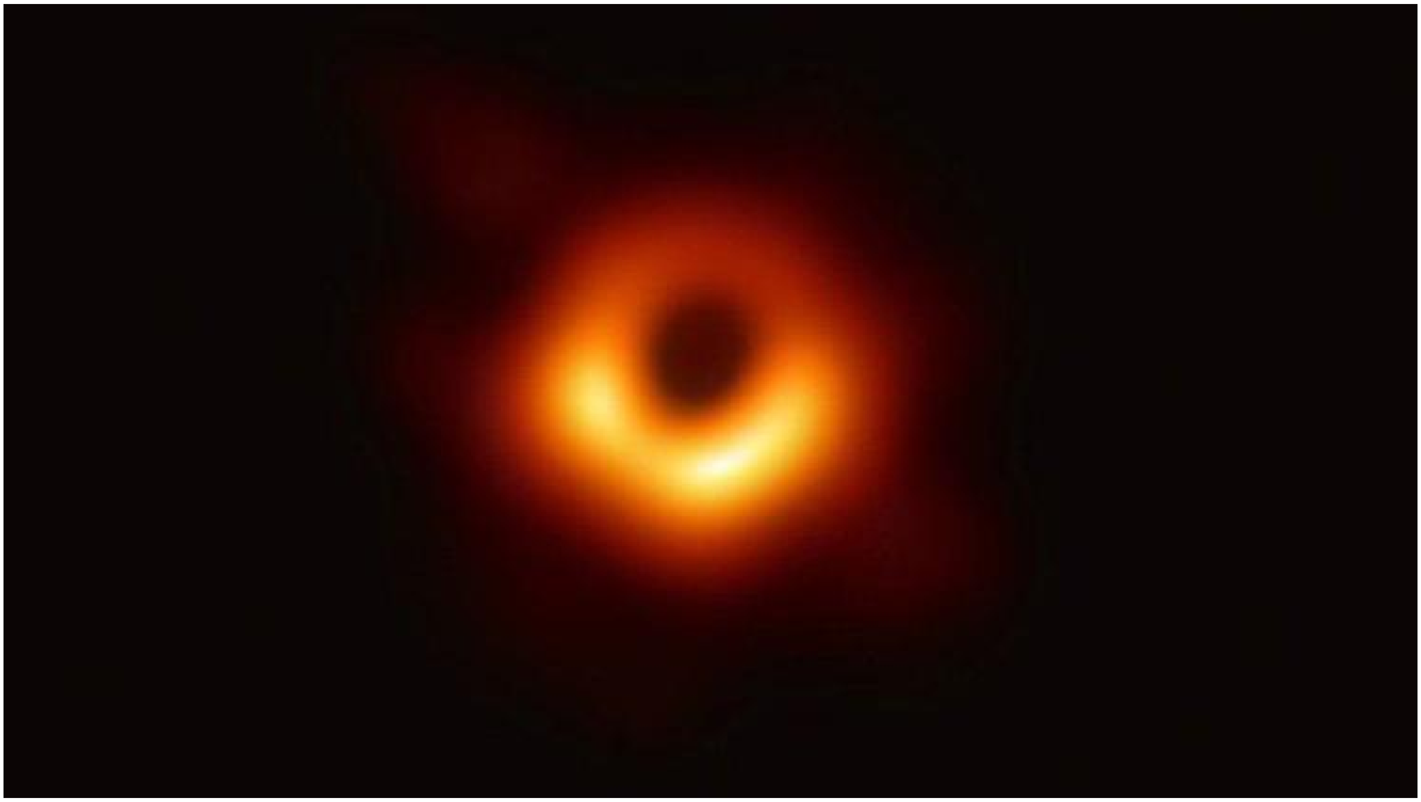
# 'See the unseeable' — local physicists on historic first photo of a black hole



Scientists have captured the first direct image of a supermassive black hole. The cosmic portrait belongs to the black hole at the center of Messier 87. (Event Horizon Telescope collaboration et al./Handout)

By **Tamara Dietrich**
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The image might not look like much at first — a black orb ringed by yellow and red gases in the middle of nowhere.

But this is the first image ever taken by humans of a black hole — in this case, a supermassive monster the size of our entire solar system spinning at the center of the giant M87 galaxy in the constellation Virgo, 55 million light-years from Earth.

“We have seen what we thought was unseeable,” Harvard astronomer Shep Doeleman said this week. Doeleman led the yearslong planetwide effort called Event Horizon Telescope that captured the image.

The photo doesn’t tell physicists anything they didn’t already know, theoretically, ever since Albert Einstein dropped his theory of general relativity a century ago.

But physicists who worked on the EHT project call their achievement one more successful stress test for general relativity — the notion that matter and gravitational force can cause space-time to ripple and warp.

And, if gravity were powerful enough — say, at the boundary of a black hole, called the event horizon — it can even gobble up space-time, never to be seen again.

“That, I think, is pretty cool,” said physicist Marc Sher at the College of William and Mary in Williamsburg. “That (general relativity) still works. Einstein wins again, basically.”

“All of our evidence about the existence of black holes, up until a few days ago, was indirect,” said Balsa Terzic, associate professor of physics at Old Dominion University in Norfolk. “Which means we only knew of their existence by how they affect stars around them.

“It was great to see (the effort) come to fruition and result in such a beautiful picture.”

## Mass matters

Beautiful, but violent.

What the image shows is the shadow of the core of the supermassive black hole surrounded by a bright “accretion disk” of gas, dust and maybe a planet or two getting swallowed up, said Sher. And all of that cosmic debris is spinning at a sizzling million degrees.

General relativity gives us the impetus to look for black holes, said Terzic, and they’re not hard to find, indirectly.

Most galaxies have supermassive black holes at or near their centers, including the Milky Way.

There’s also evidence of intermediate black holes, and theories of smaller, primordial versions with the mass of our sun but the size of Williamsburg, said Sher.

“Those are the most common,” said Sher. “They’re all over the place, and I don’t see how we see them except by seeing stuff falling in.”

Black holes are believed to form when a star loses its tug of war between gravity pulling matter in and hydrogen burning into helium pushing it out.

“When a star runs out of gas, runs out of hydrogen to burn, gravity wins,” Terzic said. “And when gravity wins, the star collapses.”

If it’s big enough, roughly three times the size of our sun, the star will explode into a supernova before its inner, heavy core collapses and forms a black hole.

But if it’s smaller than three solar masses, it will collapse into a neutron star.

And mass matters.

Earth turned into a black hole, for instance, would only measure a fraction of an inch across. Our sun, about four miles across.

The black hole at the center of M87 is one of the biggest black holes ever computed at 6.5 billion times the mass of our sun.

Supermassives are believed to form when two black holes or two galaxies collide and merge.

The physics behind it all, said Terzic, "is mind-boggling."

"Just the idea that nature can be so fascinating, so incredible, is a great advertisement for science for newer generations," he said. "Because if something like this doesn't excite you as a young scientist, then not very much in science can."

## Headlines on the moon

Sher and Terzic weren't on the Event Horizon Telescope team, but still marvel at the mathematics and science behind it, perhaps even moreso than at the photo itself.

Getting that shot was something that not even the most powerful radio telescope on Earth could handle.

"To see something like the black hole at the center of this galaxy, you'd have to have something the size of the Earth," said Sher. "And you can't make one telescope the size of the Earth, obviously.

"What you can do is get a whole bunch of little telescopes and connect them together electronically so that they're effectively acting as one."

And so over a stretch of 10 days in April 2017, eight radio observatories on four continents observed M87 in unison.

The amount of data they gathered was too massive for the internet to handle, so it was put onto hard drives and physically flown to a central location, where the data were timed precisely down to a billionth of a second.

"So you can tell that it was the same wave front on each one," said Sher. "And then you do a lot of analysis."

It took 200 people two years to do that analysis, which came up with the historic image.

"Great feats of scientific and engineering ingenuity went into this," said Terzic. "To be able to devise a tool so precise and so sensitive that you can really — and I computed this yesterday — that you can read the headlines of the Daily Press on the moon. That's how sensitive it is."

The team also trained its telescopes on the supermassive at the center of the Milky Way, a black hole called Sagiittarius A* that's only a bit smaller than M87 and much closer. But it spins faster, making it harder to image.

The EHT team is still analyzing data gathered from both black holes and expects to keep gathering even more. Next year, more observatories will be joining them.

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