particle — the one that carries away the mass difference between the two superpartners — is large enough. But a very light particle could escape unobserved.

The trouble is that models that include two superpartners with similar masses also tend to predict that the Universe should contain a much larger amount of dark matter than astronomers observe. So an extra mechanism would be needed — one that can reduce the amount of predicted dark matter. This adds complexity to the theory.

Meanwhile, physicists have uncovered more hints that muons behave oddly. An experiment at the LHC, called LHCb, has found tentative evidence that muons occur significantly less often than electrons as the breakdown products of certain heavier particles called B mesons[2]. According to the standard model, muons are supposed to be identical to electrons in every way except for their mass, which is 207 times larger. As a consequence, B mesons should produce electrons and muons at nearly equal rates.

Other options

The task of explaining Muon $g-2$'s results becomes even harder when researchers try to concoct a theory that fits both those findings and the LHCb results. In particular, the supersymmetry model that explains Muon $g-2$ and dark matter would do nothing for LHCb.

Some solutions that could fit both do exist. One is the leptoquark — a hypothetical particle that could have the ability to transform a quark into either a muon or an electron (which are both examples of a lepton). Leptoquarks could resurrect an attempt made by physicists in the 1970s to achieve a 'grand unification' of particle physics, showing that its three fundamental forces — strong, weak and electromagnetic — are all aspects of the same force.

Most of the grand-unification schemes of that era failed experimental tests, and the surviving leptoquark models have become more complicated — but they still have their fans. "Leptoquarks could solve another big mystery: why different families of particles have such different masses," says Gino Isidori, a theoretician at the University of Zurich in Switzerland.

There is one other major contender that might reconcile both the LHCb and Muon $g-2$ discrepancies. It is a particle called the Z′ boson, because of its similarity to the Z boson, which carries the 'weak force' responsible for nuclear decay. Both leptoquarks and the Z′ boson have an advantage, says Ben Allanach, a theorist at the University of Cambridge, UK: they have not been completely ruled out by the LHC.

The LHC is currently undergoing an upgrade, but it will start to smash protons together again in April 2022. The coming data could strengthen the muon anomalies and perhaps provide hints of long-sought new particles. Meanwhile, beginning next year, Muon $g-2$ will release further measurements. Once it's known more precisely, the size of the discrepancy between muon magnetism and theory could itself rule out some explanations and point to others.

Unless, that is, the discrepancies disappear and the standard model wins again. A recent recalculation of the standard model's prediction for muon magnetism[3] gave a value much closer to the experimental result. So far, those who have bet against the standard model have always lost, which makes physicists cautious. "We are — maybe — at the beginning of a new era," Stöckinger says.

1. Abi, B. *et al. Phys. Rev. Lett.* **126**, 141801 (2021).
2. LHCb Collaboration *et al.* Preprint at https://arxiv.org/abs/2103.11769 (2021).
3. Borsanyi, Sz. *et al. Nature* **593**, 51–55 (2021).

US NATIONAL SCIENCE FOUNDATION SET FOR A FUNDING BOOM

But some worry the proposed budget boost will change the agency's scientific mission.

By Ariana Remmel

US officials are discussing whether the National Science Foundation (NSF) — which funds about 25% of all basic academic research in the country — should get a historic budget boost, potentially changing the US science landscape. During congressional hearings last month, legislators evaluated proposals that would increase the agency's funding by as much as US$100 billion over about five years. Any of these, if passed, would represent one of the largest increases for the NSF since it launched nearly 70 years ago.

A big cash influx for the NSF, which supports basic research and development in the science, technology, engineering and mathematics (STEM) workforce, could help to fortify the country's status as a global leader in innovation — at a time when US officials are worried that it's losing ground to other nations. In particular, China has invested aggressively in research and development at a rate that might soon surpass the United States' own research and development funding levels. In 2019, China's patent office received more than twice as many applications as its US counterpart did.

"I've never been as optimistic that, finally, the National Science budget will be significantly increased."

"It is not an overstatement to say that we are already losing leadership," says Rita Colwell, a microbiologist at the University of Maryland, College Park, who led the NSF from 1998 to 2004. "If we don't invest significantly in basic research and technology-transfer capabilities, we will find ourselves far below leadership in the years ahead."

The administration of President Joe Biden, the US Senate and the US House of Representatives have each put forward a slightly different vision for expanding the NSF, although each of their proposals agrees that the agency should invest in emerging technologies and assist in their commercialization. That suggestion has made some researchers nervous about losing funding for basic research — a core priority for the NSF since its inception. As US legislators debate the merits of the proposals and converge on a final plan, one thing is certain: big changes are on the horizon for the NSF.

A boost for basic science

"The National Science Foundation budget should have been substantially increased long before now," says Colwell. Since its launch in 1950, the agency has seen its budget steadily plod towards its current level of $8.5 billion. By comparison, the National Institutes of Health (NIH) — the country's top science funding agency for biomedical research — received $42.9 billion this year.

The NIH's budget more than doubled between 1990 and 2003, and during this time it was able to fund roughly 30% of the grant proposals it received (that proportion has since dropped to around 20%). Members of the scientific community say that boost was responsible for significant achievements in US science. "The mRNA vaccines are a product of doubling our investment in the NIH," said Sudip Parikh, chief executive of the American Association for the Advancement of Science, at a presentation to the National Press Club last month. The NIH

funded two research projects in 2002 that laid some of the foundation for today's highly effective mRNA-based COVID-19 vaccines (K. Karikó *et al. Immunity* **23**, 165–175; 2005).

US officials hope that a big budget boost (see 'Slow and steady') for the NSF could similarly yield breakthroughs. With its current budget, the NSF funds only 20% of grant applicants each year, even though 30% of proposals are rated highly meritorious by review panels, said NSF director Sethuraman Panchanathan during the Senate appropriations hearing on 13 April.

"My worry is that when we leave behind these ideas, somebody else picks up on" them — namely, global competitors, said Panchanathan. To properly support all the highly meritorious applications would require a doubling of the NSF budget at least, he explained.

From bench to market

What's badly needed, officials say, are more mechanisms for translating basic research into commercial technology. So all three proposals include money to create a technology directorate at the NSF.

The Biden administration's infrastructure plan proposed a $50-billion infusion of cash for the NSF, with a focus on funding research and development for emerging technologies. The Senate's Endless Frontier Act would increase the agency's budget to $100 billion over five years to support a new technology directorate. And members of the House proposed the National Science Foundation for the Future Act, which would increase the budget to $18.3 billion by 2026, and create a much smaller technology initiative called the Directorate for Science and Engineering Solutions.

Not everyone is in favour of building such a directorate at the NSF, however. Critics, including legislators in US states with national laboratories, worry that it would duplicate existing government efforts. At the Senate appropriations hearing, senator Joe Manchin pointed out that the US Department of Energy (DoE) already supports work at national laboratories involving technologies, such as quantum computing and artificial intelligence, that are highlighted in the Endless Frontier Act. Manchin, a West Virginia Democrat, chairs the Senate committee that oversees the DoE. He said that tasking the NSF with a greater responsibility for developing innovative technologies might just "reinvent the wheel".

In his testimony, Panchanathan assured legislators that the new directorate would partner with initiatives at the DoE and other federal agencies, while also capitalizing on existing areas of expertise at the NSF.

Far from diminishing the importance of basic research, a technology directorate could "add a dimension" to the NSF mission, says Neal Lane, a science-policy researcher at Rice University in Houston, Texas, who served as NSF director from 1993 to 1998.

Still, researchers worry that the rapid expansion of technology-focused initiatives at the NSF might eclipse its primary focus on basic science — a mission unique to the NSF among federal agencies. Paul Hanle, former president of the climate-science research group Climate Central, says the NSF's investments in fundamental research need to be carefully safeguarded so that the new technology focus does not "gobble up resources and push inquiry-based science into the sidelines".

Given that the three proposals are similar, change at the NSF seems inevitable, says Christopher Hill, a science and technology-policy researcher at George Mason University in Arlington, Virginia. But, he says, a cash infusion alone won't lead to technological innovations. For this initiative to be successful in the long term, he adds, the NSF might have to undergo a cultural shift that would reflect its broadened focus.

During the congressional hearings, some legislators expressed concern that a marked boost in NSF funding would not be distributed equitably. For instance, they pointed out that more than one-quarter of NSF funds in 2020 went to just three US states: California, Massachusetts and New York.

Members of the science community are also concerned that an influx of funding will draw more graduate students and postdocs, who won't be able to find jobs if the budget later tightens. This happened after the NIH's budget stagnated following its boom.

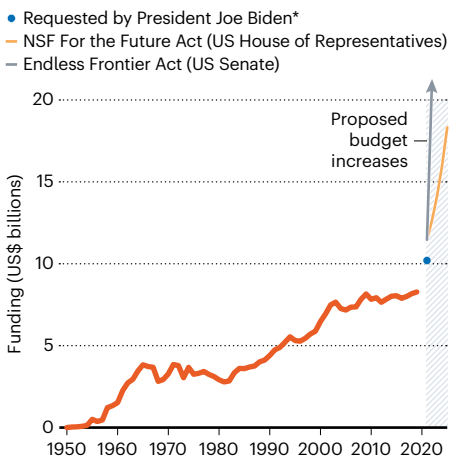
Still, proponents of a budget boost hope that it could help to address a lack of diversity in the STEM workforce.

For now, Congress continues to iron out the details, with the goal of arriving at a single plan. The Senate has introduced a new draft of the Endless Frontier Act, with updated language to address the broad perspectives presented in the hearings.

"I've never been as optimistic that, finally, the National Science budget will be significantly increased," says Lane.

SLOW AND STEADY

Since its launch in 1950, the US National Science Foundation has experienced only gradual changes in its budget. Now it stands to gain a massive funding boost if any of the proposals under consideration are adopted.



Years are fiscal years, and funding is in constant 2020 dollars to adjust for inflation. Data exclude the $3 billion given to the NSF in 2009 through the American Recovery and Reinvestment Act. *Excludes $50 billion requested by Biden with no time frame specified.

KEY COVID RESEARCH HIT BY CUT TO UK FOREIGN-AID BUDGET

Britain's scientists buffeted by uncertainty as pandemic's economic fallout shrinks project funds.

By Holly Else

Bitter and angry are the words that epidemiologist Oliver Pybus uses to describe his feelings when he opened an e-mail from his university's research-services department this month. The e-mail told him that funding for one of his research projects would be cut by one-quarter. It was the second such notification that he had received in 2021. The first listed a 70% cut to another project.

Pybus, who is at the University of Oxford, UK, is part of one of the world's leading teams working on identifying and tracking new variants of the SARS-CoV-2 coronavirus. The latest cut to his team's funding will affect a surveillance project in Brazil, where COVID-19 infections, some caused by fast-spreading variants, are surging (see page 15). Both cuts are the result of reductions that the UK government made last year to its foreign-aid budget, some of which funds research.

"There can't be many more important scientific projects today than this," says Pybus. He and his team are tracking the genomic changes in the SARS-CoV-2 virus, and have so far identified significant variants of concern. "We have