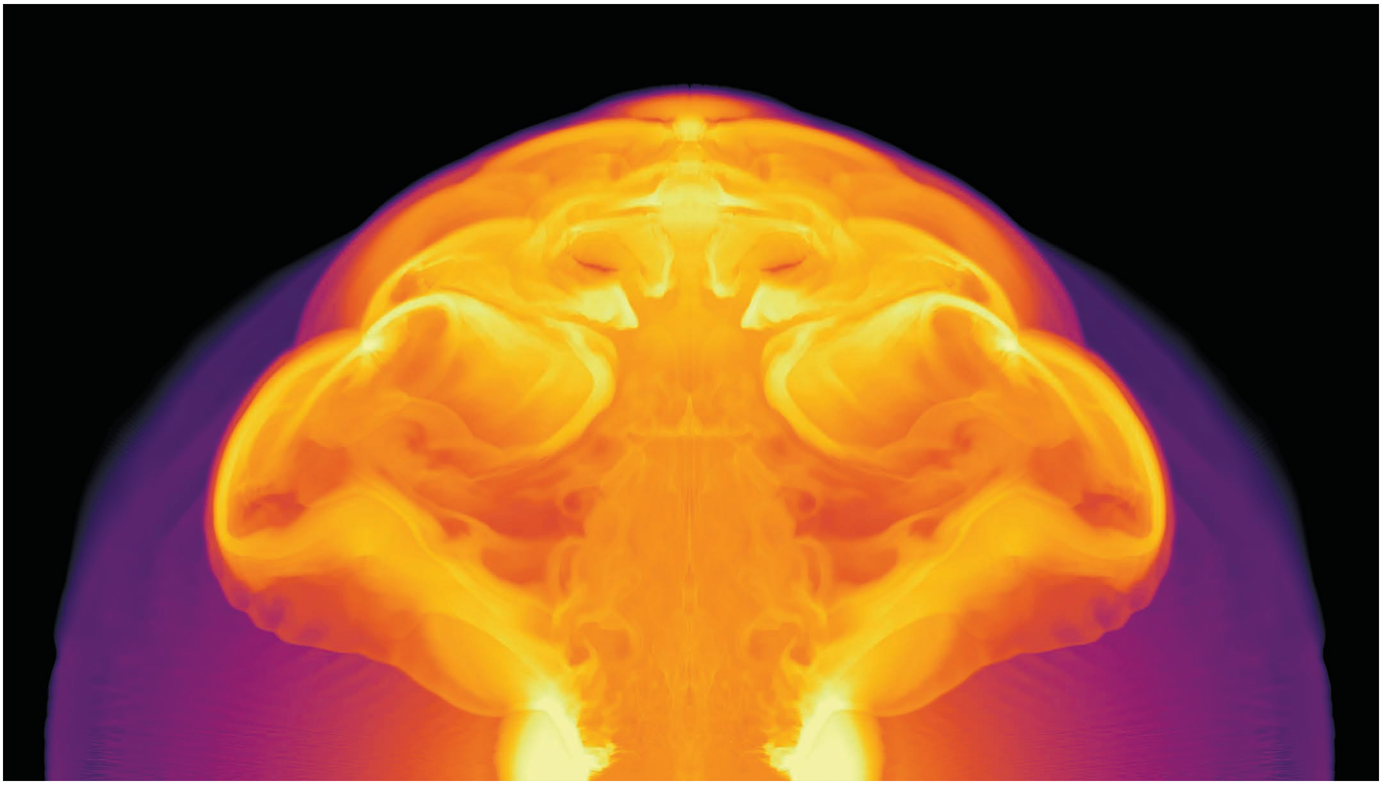
NEWS IN FOCUS

JAPAN Coming election highlights stresses on scientific community **p.310**

METROLOGY Plans to redefine scientific units are picking up speed **p.312**

MEDICINE US panel supports new gene-therapy technique **p.314**

DEMOGRAPHICS How digital technologies are shaping the workforce **p.316**



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Signatures of gold and platinum were seen after the collision of two small but very dense stars.

ASTROPHYSICS

Stellar crash delivers thrills

Gravitational waves trigger frenzied hunt that helps to answer mysteries of periodic table.

BY DAVIDE CASTELVECCHI

In the biggest astronomical hunt ever mounted, 70 teams of astronomers have for the first time detected the cataclysmic collision of two neutron stars — some of the densest objects in the Universe. The recordings of that crash help to solve several cosmic mysteries, and they confirm theories that neutron-star mergers are the ultimate source of gold, platinum and many rare-earth elements, according to astronomers who announced the findings on 16 October.

The collision was felt first on 17 August as a space-time tremor by the Laser Interferometer Gravitational-wave Observatory (LIGO) in the United States and by its Italy-based counterpart Virgo. Less than 2 seconds later, NASA's Fermi Gamma-ray Space Telescope detected a smattering of high-energy photons from roughly the same patch of sky.

That confluence of observations was the first time that researchers have simultaneously recorded gravitational waves and light from the same event.

Alerted by the LIGO–Virgo team, astronomers then raced to find and study what was seen as a bright object in the sky using telescopes big and small, famous and obscure, on land and in orbit, and spanning the spectrum of electromagnetic radiation, from radio waves to X-rays.

"In terms of the intensity of observations, I don't think there's been anything like this before," says Edo Berger, an astronomer at Harvard University in Cambridge, Massachusetts, who was part of the hunt. The discoveries have been reported in more than 30 papers published in 5 journals.

Cody Messick was at his home at 08:41 local time (12:41 UT) on 17 August when he first found out about the event. "I remember standing on my stairs and looking at my phone, thinking: 'Wow!" he says. Messick, who is a physicist at Pennsylvania State University in University Park, belongs to a small team of LIGO first-responders who work on the two interferometers, which are based ▸

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