Astronomers see first light flare from two distant black holes colliding

A whopping 7.5 billion light-years from Earth, two black holes, each about the size of Long Island, rapidly spun around each other several times per second before smashing together in a cataclysmic explosion that sent shockwaves through the Universe. Normally, violent unions like this are dark events, but astronomers think they saw a flare of light emerge from this celestial dance – potentially the first time light has ever been seen from black holes merging.

It's a unique discovery since black holes are notorious for not producing any light at all. These super dense objects are so massive that nothing can escape their gravitational pull – not even light. So how exactly did researchers see a flare from two black holes that aren't supposed to flare?

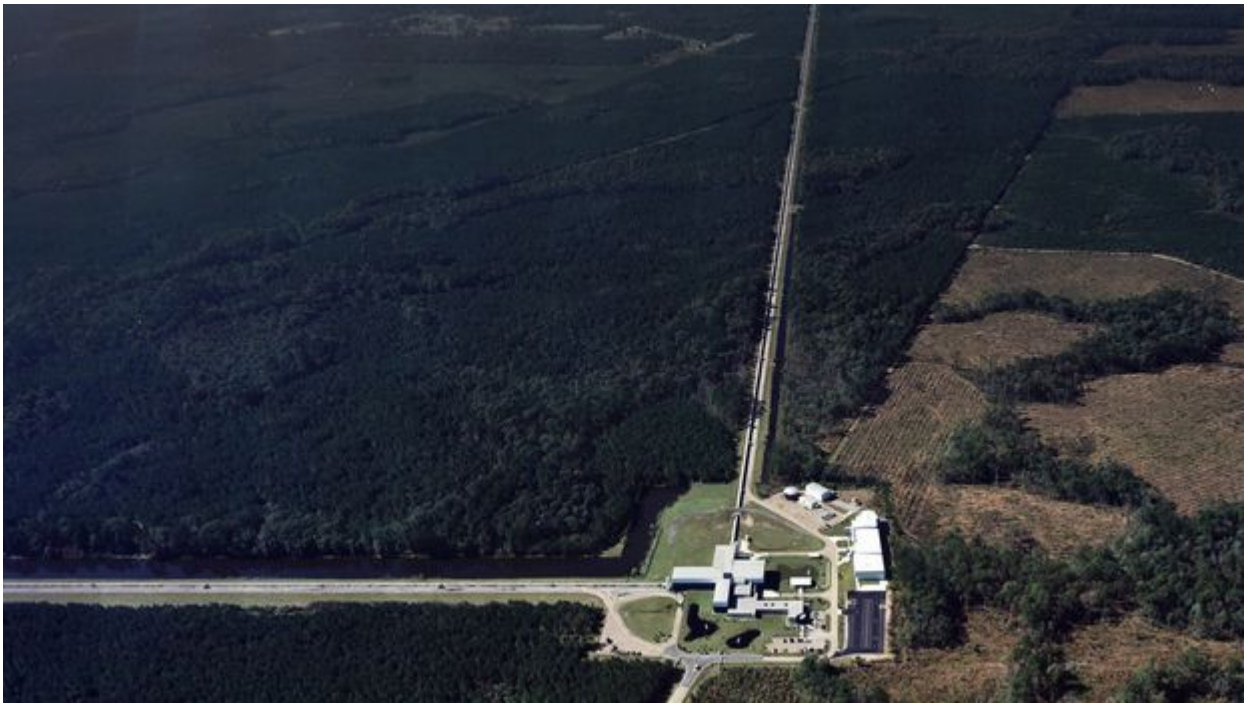
Well, the black holes may have just been in the right place at the right time, according to a new study published in the journal *Physical Review Letters*. When they spun together, they were located inside a giant disc of gas and dust. This disc of material spans light-years and actually surrounds a third black hole – a supermassive one at the center of a galaxy. Since the dueling black holes were inside this dusty environment, their spinning and eventual merger created something like a shock wave that slammed into the surrounding dirt and gas. That heated up the nearby material, causing it to glow brighter than normal – and allowing researchers from Earth to spot it.

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anything," Matt Graham, a research professor of astronomy at Caltech and lead author of the study, tells *The Verge*. "But because the black holes are surrounded by this stuff, by this accretion disc, that's different."

The researchers pinpointed this oddball event with the help of the LIGO-Virgo collaboration, an international scientific partnership that's become increasingly skilled at detecting cataclysmic events like black holes merging. More specifically, LIGO and Virgo seek out tiny ripples in the fabric of the Universe, known as gravitational waves, that stem from distant celestial events. Whenever two massive objects in the faraway Universe merge, they create undulating waves in the fabric of space and time that travel outward at the speed of light. When they reach Earth, such ripples are very tiny, but LIGO's two observatories in the US and Virgo's observatory in Italy are just sensitive enough to pick them up.

LIGO made history in 2015 when the collaboration detected gravitational waves for the first time from two black holes merging. Since then, LIGO and now Virgo, which came online in 2017, have been beefing up their resumes, detecting a whole slew of mergers throughout the Universe, including those of black holes, neutron stars, and maybe even a black hole colliding with a neutron star. When neutron stars collide, the mergers can sometimes be picked up by observatories that measure their light, even though the objects are really faint. When black holes collide, it's not something we can see — until perhaps now. "It's a weird and wonderful event, and in fact we don't know how rare they are," Chiara Mingarelli, an assistant professor at the University of Connecticut studying gravitational waves, who was not involved in the study, tells *The Verge*.



One of LIGO's observatories in Livingston, Louisiana. Image: LIGO

To find this flare, Graham and his colleagues capitalized on LIGO's triumph at finding mergers throughout space to help them solve a puzzle. Graham and his team study really active supermassive black holes in galaxies — known as quasars — and they'd been noticing a weird trend. Sometimes these quasars would flare unexpectedly, glowing super bright without warning, and they wanted to know why. "And we sort of said, 'Well I wonder what happens if you had black holes in that environment?'" says Graham.

Two of Graham's colleagues, Saavik Ford and Barry McKernan, put out a paper theorizing that black holes merging in these gaseous discs could cause the mysterious flare-ups. "The idea that there might be black holes in the centers of galaxies, very nearby a supermassive black hole, is actually pretty uncontroversial," Ford tells *The Verge*, adding, "[We] sat down to think about what the consequences of that might be, and we started to flesh out a theory that we've been pursuing for the last decade."

They then decided to put that theory to the test. In 2019, LIGO did a third observational run, scanning for a new crop of

mergers in space. Meanwhile, Graham and colleagues were working at Caltech's Zwicky Transient Facility, which performs a survey of the entire night sky, looking for odd behavior – like flares in distant galaxies. The astronomers decided to wait about six months after LIGO's observations had ended to see how many mergers the collaboration detected. They then tried to match up those mergers with the flares they had detected with ZTF, to see if any of them corresponded.

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Once they got all the potential mergers from LIGO and Virgo, it was just a matter of narrowing everything down. They matched up all the flares they had seen with ZTF to the mergers LIGO had spotted, making sure they matched the right part of the sky, at the right distance from Earth. The team also looked at timing; they predicted that a flare caused by a merger would occur about 60 to 100 days after the collision took place, as it would take time for things to heat up and cause that glow. They then made sure the flares they found matched the right profile they expected, and it didn't look like they'd been caused by an exploding star or some other explanation.

That ultimately led Graham and his team to the black hole merger they found. And actually finding something they'd theorized about was pretty exciting. "It's the sort of thing that you dream about as a scientist," says Ford, "to say, 'I think the universe is going to do that. I'm going to call my shot.' And have the Universe go, 'Yeah, here you go!'"

Though, things still aren't totally confirmed just yet. The black hole merger detected by LIGO-Virgo is still just a candidate; it hasn't been officially named as a merger, and LIGO hasn't released detailed data about the detection. But the good news is Graham's team might get extra verification in the future that the flare they recorded did indeed come from swirling black holes. When the black holes merged, it's likely the resulting black hole that was formed got kicked out of the

surrounding dusty disc. However, that hole is still orbiting around the supermassive black hole at the center of the galaxy, and it’s probably going to cross paths with the hot disc of gas in a year or two, heating up the material and causing another bright flare. So if the team sees another brightening in the same galaxy, they’ll be pretty certain their findings were correct.

When that happens, the measurement of the flare could help the team learn more about this galaxy and better constrain just how massive the supermassive black hole is at the center. “It will actually allow us to directly probe these disks around supermassive black holes in ways that we that we couldn’t do before,” says Mingarelli.

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This discovery also gives astronomers another clue about how some faraway galaxies form. It tells them that there may be strange objects doing strange things in the discs that surround supermassive black holes. “It’s not just a large gas disc falling into a supermassive black hole,” says Graham. “You’ve got stars and black holes in there doing things as well.”

Plus, this bizarre dance of black holes inside a giant gaseous disc may be the only way we can actually “see” black holes merging in deep space. And that’s even more information that researchers can use to study the cosmos. “We actually now have this probe, both from the electromagnetic signature, and the gravitational wave – both of which provide information,” says Ford. “It’s a brand new, totally different tool for studying how galaxies got to be the way they are.”

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