NATIONAL GEOGRAPHIC

Genius

Astronomers May Finally Have of a Black Hole

Using a massive telescope network, scientists have data in hand that could open ne

HEART OF THE MATTER An illustration of the supermassive black hole at the c

PHOTOGRAPH BY NRAO, AUI, NSF

By **Ron Cowen**

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WESTFORD, MASSACHUSETTS—For the monster at the Milky Way's hea

After completing five nights of observations, today astronomers may finall the famous gravitational sinkhole known as a black hole.

More precisely, the hoped-for portrait is of a mysterious region that surrou horizon, this is the boundary beyond which nothing, not even light, can escape the

As the final observing run ended at 11:22 a.m. ET, team member Vincent F MIT Haystack Observatory in Westford, Massachusetts. For the past week, Fish h with his cell phone next to him, the ringer set loud.

As the last of the data arrived at project observatories, he watched celebrat special chat line for radio astronomers and engineers. One noted that he was abou

Scotch. Another was listening to the triumphant chords of Bohemian Rhapsody.

“I’m very happy and very relieved, and I’m looking forward to getting a goo

But that sense of relief is tinged with anticipation: So much data takes time months to find out if their massive effort was truly a success.

“Even if the first images are still crappy and washed out, we can already tes predictions of Einstein's theory of gravity in the extreme environment of a black h Falcke of Radboud University in Nijmegen, The Netherlands.

Introduced in 1915, Einstein’s revolutionary theory says that matter warps and we experience that distortion as gravity. The existence of extremely massive b predictions of Einstein’s theory. (Read "Einstein's Relativity Affects Aging on Eart

“They are the ultimate endpoint of space and time, and may represent the Falcke. Yet astronomers have only circumstantial evidence that they lie hidden at universe. Even Einstein wasn’t sure that they actually existed.

According to Falcke, the first images “will turn black holes from some mytl we can study.”

GRUELING WEATHER WATCH

Getting this far took years of planning and cooperation between internatio from the tallest mountain in Hawaii to the frozen terrain of the South Pole. This e observatories created a virtual telescope dish as wide as the planet.

Known as the Event Horizon Telescope, the radio-dish network opened its window that started on April 4.

The telescope zeroed in on two supermassive black holes: a beast as massiv A*, which lies at the heart of our Milky Way galaxy, and a black hole about 1,500 t galaxy M87. (Also see "Black Hole at Galaxy's Heart Launches Planet-Size 'Spitba

The Event Horizon Telescope has probed the neighborhood of each of thes

time the network has included the South Pole telescope and the Atacama Large M
a group of 66 radio dishes in Chile.

ALMA sharpens the Event Horizon Telescope's acuity 10-fold, enabling it t
the moon—and thus image the surprisingly small event horizons of the two black

After years politicking for observing time and outfitting each site with criti
was ultimately at the mercy of something over which they had no control: the wea

INSATIABLE FORCE

Although their name suggests emptiness, black holes are the most densely filled objects in the universe, giving them enormous gravitational pull. Stellar black holes, formed from the collapse of giant stars, can compact the mass of ten suns to the size of New York City. Supermassive black holes at the center of galaxies can have the mass of billions of suns. Their origin remains a mystery.

JASON TREAT AND ALEXANDER STEGMAIER, NGM STAFF. ART BY MARK A. GARLICK

SAGITTARIUS A*

In 1974 scientists discovered a very compact source of radio waves originating from a region in the Sagittarius constellation, 26,000 light-years from Earth. Dubbed Sagittarius A* (Sgr A*), the source is now known to be a supermassive black hole at the center of our galaxy weighing more than four million suns.

1. The Singularity: According to Einstein's equations, at the center of a black hole a star's entire mass has collapsed into an infinitely dense, dimensionless point called a singularity. Singularities likely don't really exist but point to a mathematical hole in our understanding of gravity.

2. Event Horizon: The event horizon, extending some eight million miles around Sgr A*, is the boundary beyond which even light cannot escape the black hole's gravity.

3. Static Limit: A black hole's spin can twist space, speeding or slowing matter orbiting nearby. The static limit is the orbit where objects traveling at light speed against the black hole's spin seem to stand still.

4. Accretion Disk: A whirling disk of superheated gas and dust likely spins at near light-speed around Sagittarius A*. The disk emits heat, radio noise, and x-ray flares but is placid compared with accretion disks in other galaxies.

5. X-Ray Jets: Though tranquil today, Sagittarius A* may have fed on a star or gas cloud a hundred times the mass of the sun as recently as 20,000 years ago. The meal produced x-ray jets blasting outward from the black hole's poles, which are tilted 15 degrees from the plane of the galaxy.

Astronomers observe these black holes in millimeter radio waves, the wave
penetrate the dense concentrations of gas and dust at the center of the galaxy and

But water absorbs and emits radio waves, which means precipitation confo

To minimize this problem, radio telescopes are placed at high altitudes—th
plateaus—but incoming clouds, rain, or snow can still take an observatory offline.
can also shut down a telescope.

"The probability of having really good weather at every site is almost zero,'

With only five nights available during the observing window, Fish and his
wracking decision whether to activate the network, juggling information about cu
and how those conditions might change over the coming days. From the MIT facil
weather at each site on one screen and communicating with astronomers on anotl

"It's a heartbreaker if you fire off a night and [bad] weather closes in," or if
turns out be a good night, says Shep Doeleman, director of the Event Horizon Tel
Center for Astrophysics in Cambridge, Massachusetts.

HOPING FOR PEANUTS

Now that all five days' worth of observations have been completed, astronc
analysis—to find out if they've produced a black hole portrait.

Each observatory records so much data that it can't be transmitted electro
all the telescopes—equivalent to the storage capacity of ten thousand laptops—has
The drives must be mailed to the Event Horizon Telescope's processing centers at
Institute for Radio Astronomy in Bonn, Germany.

The hard drives from the South Pole telescope can't be flown out until the
end of October.

Once the data reach each processing center, a stack of servers will perform
time-stamped signals from the eight observatories. Comparing and combining the

extraordinary care, so that critical information about the size and structure of the
added together.

The technique of combining radio waves, known as very long baseline inte
astronomy. But usually the telescopes are not so numerous nor spread out over su

"We're trying to make coherent a network the
when you think about it," says Doeleman.

What astronomers hope to finally see when th
light surrounding a dark circle—the shadow of the bl
from luminous gases, heated to hundreds of billions
black hole, tracing the region just beyond the event h

Some simulations suggest that the halo may b
the other, resembling "a peanut that would not win a

Even if they can't generate an image from this
colleagues already have plans to try again next year,
telescopes.

"Over the next ten to 50 years," Falcke says, "
sharp images as we extend the network into Africa, a

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