High-Precision Map of the Universe Defies Conventional Cosmology

Analysis of the most precise three-dimensional map of the universe delivers hints of a tension with the standard model of cosmology.

BY DAVID EHRENSTEIN

A
alysis of a new high-precision map of millions of galaxies hints at a conflict with the standard model of cosmology known as the lambda cold dark matter model, or ΛCDM. Last week, at the APS April Meeting in Sacramento, California, the Dark Energy Spectroscopic Instrument (DESI) collaboration reported that their results favor a model in which dark energy — the force accelerating the expansion of the universe — has properties that change with time.

Researchers have previously proposed versions of dark energy that conflict with ΛCDM’s assumption of fixed properties, but the new results are the best indication so far that dark energy’s properties change with time.

Earth is shown at the center of this slice of DESI’s full 3D map of the universe. The magnified section reveals the underlying structure of matter, like galaxies. Credit: Claus Luegmann/DESI collaboration; custom color palette by researchers.

From Mudskippers to Jellyfish, Aquatic Animals Inspire Robot Designs

For the APS March Meeting, early-career scientists shared their work on waterborne fauna.

BY SOPHIA CHEN

Fish, water-hopping bugs, and jellyfish may traditionally be the purview of biologists, but this year’s March Meeting in Minneapolis featured plenty of research on aquatic animals, particularly their locomotion. Intensive, collegial collaborations aim to incorporate these findings into designs for more effective robots. Here are a few projects that piqued our interest.

Jellyfish cyborgs

Simon Anuszczyk, an aeronautics engineering graduate student at Caltech, and his adviser, Caltech engineer John Debitis, have developed an electronic system that affixes to real jellyfish and makes them swim faster. That’s right: They created a jellyfish cyborg.

Jellyfish move by contracting their umbrella-shaped bell, propelling water in the opposite direction. The Caltech team’s device, a dome-shaped “hat,” delivers small electric pulses to the animal’s bell, causing the jellyfish to contract with higher-than-normal frequency. The stimulus allowed the jellyfish to swim 4.5 times faster than their natural speed of about one centimeter per second.

So far, the team has run tests on a previous version of the biohybrid jellyfish in the ocean. For this model, they use two tests in a tank six meters deep and plan to study it in the ocean.

The group chose jellyfish because they are “the most efficient animal in the world,” says Anuszczyk, in terms of energy consumption per distance traveled per mass. Jellyfish also live in every ocean and can swim to great depths.

This makes them useful picks for the team’s ultimate goal: to deploy jellyfish for undersea applications. For example, only a quarter of the ocean floor has been mapped with modern, high-resolution technology. If the team’s devices were equipped with special sensors, jellyfish could collect data in previously unexplored parts of the ocean, or help monitor the effects of climate change.

“We might study the carbon cycle or ocean acidification by attaching a pH sensor onto the jellyfish,” says Anuszczyk.

The group worked with bioethicists while designing their cyborg. Jellyfish lack a centralized nervous system and pain receptors, Anuszczyk says. And in their experiments, they found that the jellyfish did not release mucus, a typical stress response, and healed from any damage within 24 hours of the device being removed.

Children and grown-ups of all ages enjoyed Squishy Science Sunday, including the author’s kids (Credit: Left: Andrew & Celeste; center: right:96-2003-2).

March Meeting Brings Squishy Science to Minneapolis Families

An afternoon of physics — and, well, cotton candy.

BY KENDRA REDMOND

Cries of “Ew!” and “Slimy!” aren’t the responses most APS meeting presenters hope to receive, but Squishy Science Sunday volunteers accepted the feedback with a grin. Throughout the four-hour public outreach event, kids of all ages poked and prodded, squished and mixed, and played and created while exploring the softer side of physics.

The most overheard utterance? “That’s so cool!”

A publication of the American Physical Society

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Bold history. Bright future.

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March Meeting Sites

in 7 Countries

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People Want to Help Us: Ukrainian Student Attends March Meeting

With an APS travel grant, Polina Kofman joined 13,000 physicists in Minneapolis.

By Liz Bozman

Theoretical physicist Polina Kofman might be drawn to the “peculiar and exotic,” but some things she does the old-fashioned way. “I prefer to write equations on paper, old style,” she says. For trickier work, she turns to Wolfram Mathematica or Python.

Lately, she’s been using these tools to study the peculiar and exotic world of qubits, the most basic units of information in a quantum computer. When experimenting with a qubit, a physicist is manipulating “a quantum wave function in one system” — in this case, “ground and excited,” she says. “It’s quite a hot topic right now.”

Her story is important to share, “for Ukrainians to see they are not alone,” Kofman says — that “people want to help us.”

Kofman, whose research today focuses on the interaction of qubits with graphene, recently presented her work at the 2024 APS March Meeting in Minneapolis, Minnesota. Although she arrived from Portugal, Kofman is a Ukrainian graduate student, hoping to someday return to her home country to contribute to the scientific community.

Kofman can’t study directly but everyone knows the impetus for the lofty task. Less than six weeks earlier, the UN secretary general had fired Astin after he stood by the bureau’s scientific findings in the face of opposing political interests. Outraged, hundreds of bureau staff threatened to quit alongside him, and he was temporarily — and later permanently — reinstated.

The episode capped a yearslong back-and-forth between the science agency and the bullheaded seller of a disproven product. It also forced the American public to grapple with a vital question: To which principles were U.S. government scientists beholden?

The saga had begun five years earlier, with a small, red packet of AD-X2.

In 1947, a charismatic California businessman named Jess Ritchie began selling a car battery additive, dubbed “AD-X2.” With lead in short supply in the years after World War II, Ritchie claimed that his powder could double or triple a lead-acid car battery’s life.

But scientists at the National Bureau of Standards had already studied AD-X2 nearly 20 years earlier. “These materials do not charge storage batteries,” a 1931 notice from the bureau read, “nor do they materially improve the performance of storage batteries.”

For Ritchie, the notice was a problem. So in April 1948, he asked the bureau to exempt AD-X2 from the notice. The bureau, having already studied the issue, declined. But Ritchie had customers in powerful positions. Later that year, the Better Business Bureau and a U.S. senator from California climbed into the ring, asking the bureau to test AD-X2.

Already testing another additive, bureau scientists added AD-X2 to the lineup. The results were the same: The powder, a mix of sodium and magnesium sulfates, had no measurable impact on battery performance, which the bureau reported in a new notice.

Ritchie responded in protest, organizing a letter-writing campaign among his supporters. By early 1952, multiple federal agencies and a congressional committee had all requested new tests on AD-X2, and 29 members of Congress had contacted the bureau.

As the episode wrapped up, political leaders were being removed from public, making headlines in The Washington Post and The New York Times. The press pitted Ritchie, the self-made man, against the Gehlert govt. trying to squash him. Public sympathy fell on Ritchie’s side, making headlines in The New York Times.

Astin didn’t say it directly, but Astin remained quiet, trusting the bureau’s integrity. “Tonight, I plan to speak as the physicist,” he said, “and attempt to explain why I and the other members of the organization believe in the bureau and the importance of its operation to the national welfare and security.”

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Astin’s testimony
Satellite Events Connect Physicists Around the World to the March Meeting

Sites in seven countries expanded opportunities to participate and collaborate.

BY MCKENZIE PRILLAMAN

The Philippines was home to one of seven satellite sites in Asia, Africa, and South America that held an event for the local physics community with support from APS. These events were organized in the Philippines, India, South Africa, and the United States, and they strengthen APS's partnerships abroad, according to Michelle Irvine, the se- nior international programs manager at APS.

The COVID-19 pandemic, which curbed travel and in-person gatherings for many, first sparked the idea for satellite events. “We want- ed to give people an opportunity to be involved in the March Meeting without having to necessarily trav- el,” Irvine says.

The 2022 March Meeting, the first post-pandemic satellite event, had four satellite sites. That number nearly doubled this year, with sites in Hong Kong, Wellington, New Zealand, Kuala Lumpur, Malaysia, Pakistan, Jordan, and Hong Kong. Each local event looked different.

In the Philippines, Franco and her co-organizer Thoreen Soldevil-la arranged a virtual session to introduce UPPA and give two early-career scientists an opportunity to present their undergraduate re- search. “It’s a way for us undergrad students to demonstrate our skills,” says Soldevilla, an undergraduate in physics at the University of the Philip- pines Diliman and external affiliate at UPPA.

In early May, the duo will hold a watch party of some virtual sessions from the March Meeting, with local physicists present to help ex- plain the science — as part of UPPA’s annual Physics Month events, which aim to make physics more accessible to the public.

Meanwhile, the three-day, in-person satellite event in Jordan, attended by 100 researchers from a dozen institutions gathered to watch live-streamed sessions during the March Meeting, says organizer Gihan Kamel, a principal scientist at the Synchrotron-light for Experi- mental Science and Applications in the Middle East (SEASEM). “I was the highlight of the local meeting was a virtual session that spotlighted women in physics.”

“I’ve been the only woman scien- tist at SEASEM for something like nine years now,” Kamel says. While another woman recently joined the institution as a researcher, Middle Eastern women face many con- straints from family, tradition, cul- ture, and religion, Kamel notes.

But Kamel recognizes that the gender gap in science is an issue worldwide. So she invited women from across the globe, all of whom have ties to SEASEM, to discuss their professional paths and re- search. “They have different perspec- tives and different work set-ups and dif- culties,” Kamel says. “But at the end, we are all sharing the same prob- lem.” This is the second year Kamel has mobilized directly against this political matter in order to pre- vent the event from being canceled or cut, as has been the tradition in the hands of certain bureaucrats,” she says. “It’s a wonder they are in existence at all af- ter five years of struggle.”

For many scientists, the news of Astin’s firing was deeply unsettling. Enrico Fer- mi, then president of APS, as- sembled several meetings to gather in- formations and, with support from APS, the council decided to act. Their argument was that Astin’s firing is dangerous to APS and to physicists in general in this political matter in order to pre- serve our apolitical stance,” says John- son Martin, a professor of University science historian. APS began work on a statement.

The Federation of Atomic Sci- entists, the Washington Academy of Sciences, the International Electro- chemical Federation, and other organ- izations and individual scientists did the same, calling out the dangers of politically charged issues in the physics community. Nearly 400 bureau sci- entists said they would leave alongside Astin before the APS executive office holi- bited the bureau’s work.

When the press caught wind of the firing and the backlash from the science community, the press narrative did not stick, Astin, not Ramesh, became the victim — a civil servant of integrity refusing to bow to political pressure. “The tides have turned,” says Martin. In response to what limes magazine at the time called “the ensuing bula- balo of scientific outrage and threat- ened resignations,” Weeks temper- ously reinstated Astin and agreed to let the National Academy of Sciences review the AD-X2 tests and have the final word.

On May 3, the APS Council ap- proved a forceful statement. “It is the duty of a scientist to investigate scien- tific and technical problems by open- ly stated objective methods without shading his conclusions under politi- cal or other pressures,” it read. “On this principle the progress of science depends. We have never doubted that the work of the bureau of Standards has been conducted in this spirit.”

That same day, Astin delivered his speech to APS attendees, outlining the bureau’s values and thank- ing APS and others for their support.

“We are sincerely grateful,” he said.

In the fall of 1953, a Nation- al Academy of Sciences report upheld the bureau’s work without any findings of fraud or mis- deba. The APS executive office, recognizing the need to separate science from politics, appointed a new permanent director.

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Ritchie, Weeks maintained, was the hapless victim of a biased firestorm that led to the resignation of Martin on March 24 and announced on March 31, 2022, by a Sen- ate committee hearing on the matter. Ritchie’s company “has lost severance at the hands of certain bureaucrats,” Weeks testified. “It is a wonder they are in existence at all af- ter five years of struggle.”

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And people did come — several hundred of them. Twin Cities families, and some had yet to see a kindergarten classroom, but that didn’t dampen their enthusiasm. “This is directly up his alley,” said Beth Degner Riveros told her nine-year-old. “It’s a great day for science.”

Among the most energetic attendees had to be a physics class, and some had yet to see a kindergarten classroom, but that didn’t dampen their enthusiasm. “This is directly up his alley,” said Beth Degner Riveros, watching her four-year-old try to make “sushi” out of Rice Krispie treats. “He loves making lightbulb moments were the most rewarding part of the experience,” Volunteer Bharath Venkatesh, a postdoc at the University of California, Santa Barbara, loved seeing attendees express their curiosity and ingenuity while playing with magic sand. “Kids have been coming up with experiments,” he said.

Six APS units brought Squishy Science to life with the support of APS and several sponsors. More than 100 APS members kicked off their meeting experience by volunteering, and Tewari hopes the event will become a March Meeting tradition.

“It’s really important for us as a community of scientists to engage with the public,” Tewari said. “Not only to inform the public about what we do, but also to let them know that we care about the connection of the world and that the things we are doing will have a direct impact on the lives of everyday people.”

As the event drew to a close, Sarah Degner Riveros told her nine-year-old they’d have to head home. He’d been racing from table to table for four hours, returning again and again to his favorite static-making “sushi” out of Rice Krispie Treats topped with homemade bento boxes — and even offering to teach other kids the activity. “Today was really fun,” he said. His mother agreed. “I think he might have found his thing.”

Kendra Redmond is a writer based in Minnesota.
Iranian Revolution, while Mohammadi was a child, the newly formed Islamic Republic imprisoned, tortured, and executed members of her extended family. “My childhood dreams were cruelly shattered,” she wrote in a message to the Norwegian Nobel Committee in October 2023.

Despite their suffering, her family remained loyal and optimistic and supported her studies. Mohammadi told Time magazine in a rare interview from prison in November 2023.

Quantum physics fascinated Mohammadi. She studied applied physics as an undergraduate at Imam Khomeini International University and had planned to pursue a physics doctorate, but she fell in love with the support to rights of women and students and report on the injustices plaguing Iran. “Human rights were, for me, as necessary as breathing to stay alive,” she told Time.

Upon graduation, Mohammadi worked as an engineer and continued speaking out against the oppression of women, vulnerable minorities, and prisoners of conscience; the violence and other human rights abuses, as a journalist and leader in organizations such as the Defenders of Human Rights Center in Iran. As a result, she lost her job and has been arrested 13 times, convicted five times, fined, burned from seeing her children, sentenced to 53 lashes and 31 years in prison, and subjected to solitary confinement.

In 2018, Mohammadi received the APS Andrei Sakharov Prize in recognition of her campaign for peace, justice, and the abolition of the death penalty in Iran, and for promoting human rights and freedom despite persecution. The citation also acknowledged the forces of scientists. “It was with joy when studying quantum physics at the university as a means to understand the universe,” she recalled in an acceptance speech sent from prison.

In her interview with Time, Mohammadi reflected on what a life free from persecution may have been like: “I always think that if I had been born in a European or American country and had a different life experience, I could have been an active physicist in a university or laboratory who would also advocate for human rights and peace.”

That’s exactly what we should be doing, said Joel Lebowitz, a Rutgers University physicist and mathematician who survived Auschwitz during the Holocaust.

“We, or most of us at least, are neither imprisoned nor exiled, but are free and live comfortable lives,” Lebowitz told the audience in a pre-recorded video. “It’s our duty not to be silent and forget about those who are suffering, either from the abuse of human rights or for more for their struggle for human rights.”

In another pre-recorded talk, Iranian cosmologist Enesl Mohamad highlighted the “dark aspects” of scientific pursuits that can go unaddressed — barriers erected by gender, race, nationality, and religion and, in some places, even by compositions of sanctions and restrictions on scientific collaborations, lack of academic freedom, and disregard for ethical considerations in science. “It is crucial to acknowledge the complex and challenging roles of sci- entific endeavors,” Erfani told attend- ees. “As scientists, we must embrace our collective responsibility to up- hold academic freedom, support at- risk scholars, and foster a scientific community that transcends borders and champions inclusivity.”

She spoke from experience. Erfani was an assistant professor at the Institute for Advanced Studies in Basic Sciences in Iran from 2013 until she resigned in 2022, following the death of Mahsa Ami- ni, a 22-year-old woman who died in custody of the Iranian morality police. Erfani now lives in exile in Germany, her academic future un- certain.

In light of the abuses taking place around the world, Lebowitz urged physicists around the world to “create institutions that defend the human rights of sci- entists and scholars and help those in need.” Even if an organiza- tion can only write letters of protest, those letters “are absolutely essential for knowing to the spirits of people like Mohammadi,” Lebow- itz told attendees.

APS has already sent a letter to Iran’s Minister of Justice calling for Mohammadi’s release and signifying that its community of 50,000 scientists stands with her, itsaky.

In a Nobel lecture, smuggled out from Tehran’s Evin prison and delivered by her children Kiama and Ali Rahmani in December 2023, Mohammadi wrote, “With hope and eagerness, and alongside the resilient and courageous women and men of Iran, I extend my hand to all forces, movements, and individuals that are fighting for the liberation of women, vulnerable minori- ties, and alongside the resilient and courageous women and men of Iran, I extend my hand to all forces, movements, and individuals that are fighting for the liberation of women, vulnerable minorities, and on democracy.”

Kordt Rdmial is a writer based in Minnesota.

Satellite Sites continued from page 3

has organized a satellite event in Jordan.

Brazil, too, hosted a March Meet- ing satellite site for the second year in a row. “It brings people together from São Paulo and greater São Paulo — to come not just to participate in the APS meeting, but also to talk to each other and collaborate,” says organiz- er Nathan Berkovits, professor at the Institute for Theoretical Physics at São Paulo State University and director of ICTP South American Institute for Fundamental Research.

The daylong event, which wel- comed around 30 people, featured in-person presentations by students and postdocs and a virtual session where speakers discussed their re- search.

But hosting an event abroad does present challenges. For in- stance, it’s hard to get people who are watching a session online to be engaged and ask questions. Berkovits says he proposes hosting a joint virtual session where some talks take place at the satellite site and others occur at the main March Meeting site in the U.S.

The event’s hybrid nature also created some difficulties with en- gagement for the two-day event in Cameroon, says organizer Paul Woofo, professor of physics at the University of Yaoundé I and founder of the Cameroon Physical Society. Still, five physicists from the country presented research at an applied nonlinear dynamics virtual session at a virtual session, and more than 40 researchers, many of whom were students, attended an in-person component.

Overall, the satellite event organ- izers say they were excited to col- laborate with APS, and Irwin feels the same way. “We have lots of con- nections and colleagues all around the world,” she says. These satellite sites are “something that’s very sim- ple where we can work together.”

McKinnon Pitman is a science writer based in Washington, D.C.

Satellite Sites continued from page 1

DES1 has founded at KEK and National Observatory in Atsibara. Credits: Marilyn Chung/

DES1 continued from page 1

far that those ideas may be on the rescue.” The research collabo- ration with AMDM lacks the statistical significance to claim a discovery, so the team is cautious about its importance until they have more data. But other ex- perts are expecting theorists to im- mediately begin proposing revisions of ACWM. “I think it’s pretty exciting that they see evidence for something be- yond standard ACWM,” says cosmol- ogist Rocky Balu of the University of Chicago. “We have a standard model that we’ve very proud of, and every- one wants to break it to see what’s behind it, and perhaps this is the first indication of it unraveling.”

DES1 was designed to measure the properties of dark energy by mapping the cosmos with unprece- dented precision. The instrument is installed on a telescope on Kitt Peak, Arizona, and can collect simultaneous measurements from two robotically positioned optical fibers, which will allow tens of millions of astromon- istic targets to be observed over five years. The first year’s worth of data, which were the basis for the new research, spanned a quantitative analysis of 10 years’ worth of data from its predecessors, the BOSS and EBOSS surveys, says one of the spokespersons for the DESI collabo- ration, Kyle Dawson of the Universi- ty of Minnesota.

DESI measures the past 11 bil- lion years of the universe’s expan- sion thanks to a “standard ruler,” imprinted in the universe as a characteristic scale of the clustering of galaxies. The standard ruler was fixed in the ear- liest universe, when sound waves pro- pelled from regions with higher-than-av- erage matter density that served as seeds for the formation of galaxies, leading to a preferred separation between pairs of galaxies. By mea- sureing galaxy separations at various times throughout cosmic history, researchers can determine how the expansion of the universe stretched the apparent size of the standard ruler. This preferred galaxy separa- tion for distant galaxies is “a very, very faint signal,” Dawson says. “And that’s why we need so many galaxies to be able to test it out.”

DESI mapped galaxies and quas- sars with unprecedented detail, cre- ating the largest three-dimensional map of the universe ever made. This effort marks the first measurement of the expansion history for the pe- riod of 8-11 billion years with a precision of better than 1%, provid- ing a powerful way to study dark en- ergy. With just its first year of data, DESI has surpassed all previous three-dimensional spectroscopic surveys combined and has confirmed the basics of the ACWM model.

Comparing the evolution of the angular ruler size with predictions of the ACWM model, the DESI team finds agreement. Specifically, the ra- tio of the density of the universe’s dark energy, called w, comes out to the predicted value of -1. But when we try to use precision to allow w to vary over cosmic history, the DESI data favor this modifi- cation, although the error bars still overlap with the constant w theory. When performing a combined anal- ysis of their data with previous mea- surements of the cosmic microwave background (CMB) — data that are generally consistent with the DESI data — the researchers find that the error bars no longer overlap. The analysis favors a time-dependent w at a statistical significance of 2.6 sigma, which is close to the 3 sigma needed to claim “evidence” for such a result. This significance stays the same or grows up to 3.9 sigma when the team combines these data with any of three previous supernov- a-based cosmology data sets.

The collaboration also reported several other cosmological parameters, including the Hubble constant and the current expansion rate of the universe. One of the biggest cosmic- logical mysteries is the disagree- ment among measurements from probes that measure the “early” universe — such as those based on the Big Bang’s ripples — and those derived from measure- ments that probe the “late” universe — such as those based on gauging the distances to supernovae used as “standard candles.” The value ob- tained from these methods has been between 67 and 68.5 kilometers per second per megaparsec (km/s/Mpc), while DESI measures 71.4 kilometers per second per megaparsec (km/s/Mpc).

“DESI’s results confirm this discrepan- cy,” Kob said on the ACWM model hypothesis, cosmologists have been trying to understand the value of the cosmological constant (the un- changing dark energy) — which comes from and how it relates to other physical constants. “And we have not been successful understand- ing that,” he says. But if the DESI re- sults hold up, “we’re probably at a constant that we don’t understand for some dynamics that we don’t understand... And as a physicist, dy- namics is something that we’re growing up trying to explain,” he says. “I can’t wait to think about it.”

“This is the most holistic and comprehen- sive challenge to ACWM. We’re able to really test what’s been assumed for the last 20 years,” Daw- son says. He says the collaboration finished the data collection for the 3 year data set on March 31 and will be analyzing those data as rapidly as possible. He hopes that the increased precision will bring researchers closer to understanding the discrepan- cies with the ACWM model. “It’s re- ally motivating us,” he says.

David Ehrenstein is a Senior Editor for APS’s Physics Magazine, from which this is republished.
That’s Not Physics

Where do the boundaries of physics begin and end? The debate has persisted for more than a century, 

BY ANDREW ZANGWILL

If you've been in physics long enough, you've probably left a colleague or posters that make you yourself, "That talk was interesting, but it wasn't physics." It is likely that many physicists who muse about the boundaries of their field, perhaps with colleagues over lunch, usually it's all in good fun.

But what if the issue comes up when you're trying to make decisions about hiring or promoting individuals to build, expand, or even dismantle physics departments? The boundaries of a discipline bear directly on the opportunities departmental personnel can offer students. They also influence those students' evolving identities as physicists, and how they think about their own professional futures and the future of physics.

So, these debates — or physics and "not physics" — are important. But they are also not new. For more than a century, physicists have been drawing and redrawing the borders around the field, embracing and rejecting subfields along the way.

A key moment for "not physics" occurred in 1899 at the second-annual meeting of the American Physical Society. In his keynote address, the APS president Henry Rowland exhorted his colleagues to "cultivate the idea of the dignity of physics."

"Much of the intellect of the country is still wasted on the pursuit of so-called practical science which ministers to our physical needs," he scolded. "[and] not to investigations that are so-called 'academic' but not 'not respectable' to describe how acoustics research is not physics as a discipline.

Not all disciplines have had such clean paths in or out of physics. Consider the case of biophysics, or biological physics — where physicists apply their methods to the study of living systems. Whether or not this field is physics or "not physics" has vexed the community for a century. In 1920, the physics department at Harvard boldly hired an assistant professor named William Bowie to conduct research and teach courses in biophysics. Bowie did not get tenure, and the Harvard physics department did not hire another assistant professor in this area until 2013.

In 1959, the National Academy of Sciences charged the American Physics community with analyzing itself to help the government establish funding priorities. The resulting 1990-page report devoted only 20 pages to what it called "physics in biology." Tenured appointments for younger people working in biophysics "have been very scarce," it noted. "Among the reasons for this scarcity are the difficulty evaluating their work in a physics department and questions about the appropriateness of such work in a physics department."

This is why, in 2000, only 20% of Ph.D.-granting institutions employed at least one physics professor in the field of biophysics.

In 2010, the number of U.S. physics departments had biophysics groups with more than two full-time members, and three of those groups boasted a record of continuous funding and publication beginning before 1965.

Since 2000, the advent of conferences and federal funding devoted to biological physics convinced a growing number of physics departments to accept it as a legitimate and existing subfield of physics. On the other hand, several prominent U.S. physics departments remain physics-free in 2024. It appears the field is one in which a junior or two must be convinced before a unanimous verdict can be announced. Perhaps the path of each field — acoustics, cosmology, and biological physics — toward physics or "not physics" seems unique. But all three are remarkable stories of fields that could be told about virtually every other subfield of physics. To hear the tale of another discipline, simply question its suitability as a part of physics. The next time you share a meal with someone who's archetypes of stories that could be told about virtually every other subfield of physics. The next time you share a meal with someone who's archetypes of stories that could be told about virtually every other subfield of physics.

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