But an analysis by *Nature* using the Dimensions database from London-based Digital Science suggests that links between Chinese and US scientists are more prevalent than the Hoover report indicated. (Digital Science is part of Holtzbrinck, the majority shareholder in *Nature*'s publisher, Springer Nature). The analysis found more than 12,000 publications from 2015 to 2019 that had been co-authored by scientists in the United States and at one of the Seven Sons. Among those, 499 authors had a dual affiliation with a US institution and a Seven Sons university and were listed on papers declaring grant funding from the NIH or the US National Science Foundation.

But separating true threats from ordinary collaborations could be a challenge, some experts say. It has not been unusual for Chinese researchers with appointments in the military to visit the United States and work on non-classified projects, says Denis Simon, senior adviser to the president at Duke University in Durham, North Carolina. Simon led the Duke Kunshan University in China as vice-chancellor until July this year. "To assume a comprehensive conspiracy is too far from the reality," he says.

In general, universities do not have rules that bar scientists with affiliations to the foreign military from working with university researchers. But in the absence of nuanced federal guidelines, institutions might well be forced to take a fresh look at these collaborations.

"There is no longer any status quo to go back to," says Farnsworth.

Additional reporting by RIchard van Noorden.

# ASTRONOMERS DETECT 'MINDBOGGLING' BLACK-HOLE COLLISION

## Gravitational waves suggest merging black holes fell into 'forbidden' range of masses.

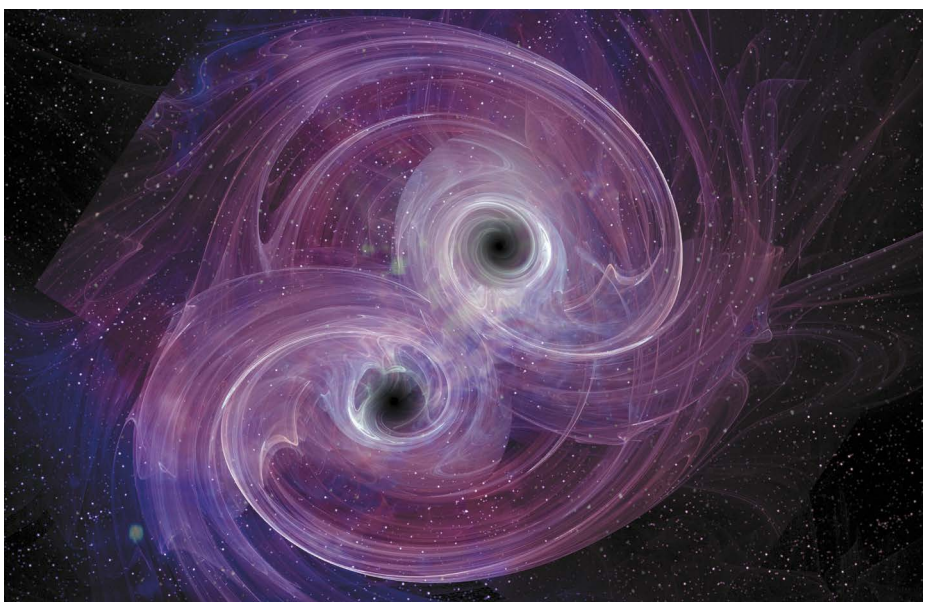
**By Davide Castelvecchi**

Astronomers have detected the most powerful, most distant and most perplexing collision of black holes yet, using gravitational waves. Of the two behemoths that fused when the Universe was half its current age, at least one — weighing 85 times as much as the Sun — has a mass that was thought to be too large to be involved in such an event. And the merger produced a black hole of nearly 150 solar masses, the researchers estimated, putting it in a range where no black holes had ever been conclusively seen before.

"Everything about this discovery is mindboggling," says Simon Portegies Zwart, a computational astrophysicist at Leiden University in the Netherlands. In particular, he says, the formation of the 150 solar mass black hole confirms the existence of 'intermediate mass' black holes: objects much more massive than a typical star, but not quite as big as the supermassive black holes that inhabit the centres of galaxies.

Ilya Mandel, a theoretical astrophysicist at Monash University in Melbourne, Australia, calls the finding "wonderfully unexpected".

The event, described in two papers published on 2 September[1,2], was detected on 21 May 2019, by the twin detectors of the Laser Interferometer Gravitational-Wave Observatory (LIGO) at Hartford, Washington, and Livingston, Louisiana, and by the smaller Virgo observatory near Pisa, Italy. It is named GW190521 after its detection date.



CAROL & MIKE WERNER/VISUALS UNLIMITED/SPL

**An artist's impression of two colliding black holes.**

### Forbidden masses

Since 2015, LIGO and Virgo have provided new insights into the cosmos by sensing gravitational waves. These ripples in the fabric of space-time can reveal events such as the mergers of black holes that would not normally be visible with ordinary telescopes.

From the properties of the gravitational waves, such as how they change in pitch, astrophysicists can estimate the sizes and other features of the objects that produced them as these objects spiralled into each other. This ability has revolutionized the study of black holes, providing direct evidence for dozens of these objects, ranging in mass from a few to about 50 times the mass of the Sun.

These masses are consistent with black holes that formed in a 'conventional' way — when a very large star runs out of fuel to burn and collapses under its own weight. But the conventional theory says that stellar collapse should not produce black holes of about 65–120 solar masses. That's because towards the end of their lives, stars in a certain range of sizes become so hot at their centres that they start converting photons into pairs of particles and antiparticles — a phenomenon called pair instability. This triggers the explosive fusion of oxygen nuclei, which rips the star apart, completely disintegrating it.

In their latest discovery, the LIGO and Virgo detectors sensed only the last four ripples produced by the spiralling black holes, with a frequency that rose from 30 to 80 Hertz within one-tenth of a second. Whereas smaller black holes continue to 'chirp' up to higher frequencies, very large ones merge before this point, and barely enter the lower end of the frequency range to which the detectors are sensitive.

In this case, the two objects were estimated to weigh around 85 and 66 solar masses. "This is quite neatly in the range one would expect the pair-instability mass gap should be," says

LIGO astrophysicist Christopher Berry at Northwestern University in Evanston, Illinois.

Selma de Mink, an astrophysicist at Harvard University in Cambridge, Massachusetts, puts the cut-off for pair instability even lower, perhaps at 45 solar masses, which would push the lighter of the two objects firmly into the forbidden zone, too. "For me, both black holes are uncomfortably massive," she says.

### Unconventional black holes

To explain their observations, the LIGO researchers considered a range of possibilities, including that the black holes had been around since the beginning of time. For decades, researchers have conjectured that such 'primordial' black holes could have spontaneously formed in a broad range of sizes shortly after the Big Bang.

**"For me, both black holes are uncomfortably massive."**

The main scenario the team contemplated is that the black holes got so large because they were themselves the result of earlier black-hole mergers. Black holes resulting from stellar collapse exist inside dense stellar clusters, and could undergo repeated mergers in principle. But this scenario is problematic because the black hole resulting from a first merger should typically get a kick from the gravitational waves and eject itself from the cluster. Only in rare cases would the black hole stay in an area where it could undergo another merger.

Successive mergers would be more likely if the black holes inhabited the crowded central region of their galaxy, de Mink says, where gravity is strong enough to prevent recoiling objects from shooting out.

It is not known in which galaxy the merger happened. But in roughly in the same region of the sky, a team of researchers spotted a quasar — an extremely bright galactic centre powered by a supermassive black hole — undergoing a flare about a month after the GW190521 signal[3]. The flare could have been a shockwave in the quasar's hot gas produced by the recoiling black hole, although many astronomers are cautious about accepting that the two phenomena are related.

This is the second time this year that the LIGO–Virgo collaboration has waded into a 'forbidden' mass range: in June, it described a merger involving an object of about 2.6 solar masses — typically considered too light to be a black hole but too massive to be a neutron star[4].


1. Abbott, R. *et al. Phys. Rev. Lett.* **125**, 101102 (2020).
2. Abbott, R. *et al. Astrophys. J.* **900**, L13 (2020).
3. Graham, M. J. *et al. Phys. Rev. Lett.* **124**, 251102 (2020)
4. Abbott, R. *et al. Astrophys. J.* **896**, L44 (2020).


Q&A

JACQUELINE SAUZIER

# Cleaning up after Mauritius oil spill

**The cargo ship MV *Wakashio* unleashed a vast oil spill when it ran aground on a coral reef on the southeast tip of Mauritius in the Indian Ocean in late July. The Japanese-owned vessel held 200 tonnes of diesel and 3,900 tonnes of fuel oil, an estimated 1,000 tonnes of which leaked into the sea when the ship's hull cracked on 6 August. It is the first reported spill of a new type of low-sulfur fuel that has been introduced to reduce air pollution. The spill has smeared oil over a 15-kilometre stretch of the coastline — an internationally recognized biodiversity hotspot. Jacqueline Sauzier, president of the non-profit Mauritius Marine Conservation Society in Phoenix, has been helping with volunteer efforts to contain the spill.**

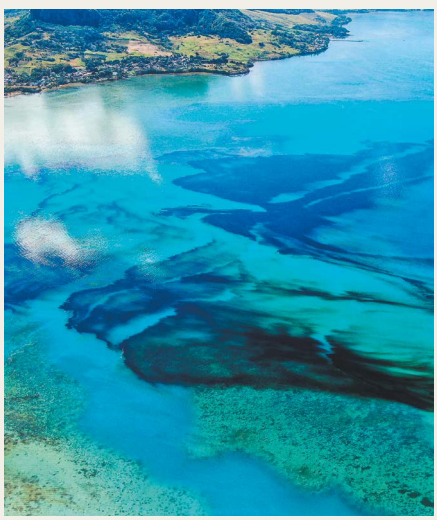
**What has been the response to the spill?**
Mauritius is not geared up to deal with a catastrophe of this size, so other countries have sent specialists to help. A French team arrived first, from the nearby island Réunion, to erect ocean booms — floating structures that contain the spill. The United Nations sent a team including experts in oil spills and crisis management. Marine ecologists and others have arrived from Japan and the United Kingdom.

Mauritians were also very proactive. In one weekend, we built nearly 80 kilometres of makeshift ocean booms out of cane trash — the leftover leaves and waste from sugar-cane processing.

People worked night and day to stop as much oil as possible reaching the shoreline, where it is more difficult to clean. We managed to contain and remove nearly 75% of the spilt oil. Only a small amount reached the shore. But there's still the issue of water-soluble chemicals that come from the oil, but dissolve into the water and therefore aren't scooped out with the oil that sits on the water's surface.

**What ecosystems have been affected?**
Unfortunately, there are a lot of environmentally sensitive areas in the region affected. The ship ran aground off Pointe d'Esny and just to the north of Blue Bay Marine Park. These sites are listed under the Ramsar Convention on Wetlands of International Importance as biodiversity hotspots. Ocean currents carried the oil northwards, so fortunately there's none in the Blue Bay Marine Park, but the mangroves on the shoreline north of Pointe d'Esny have been covered. This will definitely have an impact, because mangroves are the nursery of the marine environment.

The Île aux Aigrettes, a small island near the wreck, has also been affected. The island is home to vulnerable pink pigeons (*Nesoenas mayeri*) and other native birds, and to Telfair's skink (*Leiolopisma telfairii*). The oil didn't go onto the island itself, but chemicals might have seeped into the corals.



**Oil from MV *Wakashio* off Mauritius's coast.**

PIERRE DALAIS/EPA-EFE/SHUTTERSTOCK

**Are there particular species affected?**
It is not one species that could be at risk. It's the whole ecosystem, because of the dispersal of water-soluble chemicals in the water. Filter feeders, such as corals and crustaceans, are probably the first to be affected. We haven't seen lots of animals dying, but we will need to monitor for signs.

Something that is also concerning is that we don't know the possible long-term effects. The oil is a new low-sulfur fuel that is being introduced to reduce air pollution. This is the first time that type of oil has spilled, so there have been no long-term studies on potential impacts.

**Interview by Dyani Lewis**
This interview has been edited for length and clarity.