in Livingston, Louisiana, and Hanford, Washington. He was the first person to be alerted to a strong signal produced by the detector, but only by that at the Hanford site.

With his team leader, Chad Hanna, also at Pennsylvania State, and other colleagues, they identified that the signal looked like a textbook example of the waveform of the gravitational waves emitted by two compact objects, each slightly more massive than the Sun, as they spiral into each other.

When they looked at the data stream coming from Livingston, the LIGO researchers found a similar signal, but one with a loud, spurious glitch towards the end. It was that anomaly that had caused the real-time-analysis software at Livingston to ignore the signal, says David Shoemaker, a physicist at the Massachusetts Institute of Technology in Cambridge who is LIGO's spokesperson.

Meanwhile, researchers received another alert: Fermi had detected a short γ-ray burst that had occurred 1.7 seconds after the gravitational waves had ended.

In Italy, another technical glitch had suspended the stream of data normally sent out by Virgo. So it took another 40 minutes for researchers to realize that they, too, had a signal — albeit a faint one. The LIGO–Virgo team then notified roughly 70 teams of astronomers who were on standby to look for related events using conventional telescopes.

Four and a half hours later, the LIGO–Virgo team sent a second, much more useful alert. The timing of Virgo's feeble signal had been sufficient for the researchers to identify the source of the waves. They zeroed in on a region spanning an angle of just a few degrees in the southern sky.

Together, the alerts from LIGO–Virgo and Fermi sent astronomers into a frenzied rush. Each team wanted to be first to spot the fireworks produced by a neutron-star merger. It was daytime on most of the world's land mass, so the teams began to formulate strategies for their nocturnal observations. The region to search was not far from the Sun, which left a window of observation of just a couple of hours after dusk, before the region of sky would set below the horizon.

"We had a complicated, choreographed dance of telescopes that night," says Iair Arcavi, an astrophysicist at the University of California, Santa Barbara, whose team made non-stop observations using the Las Cumbres Observatory, a worldwide network of robotic telescopes. It began by activating a number of telescopes in Chile.

"We had a complicated, choreographed dance of telescopes that night."

Charles Kilpatrick, an astronomer at the University of California, Santa Cruz, may have been the first person to see the event. He was part of a team that was scanning the sky with the one-metre Swope Telescope in Chile. Like his competitors, Kilpatrick was closely watching the exposures one by one as they came out, comparing them with earlier images of the same patch of sky. By the ninth exposure, he saw something conspicuous in a galaxy called NGC 4993.

The group at the University of California, Santa Cruz, was also the first to measure the optical spectrum of the object. On the first night, the dot was bright blue, says astronomer Ryan Foley. But during the next few nights, the object became more red.

The switch in colour was just what would be expected from the collision of two neutron stars, says Brian Metzger a theoretical astrophysicist at Columbia University in New York City. Such events should spread debris — a mix of neutrons and some protons — in three ways. First, they fling matter from their outer layers during their final spiral inward. Then some matter gets squeezed out in the actual collision. Finally, as the two stars begin to collapse into a black hole, the debris forms an accretion disk of matter, some of which flies out instead of falling in.

Metzger's models suggest that nuclei formed early on would reach the masses of many of the elements beyond iron in the periodic table, although not the heaviest ones. This chemical composition would cause the cloud to glow blue.

The signatures of the formation of the heaviest elements, including gold and platinum, would be a cloud that glowed in the red and infrared. These would be elements forged in a separate wave of the explosion, probably the one coming from the accretion disk, says Metzger.

Eleonora Troja, an astronomer at NASA Goddard Space Flight Center in Greenbelt, Maryland, was in one of the first teams to use the Hubble Space Telescope to view the event. "The spectra were phenomenal," she says, and almost indistinguishable from the predictions. "You could clearly see the fingerprints of the metals that had formed."

"The idea that all this stuff has happened, it's too much. It is just hard to process," says Daniel Holz at the University of Chicago in Illinois. "It's unreasonable that we have done so much with just one event of its kind." ■

POLICY

Japan faces science decline

Researchers decry budget cuts and other changes that undermine basic science.

BY NICKY PHILLIPS

As Japan heads towards a national election on 22 October, scientific leaders worry that the outcome will do little to address long-standing concerns about the country's deteriorating research landscape. They say that a decline in funding and a shift away from basic research has undermined Japan's capacity to compete against both established scientific powerhouses and emerging ones such as China.

Since 25 September, when Prime Minister Shinzo Abe called for a snap election, science has barely featured in the campaign. Debate has focused on the government's plan to amend the constitution and increase taxes. The latest polls suggest that Abe's conservative Liberal Democratic Party could lose some seats, but will retain enough to lead a coalition government.

If Abe is re-elected, he says, his government will pursue an innovation agenda. At a meeting of global science leaders in Kyoto on 1 October, Abe reaffirmed his pledge to turn Japan into "a cradle of innovation" by cutting regulations that impede new technologies.

Despite Abe's lofty ambitions, the ruling party coalition has decreased the science and technology budget by more than 5% overall since it came to power in 2012. And the budget for universities has dropped by about 1% a year for a decade. "This has been pointed out as the major cause of the deterioration of research performance and, eventually, the global rank of Japanese universities," says Takashi Onishi, president of Toyohashi University of Technology and a former president of the Science Council of Japan, which advises the government. In the past two decades, the country's share of highly cited papers has stagnated, whereas those of many other leading nations are rising, according to publisher Elsevier's Scopus database.

In an attempt to elevate Japan's top research

universities, the government has introduced reforms that categorize institutions according to their research or teaching focus, and that allocate funding on the basis of performance. The government wants leading research institutions to compete globally for the best students and faculty.

Atsushi Sunami, a science-policy specialist at the National Graduate Institute for Policy Studies (GRIPS) in Tokyo, agrees with this aim, but says that to succeed, the government will need to increase its research funding. And money alone will not be enough, says Hiroshi Nagano, also a science-policy specialist at GRIPS. For universities to become world class, they need autonomy to decide their research and teaching focus, he says. "The current policy is oriented in the opposite direction."

BASIC RESEARCH LEFT BEHIND

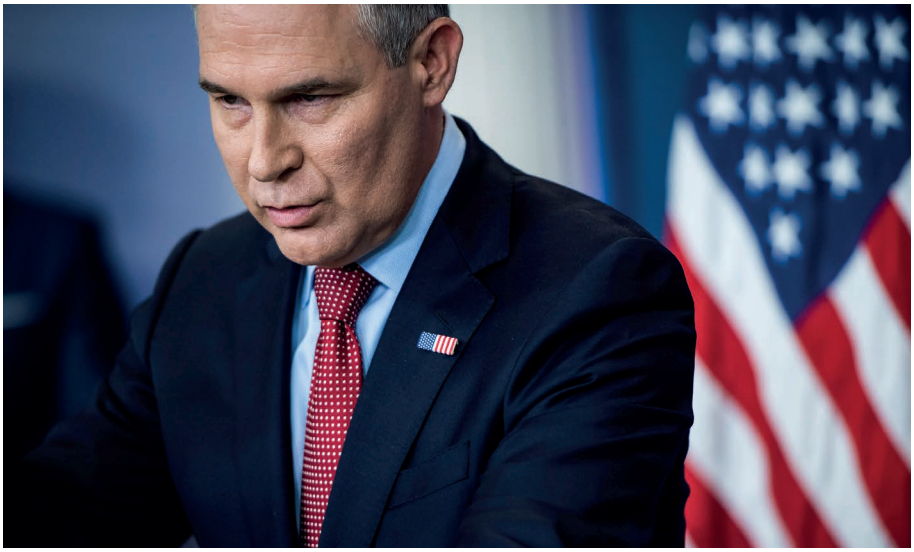
Changes to the university system implemented by Abe's government are designed to make academia more responsive to the needs of society and industry, in the hope that it will boost low private-sector investment in research. Although scientists broadly encourage this increased collaboration, some say that it has compromised support for basic research. "The government should focus on the development of basic research to supply seeds or ideas to applied sciences," says Onishi.

Science leaders point to other big concerns about the future of Japanese research. Michinari Hamaguchi, head of the Japan Science and Technology Agency in Tokyo, says that the domestic workforce will be insufficient to keep up with changes in science, technology and innovation, given the country's rapidly ageing population. He says that policies are urgently needed to encourage more women and foreigners into science and to boost the number of students in doctoral courses, which has dropped by 18% since 2003.

"The government should focus on basic research to supply seeds or ideas to applied sciences."

Students who pursue research careers are finding it harder to get jobs. Budget cuts have depleted permanent research positions at universities, and fewer younger researchers are securing permanent posts: the number of research associates on short-term contracts more than doubled from 2007 to 2013.

Biologist and 2016 Nobel prizewinner Yoshinori Ohsumi has warned that the situation for young researchers will jeopardize the country's chances of winning future Nobel prizes. Japan has the second-highest number of science laureates in the twenty-first century after the United States — but, Ohsumi says, that record is unlikely to hold. ■



JABIN BOTSFORD/*THE WASHINGTON POST*/GETTY

EPA administrator Scott Pruitt has questioned his agency's authority to curb greenhouse-gas emissions.

CLIMATE CHANGE

US agency moves to revoke emissions limits

Environmental Protection Agency disavows power-plant rule.

BY JEFF TOLLEFSON

The US Environmental Protection Agency (EPA) is moving to repeal former president Barack Obama's landmark regulations to reduce greenhouse-gas emissions from power plants.

The agency's proposal, introduced on 10 October, is a step towards fulfilling President Donald Trump's promise to end the "war on coal". But the repeal plan, which faces a lengthy review process, is certain to spark lawsuits from environmental groups and many states that support Obama's climate policies.

US emissions from electricity generation have been falling in recent years as energy companies have shifted away from coal, and towards cheap natural gas and renewables. The Obama-era power-plant rule is designed to accelerate that trend, by reducing greenhouse-gas emissions to 32% below 2005 levels by 2030.

The policy was made possible by the Supreme Court's decision in 2007 that carbon dioxide and other greenhouse gases are pollutants under the terms of the Clean Air Act. Two years later, the EPA ruled that these gases are a threat to human health and the environment. This allowed the agency to draft regulations to limit greenhouse-gas emissions.

Still, the Obama power-plant rules have been mired in legal challenges. In 2016, the US Supreme Court blocked the rule from taking effect until the resolution of a lawsuit brought against the EPA by industry groups and 27 state governments. That case is on hold while the Trump administration reviews the rule.

The legal fight over the EPA's plan to repeal the Obama power-plant regulations will probably focus on whether the Clean Air Act allows the agency to require that companies alter their energy portfolios to reduce emissions. The Obama administration set emissions limits and allowed states and companies to decide how to meet them, with options that included reducing energy consumption and developing new sources of renewable energy.

The Trump administration says that the EPA overstepped its legal authority when it finalized the rule. The administration argues that the Clean Air Act allows only regulations that can be implemented at power plants.

Jonathan Adler, who heads the Center for Business Law and Regulation at Case Western Reserve University School of Law in Cleveland, Ohio, says the Trump administration can reasonably argue that the Clean Air Act was not designed to regulate greenhouse gases. He adds that courts often defer to federal agencies on regulatory matters if they have followed all legal and procedural requirements.

"Some of the same legal doctrines that helped the Obama administration defend its regulatory decisions will now help the Trump administration," Adler says. ■

CORRECTION

The News story ‘Japan faces science decline’ (*Nature* **550,** 310–311; 2017) misspelt the name of the head of the Japan Science and Technology Agency. His name is Michinari Hamaguchi. Also, he is based in Tokyo, not in Kawaguchi.