detector) in Japan, designed to be the first underground gravitational wave observatory. Image: KONN UNIVERSITY OF TOKYO

APRIL MEETING
What Next for Gravitational Wave Detection?

BY SOPHIA CHEN

Since the day humans first directly detected a gravitational wave—September 14, 2015—Nobel Prizes have been doled out, the Laser Interferometer Gravitational-Wave Observatory (LIGO) researchers have upgraded their detectors twice, and they’ve confirmed ten more detections. The first generation of post-detection physics has also arrived. “I joined LIGO right after the first discovery,” says Maya Fishbach, a fourth-year graduate student at the University of Chicago, who presented her research at the APS April Meeting in Denver this year. She remembers her landmark moment—the first signals from a neutron star merger in August 2017—when she was “still a baby grad student.” The first in which electromagnetic observations from radio wave-lengths to gamma rays all came together to herald the new era of multi-messenger astronomy. Now, researchers can observe all magnetic and gravitational waves in tandem to study astrophysical events in richer detail than ever before. Coordinating largely online, the thousand-person collaboration sprouted to publish around a dozen papers in the month following the neutron star merger. “It’s really exciting, but also really exhausting to work with so many people,” says Fishbach. “I feel like I’ve aged so much.”

LIGO, working with its European counterpart, Virgo, has kept up the pace of cross-disciplinary analysis and scientific debate. The collaboration turned on their three gravitational wave observatories for a third observing run on April 1. Prior to this, they’d improved the sensitivity of their detectors—one in Livingston, Louisiana, one in Hanford, Washington, and one near Pisa, Italy—by 10 percent. By May 23, the detectors had already registered 13 more candidate signals. They are currently confirming the physics and light-gravitating objects for detections in a year-long observing run.

As the confirmed detections so far: 10 gravitational waves from binary black hole mergers and one gravitational wave from a binary neutron star merger. The candidate signals include 10 possible black hole mergers, two neutron star mergers, and two possible gravitational waves from a neutron star merger.

Cell-sized Robots Start to Explore the Microscopic World

BY LEAH POFFENBERGER

R obots have been created to explore the remote and harsh environments of the deep ocean and the sun’s surface. Now, Marc Miskin and his colleagues at Cornell have developed tiny robots that can explore new environments closer to home, including the human body, at the fundamental scale of biology—the cell. These cell-sized robots at their largest are the width of a human hair but can equip themselves with an arsenal of microelectronics for moving around and sensing their environment. From there, they can be guided by less than a cent. Miskin, now an associate professor at the University of Pennsylvania, presented results of his post-doctoral research involving the creation of these tiny tools at the 2019 APS March Meeting in Boston.

“They’re like a tiny one or like microorganisms. You can throw any individual robot away. And most importantly, all of this functionality is not at some arbitrary scale, but at the fundamental size of biology, the size of the cell.”

Thanks to their small size and tough constitutions, these robots are incredibly robust, allowing them to be injected into new and sometimes corrosive environments—including the body. Miskin is currently working on providing these robots with ways to adapt their environment, like voltimeters and thermometers, and ways for the robots to report back information about their world.

One of the applications we like most is neural recording and recording what’s going on inside the body,” said Miskin. “Let’s say you want to measure what’s going on with someone’s spinal cord—you don’t want to be poking around in there. It might be nicer to inject robots in your body and have them crawl over to that location.”

Figuring out how to control these robots no bigger than a cell biological cell are taking baby steps. Image: MARC MISKIN
Harassment in Physics

Blatant sexism in any professional area does experience an unhealthy deficiency in the human condition. Although scientists are more enlightened, we in the APS should expect a higher ethical standard from our members. I can only hope that the small statistical sample presented in the April 2019 Back Page feature is an aberration and not the norm.

As a PhD student and through a long career as a national laboratory scientist, I personally saw many contrary and very destructive examples. Hopefully, subsequent articles will expose the more positive interactions that current young female scientists had with their mentors.

Robert G. Lanier
Danville, California

The author of “Yes, Sexual Harassment Still Drives Women Out of Physics” (APS News, May 2019) presents a convincing case that the pervasiveness and inappropriateness of harassment of women is a blight on our profession, and needs to be addressed more seriously. Of the three types of this unwelcome behavior cited in the study, the first—‘sexist gender harassment,’ including disparaging remarks such as, “Women cannot do physics”—was mentioned by 93.3% of women reporting some form of sexual harassment.

This being the largest complaint by far, compels me to give an example that may subject that 93.3% figure to reconsideration. When I was graduate student, my advisor, Sathya Guruswamy, had just completed his class, but chose for a thesis advisor a different professor who saw promise in me. Years later, I received from the APS the Tom W. Bonner Prize for ‘outstanding experimental research in nuclear physics.’

So there is likely a component of that 93.3% that has naught to do with sexism. If you are a woman experiencing such treatment, consider that possibility. In any case, don’t let it derail your plans. If you know in your bones that physics is your destiny, make it so.

Michael Moe
Rancho Santa Fe, California

Thank you for publishing the April 2019 Back Page article “Goldwater Scholarship: Why It Matters.” I know APS could be concerned about publishing these sorts of negative reports, but I think the benefit of articles like this is quite substantial. I’m not a member of DNP but I can easily imagine this sort of behavior happens at the APS meetings I attend, and I hope that raising the awareness of these issues will result in improvements over the long term. So again, thank you for the courage to publish this.

Eric Weeks
Atlanta, Georgia

Congress Bolstering Its Access to S&T Expertise

By Jonathan Behrens

Congress has faced increasing pressure, from inside and outside the Beltway, to improve its ability to act on matters in which science and technology (S&T) play a critical role. To meet this demand, the House Appropriations Committee recently advanced legislation that would provide $6 million to reestablish the Office of Technology Assessment (OTA), a research group that provided S&T advice to Congress before it was defunded in 1995.

Meanwhile, the Government Accountability Office (GAO) is currently investigating its S&T analytic capabilities in response to separate legislation enacted last year. That legislation also asked the Congressional Research Service (CRS) to commission a study of other ways Congress could augment its advice channels, including by reestablishing OTA.

While the CRS study has not yet been released, the new legislation reflects the conviction of some House Democrats that the further step of restoring OTA is warranted. Whether the Republican-majority Senate will support the proposal remains to be seen.

GAO expanding S&T assessment team

Following the dissolution of OTA, GAO became a newly important source of S&T advice to Congress and has undertaken technology assessments in addition to its usual audits of federal S&T programs.

Earlier this year, GAO created a new Science, Technology Assessment, and Analytics (STAA) team that consolidated its S&T-related activities, and last month it released a plan for expanding the unit. GAO intends to increase the STAA staff from 49 to 70 by this October and have up to 140 employees in subsequent years, depending on the level of demand from Congress.

The head of GAO, Gene Dodaro, has said expanding the STAA team is a high priority for the agency. Acknowledging the options before Congress at a recent budget hearing, he remarked, “I know there’s been a debate in the past about whether to reestablish OTA or provide more resources to GAO. I’m here to assure you that we’re prepared, if you decide to go that way, to handle those additional responsibilities.”

OTA advocates seek ‘anticipatory’ advice

Congress established OTA in 1974 to serve as a source of nonpartisan S&T expertise. The office had about 150 staff and an annual budget of $68 million invested in these individuals' futures.

In 1989, the Goldwater Foundation (R-AZ), who served the United States for 56 years in the military and the Senate. Since 1989, the Goldwater Foundation has invested $68 million in these individuals for positions outside the military, and achieved results,” he said.

Haley’s application stood out both in her passion for high energy and her significant independence as a nuclear community. This year, 466 scholarships were given to college students nominated by 443 academic institutions in all fields. Most of these students are majoring in natural science, together with 24 engineering majors and 62 mathematics and computer science majors. This year, the Foundation chose 84 awardees as paid summer research experience in other fields. She had a better technical aspect of the application coordination their nominations.

Since high school, Bowden has known physics was her passion. Participating in the Science Olympiad for K-12 students, she enjoyed the physics portion of the competitions so much she wanted to study the subject even after the event.

Given her background, Bowden had no trouble completing the research portion of the Goldwater application. Involved in research for most of her summers, she participated in Eureka, a program at the Center for Science and Engineering Partnership at the University of California, Santa Barbara. She went on to UC LEADS, a network for her success. Her mom, a woman in STEM herself, encouraged her to “embrace math and science.” Her professors and department pushed her to explore a variety of physics topics.

This is not the first year Bowden applied to the Goldwater, however. Her most important advice was to ask professors to provide feedback when preparing the application. Reactions from those not in physics can be beneficial as well, since the technical aspects of the application need to be understood by those in other fields. She had a better understanding of how to improve her application in the second try, and it paid off.

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Haley Bowden
Jonathan Lu
Chris Moore

The Goldwater Scholarship was established in 1986 to honor the late Senator Barry Goldwater (R-AZ), who served the United States in the military and the Senate. Since 1989, the Goldwater Foundation has invested $68 million in these individuals for positions outside the military, and achieved results,” he said.

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Haley Bowden
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Goldwater Foundation Names its 2019 Scholars

By Pheobe Sharp

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n April 16, three distinguished researchers spoke at a plenary session marking the 90th anniversary of the founding of the APS journal Reviews of Modern Physics. The session was chaired by RMP Lead Editor Randall Kamien (University of Pennsylvania) and covered advances in laser-based particle accelerators, the search for dark matter, and the astrophysics of black holes.

Wim Leemans (DESY) discussed progress in building a new generation of particle accelerators in which electrons surf on plasma waves created by intense lasers. The technology has the potential for accelerating particles along tens of centimeters to energies that would require conventional accelerators that are hundreds of meters long.

Elena Aprile (Columbia University) reviewed the status of experimental searches for dark matter in underground laboratories. Although there have been no confirmed signs of dark matter to date, the highest sensitivities have been achieved with direct detection schemes based on interactions in large volumes of liquid xenon.

Andrea Ghez (UCLA) talked about the center of the Milky Way, which is known to contain a supermassive black hole. Thanks in part to a decade of observations with high resolution ground-based telescopes, videos of all three presentations are available on the APS YouTube channel: youtube.com/apphysphysics.

For the Goldwater application, Acree said the Foundation wants “to see that the person is a team player and can contribute to society,” two characteristics which Lu possesses. Lu struggled with condensing his aspirations into the word limit set by the application, but it helped him more concisely explain his goal. Acree recommends getting a wide variety of research experience when applying to the Goldwater Scholarship.

Lu hopes to get a PhD in bio-physics with a concentration in materials science.

Chris Moore - Chris Moore, a physics and astronomy major at the University of Washington (UW), comes to the Goldwater Scholarship with a diverse background. For nine years prior to college, Moore served as a U.S. Navy SEAL. Rising through the ranks to become an instructor, he knew he wanted to study science after his service, and physics was the perfect fit.

Serving in the Navy gave Moore a head-start in many of the skills that physics departments want their students to graduate with: leadership, networking, and ambition.

“Leadership is difficult to foster and something you have to learn,” he said. Coming to UW with well-developed leadership skills naturally led him to the Society of Physics Students (SPS), and eventually to becoming a leader within his SPS chapter.

For networking, Moore credits the Lunchbox Seminars, a series of workshops run by SPS for exposing him to cutting edge research in the physics community. This seminar series hosts a wide variety of leading scientists, Moore said. He noted that it’s also a great opportunity for practicing his elevator pitch, a useful tool when working to “support the intersection of science and society.”

Drive was the third key to Moore’s success. Physics majors have to be highly motivated, and receiving a Goldwater Scholarship was a national recognition of Moore’s effort. He started in cosmology, moved to condensed matter physics and now studies the dynamics of nitrogen vacancy centers in diamond. Moore is going to an REU (Research Experiences for Undergraduates) program at MIT this summer.

When considering his next steps after the Navy, he knew he wanted to “have a career impact.” Moore plans to get a PhD in condensed matter physics.

The author is the Education and Diversity Programs Coordinator at APS.
support the next generation of science students and researchers, then we can’t expect our fields to grow. Organizations like APS are instrumental in providing a platform for scientists to be heard.

“I am proud that I was able to work with other physicists to encourage our government to make smart investments in graduate education,” Sanchez said. “The scientific advancements made by academic research is dependent on a government that values science and scientists, and it’s important that we get out of our labs once in a while to meet with our representatives and make positive change in society.”

Don Q. Lamb, professor emeritus in the Department of Astronomy and Astrophysics at the University of Chicago, wrote about the importance of making the F-1 visa “dual intent,” enabling international students to simultaneously study and apply for citizenship in the United States.

“I was surprised and honored to hear that my award was granted. Receiving it means a great deal because addressing important issues that impact society is something I care deeply about. Members of APS and the APS Office of Government and Public Affairs play a critical role in advocating for policies the APS thinks are important.”

Scientists have an important role to play in advocating on science policy issues, explained Lamb. The challenges involving science in the House of Representatives and the world seem greater than ever. Scientists have a special understanding of the challenges. I feel, therefore, have a responsibility to share our knowledge and offer our expertise about policies and address them with the public and key decision makers.”

Sarit Dhar, associate professor of physics at Auburn University, also wrote an op-ed on the F-1 visa issue. “I was extremely delighted and honored,” she said about receiving the 5 Sigma Physicist Award.

“I am happy with my work on science policy advocacy, she said, “I believe having formal pathways for doing advocacy and being an effective community and policymakers is crucially important for prioritizing resource allocation and directions of science and technology research to meet the demands of the socioeconomic and security needs of our country’s future.”

Kristian Corwin, former physics professor at Kansas State University, was elated to be honored for her advocacy roles as a participant in the APS Congressional Visits Day and author of an op-ed on the link between science and the workforce. “I very much enjoyed my visit to Capitol Hill with fellow physicists to explain the importance of certain key issues to the offices of both my senators and my congressmen at the time. The conversations were both challenging and stimulating, and I would encourage others to participate in Capitol Hill visits,” she said. “Afterward, I prepared an op-ed on the importance of educating new scientists from a young age, and I very much appreciate the help and support I was given by my colleagues at Kansas State University and APS in navigating that process.”

Corwin added, “I have recently become a federal employee, with less opportunity for advocacy. However, I encourage APS members to contact their elected representatives and take advantage of the opportunities for advocacy available to them.”

Julia Phillips, retired vice president and chief technology officer at Sandia National Laboratories, was a co-author of an op-ed outlining recommendations in the report, “Neutrons for the Nation,” a study by the APS Panel on Public Affairs. In addition, she participated in key meetings to promote the report. “I was surprised and honored,” said Phillips. “I do things because I think they are important, and the recognition is an unexpected but much-appreciated bonus.”

As for why Phillips believes advocacy is important, she said: “Neal Lane, President Clinton’s science advisor, spoke frequently and eloquently about the need for all of us to be ‘citizen scientists.’ By that, he meant that we all need to engage with the public and policymakers in constructive ways – both talking about our work and its importance, and really listening to hear the questions and concerns of those who come from different backgrounds. Neal’s call to action really resonated with me, and I have long tried to engage with policymakers and the public to explain what my colleagues and I do, and why they should care about it. Engaging with non-scientists is a great opportunity to think about what we all do in a new way and to share the beauty, excitement and importance of our work.”

Elliott Kapit, associate professor at the Colorado School of Mines, met with the science staffer from the office of Senator Cory Gardner (R-CO) to ensure that key language was included in the National Quantum Initiative Act (NQI), which was signed into law by President Trump last year.

“I’m very honored to receive the award! I was happy to help the APS work with Senator Gardner’s office (which was very receptive and helpful) to ensure that the National Quantum Initiative Act was properly structured to best fund quantum technology research without cutting support for other areas,” said Kapit.

He added, “I think science policy advocacy is vital, because almost definitely, new research is strange and complex, and its purpose and importance are generally not at all obvious to people without advanced degrees or training. So, if we as physicists don’t make the effort to explain in plain English what we’re doing and why it’s interesting and valuable, then we can’t expect anyone to care, much less want to support our work.”

Ivan Deutsch, a physics and astronomy professor at the University of New Mexico, also played a role in ensuring that the language in the NQI was appropriate. He met with staffers in the office of Senator Tom Udall (D-NM).

“Honestly, it was an amazing surprise. I never expected that the small part I played in working with the American Physical Society to get the National Quantum Initiative ‘right’ would be directly recognized. I was doing what I thought necessary to ensure that the NQI would best benefit all of the physics community. I know that there are many others who have been tireless in their efforts to whom we owe a debt of gratitude.”

Science policy is important, he added, because “as we all see, science is becoming increasingly politicized. Only scientists can provide the necessary perspective to policymakers to ensure that key goals of discovery and innovation are carried out in a way that benefits all of society.”

Francis Slakey, APS chief government affairs officer, said the award recipients were excellent partners with APS OGA in advocating for key science policy issues.

“The 5 Sigma Physicist award winners are representative of the best in science, and we are thankful that they volunteered their time and expertise to advance science policy goals. We congratulate them on a job well done and look forward to working with them and many other APS members in the future,” said Slakey.

The author is APS Senior Press Secretary.
First Black Hole Image: In A Nutshell

By Sophia Chen

On April 10, 2019, the Event Horizon Telescope collaboration (eventhori-zontlescope.org) released the first direct image of a black hole. This black hole rotates almost directly face-on: its angular momentum vector points into the page at an angle of 17 degrees, counterclockwise. That is, the black hole rotates in the clockwise direction. The researchers infer its orientation from the position of a jet that appears in X-ray images of the area and from models they have built and tested.

Notable features: The light comes from gas, predominantly hydrogen, which orbits the black hole and emits radio waves. The bright ring of light is the so-called photon orbit, where gravity is so strong that nothing or no light can escape. The closed paths around the black hole are

Researcher refer to the boundary between the ring of light and the interior darkness as the black hole. Researchers refer to the boundary between the ring of light and the interior darkness as the black hole.

The data can also reveal more about the life and death of stars.

“[A]n important piece of this puzzle is the nature of black holes at the center of these systems,” says Fishbach. “Most black holes are at the center of galaxies, and the way those galaxies form and evolve is closely tied to the black hole at the center.” Moreover, the existence of black holes at the center of galaxies has implications for our understanding of the universe. The data from these observations can help us to better understand the behavior of black holes and the role they play in the formation and evolution of galaxies.

Why does it look like a donut?

The gas is actually evenly distributed around the black hole. However, optical effects cause some parts of the gas to appear brighter and makes the donut shape. The gas is being affected by relativistic beaming, or Doppler boosting, which causes light from some parts of the gas to appear brighter and makes the donut brighter on one side.

The author is a freelance science writer based in Tucson, Arizona.
The Workshop and the World

BY ROBERT P. CREASE

But it’s real for us! It’s real for us! Doesn’t matter what the muggles say, it’s real for us! —Lauren Fairweather

In our hundred years ago, Francis Bacon had a terrific idea. Let’s stop learning about nature accidentally. Each country needs to establish laboratories for people to investigate nature systematically. The labs can collaborate, and countries can use the findings to govern better. This will make human life, and the fortunes of the countries, flourish. Inspired by this vision, began to train and support science, and have now built up what is in effect a global scientific workshop.

What went wrong? In the past few years in particular, more blatantly than ever, politicians and others are confident they can ignore the findings of the workshop.

Lauren Fairweather’s song “It’s Real for Us” is about how a song is love for the magical world of Harry Potter helps her cope with a world she finds difficult and alien. Substituting magic for what’s real sometimes helps individuals pursue their desires and dreams. Turn this upside down, however, and you get the current science denial worldview of many politicians, though without Fairweather’s self-conscious innys. Whether they actually believe in the magical world or are spinning things to get votes does not matter; what matters is that their substitution of myths and cherry-picked or fake facts works for them and their voters.

Denouncing, conducting exposés, and doing epistemology have little effect. Denouncing science denial leaves intact the social and political atmosphere that fosters it. Exposing is ignorable and can be portrayed as tainted. Conducting epistemology, proclaiming something like “Science works!” and showering people with facts and data about how great science is, preaches to the converted and comes off as abstract and abstract. One has to start by understanding what makes the social and political atmosphere in which science denial takes place flourish, and what can be done about it.

Some of the features that make science work are that it is a collective enterprise, technical and abstract, fallible, affects nature, can be passed on and communicated; and that its tools can cut to the chase in a way that speaks truth to power. To design-making be guided by facts rather than ideology or financial interest.” That’s reasonable and open-ended, because those who let gut instinct, ideology, class, or personal interest determine how the world works do not act in the public and national interest.

Another tactic is to show how science deniers betray the very values they profess. Galileo was a master at this, citing church authorities and doctrine in defense of his work. The point of the Bible, he said, is “to teach us how one goes to heaven, not how one goes green.”

A modern-day Galileo on Fox News might say something like, “The Founding Fathers taught us how to create legislation, not to legislate Creation.”

Here’s an even more incendiary comparison: Science—denying politicians are like the Islamic State militants who bulldoze archaeological treasures and smash statues. Both believe that they are motivated by higher authority and that mainstream culture threatens their beliefs, and want to destroy the means by which that mainstream culture survives and flourishes. If anything, the ISIS militants are more honest, for they openly admit that their motive is faith and ideology while Washington’s cultural vandalism do not. It’s disingenuous, prevents honest discussion of the issues, and falsely discredits and damages American institutions. Is comparing science—denying politicians to ISIS militants really over the top? When the North Carolina state legislators forbade incorporating scientific findings into state policies by state law, it damaged the ability of the state’s officials to protect its coastline, its resources, and its citizens; it prevented other officials from fulfilling their duty to advise and protect innocent citizens against threats to life and property. At debates and press conferences, such politicians should be asked: “Explain the moral difference between ISIS militants who attack cultural treasures and politicians who attack the scientific process.” How they respond will reveal much about their values and integrity.

Another tactic is to use comedy and ridicule. Comedians have an ability to cut to the chase in a way that speaks truth to power, having a license to be inappropriate. A Doonesbury cartoon strip once featured an “honors” science denier interviewed on a radio talk show. “I don’t oppose sound climate policy because it’s flawed,” he says. “I oppose it because I care more much about my short-term economic interests than the future of the dumb planet. Hello?” Humor contributes to what the American philosopher C. S. Peirce called “the social impulse” that destroys “enactacy,” or the urge to cling to select beliefs, by drawing listeners into a wider and wider space in which the presence of more factors comes into play. In Max Weber’s terms, such humor illus-

trates in detail that science deniers are adopting the “ethics of conviction” as opposed to the “ethics of responsibility.”

Another strategy is to tell parables. A parable, like an Aesop’s fable, is a real or fictional story with a built-in, easily graspable lesson. Most people learn more easily through stories than data. Jews and Enemy of the People, which expose the all-too-rational calculus of science denial, are good examples. We need twenty-first-century Aesops to tell more dramatic stories of what happens when we wish away sharks.

Did you hear the one about the person who was convinced, not altogether wrongly, that the medical establishment was corrupt, and decided he was the only person who could fix it? “Make America Healthy Again!” was his slogan. His campaign to be the next person in charge succeeded. His solution was to get rid of medical and lab tests, destroy thermometers for taking temperature and stethoscopes for listening to heartbeats. The people ended up worse off but happier, convinced they were in good hands.

Yet another strategy is to prosecute science deniers. In 2013, US Senator Sheldon Whitehouse of Rhode Island proposed that organizations bankrolling campaigns of climate science disinformation should be investigated for racketeering, a fraudulent activity that includes conspiracy to deceive the public about such things as risk. Such laws have been successfully used to prosecute tobacco companies for misleading the public about health hazards. What’s the difference between enacting the public by hiding evidence that smoking is hazardous, and endangering the public by concealing evidence of climate change? The crime is like shouting “Stay put! Everything’s OK!” in a burning store so that people carry on shopping. This is a crime of concealing of free speech? Or is being misleading and deceptive about serious hazards a crime?

Such short-term tactics can discourage lazy and ideological thinking, curb the human appetite for fake assertions, and entice citizens to look past private interests and to regain an appreciation for the natural world. They increase damaging consequences for magical thinking in an environment that encourages it. These tactics will not eradicate science denial, but doing all of them all the time may help discourage politi-

cians who practice it from getting elected.

More long-term strategies are also needed to fight science denial. By far the most important one is to tell the story of how we got into this situation. The early promoters of science, including Bacon, Galileo, Descartes and others, also encountered science denial, and had to forge ways of countering it. Most instances of science denial are simply recycled versions of what they encountered, and we can learn much from how they responded. Furthermore, science denial arises because of the way our traditions developed. We didn’t get in this position from out of nowhere, but only thanks to how our traditions developed. Only by reviewing how the authority of the scientific workshop was promoted, defending some under attack and responded can we have an idea of how to go forward today.

“The most people learn more easily through stories than data. Jaws and Enemy of the People, which expose the all-too-rational calculus of science denial, are good examples. We need twenty-first-century Aesops to tell more dramatic stories of what happens when we wish away sharks.”

Why is this person comfortable?” IMAGE: DELICTA KAMIS

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