Peering into Black Holes Using an Earth-sized Telescope

UMass Amherst join radio astronomers worldwide to form the 'Event Horizon Telescope'

April 5, 2017
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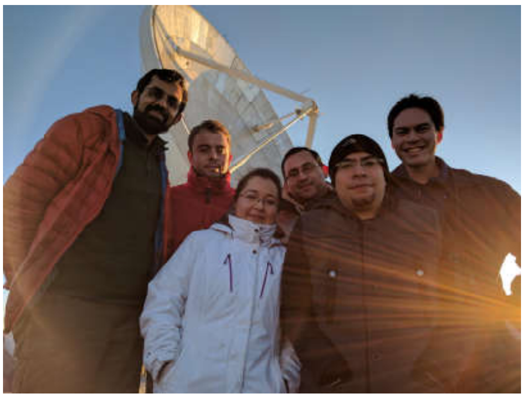
AMHERST, Mass. – Turning the Earth into one giant telescope by coordinating observations from instruments arrayed around the world, teams of radio astronomers are aiming their telescopes for the next 10 days at the thin edge – also known as the event horizon – of the super massive black hole at the center of our galaxy, the closest such object to Earth.



Gopal Narayanan, left, with some of the EHT team at the LMT in January 2017. Next to Narayanan is UMass Amherst graduate student Aleks Popstefanija, then Mexican graduate student Sandra Bustamente from Mexico's Institute of Astrophysics (INAOE), graduate student Antonio Hernandez of Mexico's National University at Morelia, graduate student David Sanchez from INAOE and

One goal is to make the first images of the event horizon and to try to determine its mass, because this object "is the best lab we have to study the extreme physics out there," says astronomy research professor Gopal Narayanan at the University of Massachusetts Amherst.

"These are the observations that will help us to sort through all the wild theories about black holes. And there are many wild theories," he adds. "With data from this project, we will understand things about black holes that we have never understood before." He and co-principal investigator, astronomer Neal Erickson, say creating the huge "Event Horizon Telescope" (EHT) has been a technological and logistical challenge.

postdoctoral researcher Lindy Blackburn of Harvard at right.

The Large Millimeter Telescope (LMT), a joint project of UMass Amherst and Mexico's Instituto Nacional de Astrofísica, Óptica y Electrónica (INAOE), is the largest, most sensitive single-aperture millimeter-wavelength telescope in the world. It will coordinate with telescopes in Hawaii, Arizona, at the South Pole, in Chile and in Spain in a concerted observational campaign from April 5-14 to study the event horizon at the center of our galaxy.

Though the Milky Way galaxy's central black hole has a mass 4 million times that of our sun, it is 26,000 light years away, Narayanan points out. At that distance, the event horizon is so small it would require an Earth-sized telescope dish to image it. "That's like trying to image a grapefruit on the surface of the moon," he says.

For this challenge, hundreds of scientists in the EHT project created their tool with eight telescopes. Using Earth's rotation and aiming each telescope at the same object, over the course of many hours their sampled curves, combined, resemble the observational effect of one large instrument. The strategy of combining several telescopes to create a simulated larger dish area, known as Very Long Baseline Interferometry (VLBI), is not new, Narayanan says. It has been in use for decades, but this is the first time millimeter-wave VLBI to be undertaken on such a massive scale.

He explains, "At the very heart of Einstein's general theory of relativity there is a notion that quantum mechanics and general relativity can be melded, that there is a grand, unified theory of fundamental concepts. The place to study that is at the event horizon of a black hole."

Narayanan adds that this research "illustrates that in all of physics, extreme limits are the most interesting. At these limits, you really figure out where things are breaking down, and it's where new discoveries are made." Einstein's theory of general relativity predicts that there will be a shadowy circle around a black hole, and its shape will put "very important constraints" on its mass and its spin, the astronomer says. "These ideas have not been tested. The EHT aims to image the shadow to test predictions and to determine the mass and spin of black holes."

Another of the EHT's goals is to study the physics of accretion, the process by which a black hole's gravity pulls in nearby matter. The fallen material forms a flattened band of spinning matter around the event horizon called the accretion disk. EHT scientists also want to understand the genesis and behavior of large plasma jets launched from the central black hole of most galaxies. Another intriguing idea that may be explored in this experiment is the so-called "information paradox." This phenomenon is Stephen Hawking's prediction that matter falling into a black hole cannot be lost beyond the known universe, that it must somehow leak back in.

UMass Amherst astronomy professor Peter Schloerb, director of Five College Radio Astronomy observatories and one of the LMT's principal investigators, says that since the LMT joined the EHT group it has become "one of the most valuable telescopes" in the array and a vital part of the mission. With its central geographical location at 15,000 feet on Volcán Sierra Negra in Mexico, and its large aperture, the LMT is pivotal to EHT success. EHT is funded by the participating telescopes and the

U.S. National Science Foundation and led by professor Shep Doeleman at Harvard University.

During the campaign that began this week, the EHT will also image the super-massive black hole in the center of Messier 87, a giant elliptical galaxy much farther away than the center of the Milky Way. But the black hole at the center of M87 is 6 billion times the mass of our sun, so the event horizon around it is larger, Narayanan explains.

David Hughes, LMT director, says, “The EHT presents an exciting opportunity for the LMT to play an important role in this international network of millimeter-wavelength telescopes. In the following days, the LMT will contribute to this experiment which can make a fundamental test of a prediction of Einstein’s theory of general relativity under the most extreme physical conditions. All we can do now is point our telescope towards these super-massive black holes and wait to see if the EHT has detected for the first time the most convincing physical manifestation of a singularity in space, the black-hole shadow and its event-horizon.”

Narayanan says the EHT project is especially valuable to students because it offers “precious, hands-on opportunities” at the LMT. UMass Amherst graduate student Aleks Popstefanija has been active in EHT campaigns there. Narayanan says, “The LMT offers UMass Amherst students, grads and undergrads valuable training. Such facilities are few and far between and there is no better chance for learning. Our students will become the next generation of radio astronomers who will build the next generation of instruments, and use them to do new science. To be part of that mission is very exciting and very gratifying.”

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