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.

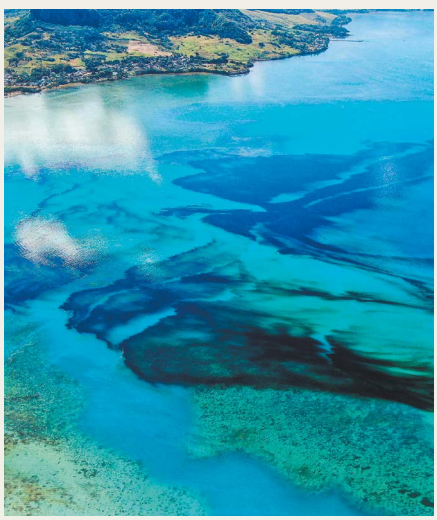
What has been the response to the spill?
Mauritius is not geared up to deal with a catastrophe of this size, so other countries have sent specialists to help. A French team arrived first, from the nearby island Réunion, to erect ocean booms — floating structures that contain the spill. The United Nations 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.