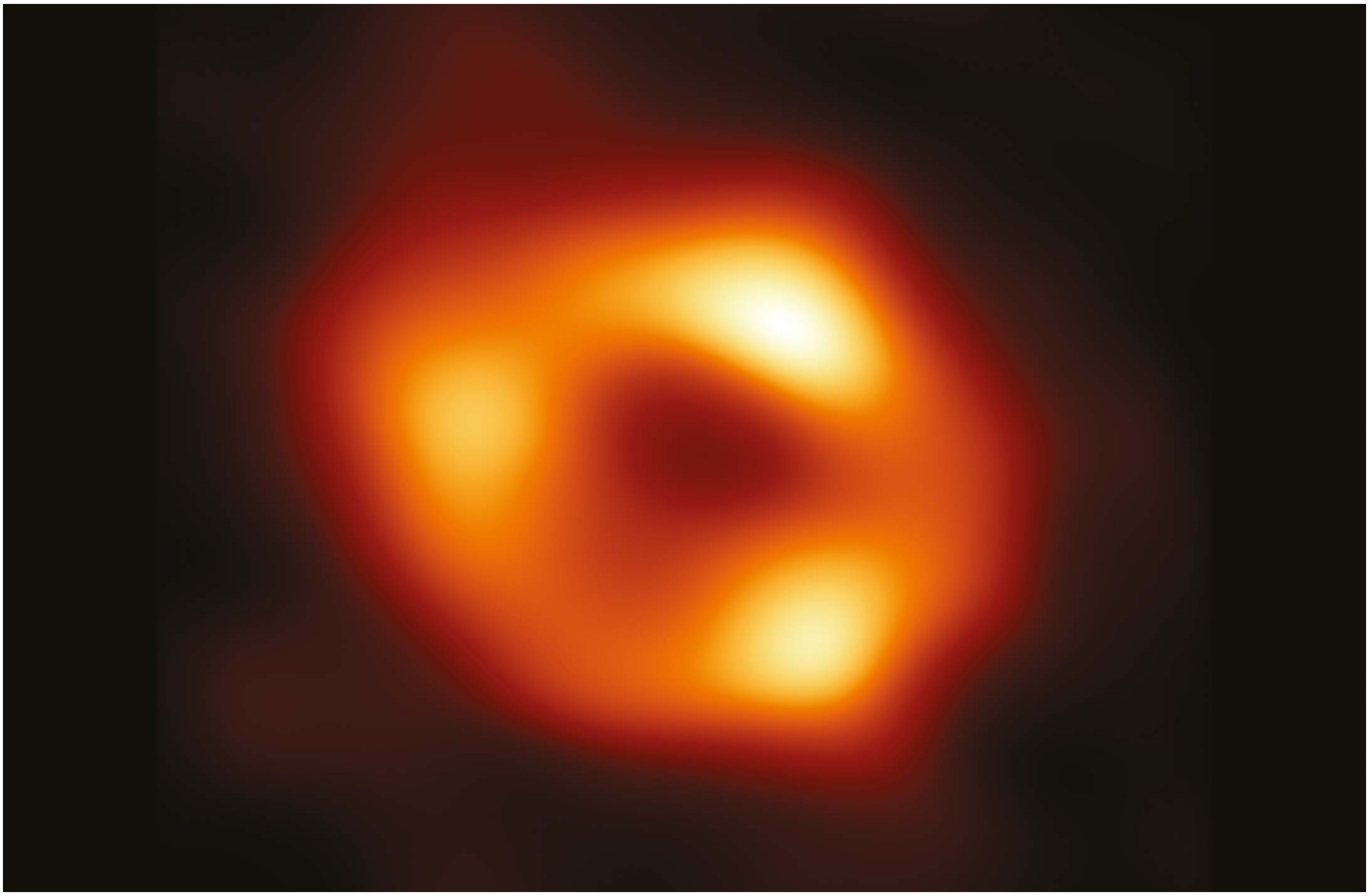
News in focus



EVENT HORIZON TELESCOPE COLLABORATION

This picture of Sagittarius A* was created from data from eight radio observatories around the world.

BLACK HOLE AT THE CENTRE OF THE GALAXY IMAGED FOR THE FIRST TIME

The Event Horizon Telescope network has captured the second-ever direct image of the black hole — called Sagittarius A* — at the heart of the Milky Way.

By Davide Castelvecchi

Radioastronomers have imaged the supermassive black hole at the centre of the Milky Way. It is only the second-ever direct image of a black hole, after the same team unveiled a historic picture of a more distant black hole in 2019.

The long-awaited results, presented on 12 May by the Event Horizon Telescope (EHT) collaboration, show an image reminiscent of the earlier one: a ring of radiation surrounds a darker disk of precisely the size that was predicted from indirect observations and from Albert Einstein's general theory of relativity.

"Today, right this moment, we have direct evidence that this object is a black hole," said Sara Issaoun, an astrophysicist at the Harvard and Smithsonian Center for Astrophysics in Cambridge, Massachusetts, at a press conference in Garching, Germany. The team published its results in a special issue of *The Astrophysical Journal Letters* (K. Akiyama *et al. Astrophys. J. Lett.* **930**, L12; 2022).

"We've been working on this for so long, every once in a while you have to pinch yourself and remember that this is the black hole at the centre of our Universe," said wEHT team member Katie Bouman, a computational-imaging researcher at the California Institute of Technology in Pasadena, at a press conference in Washington DC.

Planet-sized telescope

During five nights in April 2017, the EHT collaboration used eight observatories across the world to collect data from both the Milky Way's black hole — called Sagittarius A*, after the constellation in which it is found — and

M87*, the one at the centre of the galaxy M87.

The observatory locations ranged from Spain to the South Pole and from Chile to Hawaii (see 'Global effort').

The EHT researchers unveiled their image of M87* in 2019, showing the first direct evidence of an event horizon, the spherical surface that shrouds a black hole's interior.

But the Sagittarius A* data were more challenging to analyse. The two black holes have roughly the same apparent size in the sky, because M87* is nearly 2,000 times farther away than Sagittarius A*, but about 1,600 times larger. Any blobs of matter spiralling around M87* are covering much larger distances – bigger than Pluto's orbit around the Sun – and the radiation they emit is essentially constant over short time scales. But Sagittarius A* can change quickly, even over the few hours that the EHT observes it every day.

"In M87*, we saw very little variation within a week," says Heino Falcke, an astrophysicist at Radboud University in Nijmegen, the Netherlands, and a co-founder of the EHT collaboration. "Sagittarius A* varies on time scales of 5–15 minutes."

Because of this variability, the EHT team generated not one image of Sagittarius A*, but thousands. "By averaging them together, we are able to emphasize common features," says EHT member José Gómez, at the Institute of Astrophysics of Andalusia in Granada, Spain.

In addition to showing a ring of radiation around a darker disk, the resulting image contained three brighter 'knots'. "We see knots in all the images we created," says Issaoun, but each had them in different places. The averaged knots that appear in the image are probably artefacts of the interferometry technique used by the EHT, she adds.

The appearance is different from that of M87*, for which the brighter region in the image had more of a half-moon shape, which could indicate a denser blob of matter being accelerated along the line of sight.

The EHT team conducted supercomputer simulations to compare with its data and concluded that Sagittarius A* is probably rotating anticlockwise along an axis that roughly points along the line of sight to Earth, said Gómez.

"What blows my mind is that we're seeing it face-on," says Regina Caputo, an astrophysicist at NASA's Goddard Space Flight Center in Greenbelt, Maryland. NASA's Fermi Gamma-ray Space Telescope, which Caputo works with, had previously detected giant glowing features above and below the centre of the galaxy, which could have been produced by Sagittarius A* during periods of intense activity in the past. But those features, known as Fermi bubbles, seem to require matter to swirl around the black hole edge-on, rather than face-on, as seen from Earth.

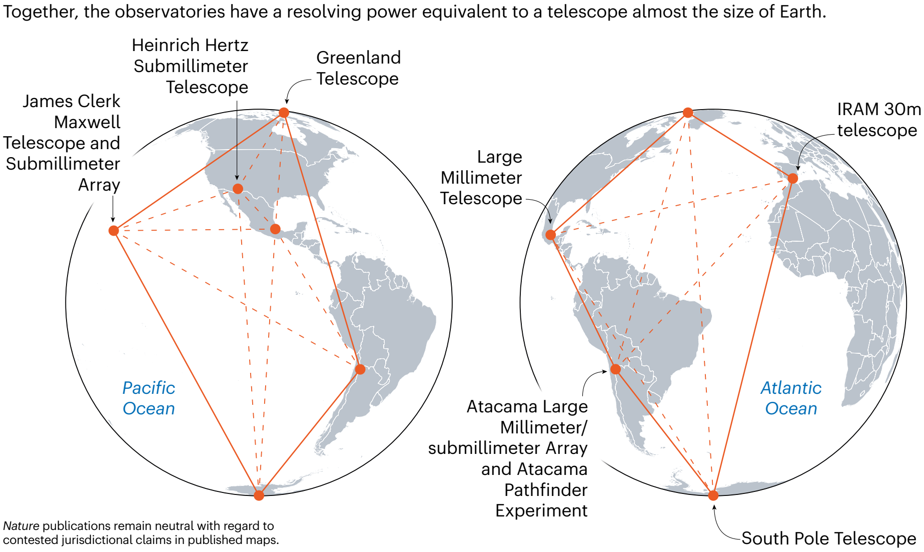
"Every once in a while you have to pinch yourself … this is the black hole at the centre of our Universe."

The first hints of the existence of Sagittarius A* were seen in the 1970s, when radio-astronomers discovered a seemingly point-like radio source in the central region of the Galaxy.

The source turned out to be unusually dim, dimmer than an average star. Still, decades-long observations of the motions of nearby stars revealed that the object was extremely massive: using the most recent observations, scientists have calculated that it is 4.15 million times the mass of the Sun, give or take 0.3%. These calculations, done by tracking how stars orbit Sagittarius A*, provided strong evidence that the radio source is so massive and dense that it could be nothing but a black hole.

GLOBAL EFFORT

The Event Horizon Telescope combined signals from eight radio observatories across the world. Together, the observatories have a resolving power equivalent to a telescope almost the size of Earth.



Nature publications remain neutral with regard to contested jurisdictional claims in published maps.

Sagittarius A* is practically invisible to optical telescopes because of the dust and gas on the galactic disk. But beginning in the late 1990s, Falcke and others realized that the shadow of the black hole might be large enough to be imaged with short radio waves, which can pierce that veil. But researchers calculated that doing so would require a telescope the size of Earth. Fortunately, a technique called interferometry could help. It involves simultaneously pointing multiple far-away telescopes at the same object. Effectively, the telescopes work like shards of one big dish.

The first attempts to observe Sagittarius A* with interferometry used relatively long 7-millimetre radio waves and observatories a few thousand kilometres apart. All astronomers could see was a blurred spot.

Teams across the world then refined their techniques and retrofitted major observatories that were added to the network. In particular, researchers adapted the South Pole Telescope and the US$1.4-billion Atacama Large Millimeter/submillimeter Array in Chile to do the work.

Then, in 2015, groups joined forces as the EHT collaboration. Their 2017 observation campaign was the first to span distances long enough to resolve details such as the size of Sagittarius A*.

Future plans

The EHT team collected more data in 2018 but cancelled its planned observation campaigns in 2019 and 2020. It resumed observations in 2021 and 2022, with an improved network and more sophisticated instruments.

Remo Tilanus, an EHT member at the University of Arizona in Tucson, says the team's latest observations, in March, recorded signals at twice the 2017 rate, most of them at 0.87-millimetre wavelength – which should help to increase the resolution of the resulting images.

Researchers hope to find out whether Sagittarius A* has jets. Many black holes, including M87*, display two beams of matter rapidly shooting out in opposite directions, thought to be a result of the intense heating of infalling gas and powered by the black hole's spin. Sagittarius A* might have had large jets in the past – as heated clouds of matter above and below the galactic centre suggest. Its jets would now be much weaker, but their presence could reveal important details about our Galaxy's history.

"These jets can inhibit or induce star formation, they can move the chemical elements around" and affect the evolution of an entire galaxy, says Falcke. "And we're now looking at where it's happening."

Additional reporting by Freda Kreier.

Correction
This News story incorrectly described Katie Bouman as a former EHT team member. She is a current member of the EHT team.

Corrected 20 May 2022