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BLACK HOLE SNAPPED: HOW THE PICTURE OF ONE OF THE UNIVERSE'S MOST SECRETIVE OBJECTS WAS CLICKED

Relevant for: Geography | Topic: The Earth and the Solar System

The story so far: In 2017, a consortium of institutions around the world decided to pool the scanning abilities of eight telescopes — from Hawaii to the South Pole — and focus on getting a picture of a black hole. By definition, a black hole can't be seen. As a cosmic gobbler of all matter on its periphery, these sinkholes have gravitational fields so powerful that even light cannot escape them, rendering its contents invisible. Because the concept of black holes (the cemeteries of spent stars above a certain mass and massive cosmic objects) followed from Einstein's theories of general relativity, scientists have had intricate mathematical descriptions and speculation of how they look, how many of them exist, how they behave, where they might be located and their relationship to the universe. Based on this, there have been a plethora of visual and artistic descriptions of black holes. However, there has never been visual confirmation of their existence, until now.

On April 10, astronomers shared an image, now christened on Indian Twitter as a 'giant *meduvada* in the sky,' from the black hole at Messier 87 or M87. It was a blurred, yellowish orange frame surrounding a black centre. While this wasn't vastly different from how astronomers and artists have visualised black holes for decades, it's still great to see reality correspond to imagination. The black hole measures 40 billion km across — three million times the size of the earth — and is 55 trillion light years from earth. (A light year is about 9.46 trillion km). It is bigger than our entire solar system and a scientist described it to the BBC as "the heavyweight champion of black holes in the Universe." The image has been analysed in six studies co-authored by 200 experts from 60-odd institutions and published on Wednesday in *Astrophysical Journal Letters*.

Since the 1970s, astronomers have known that there are 'super massive' black holes (about a billion times heavier than the sun) in the Milky Way or galaxies close to it. While black holes themselves are invisible, the region around them — the luminous frenzy of charged particles from matter in their vicinity — is, in theory, 'visible'. The bigger a black hole, the greater the odds of it having a massive event horizon — the fiery periphery of a black hole — and the better our chances of observing wisps of radiation from it. After the discovery of a super massive black hole in M87 (a 'neighbouring' galaxy about 55 trillion light years away) and one in our Milky Way, astronomers formed a network of ultra-sensitive telescopes — called the Event Horizon Telescope — to dedicatedly train their sights towards trying to capture some radiation from them and hopefully, snap a real picture from the black hole's periphery.

Because black holes are the result, mostly, of heavy stars collapsing in on themselves, radiation emitted by particles within the disc are heated to billions of degrees as they swirl around the black hole at close to the speed of light, before vanishing into them.

The astronomers used a technique known as interferometry, which combines radiation from eight telescopes from around the world in a way that it appears as one single telescope capture. What this virtual telescope would capture were traces — electromagnetic radiation — from jets of particles spewed from the event horizons of the black hole. This faint radiation, in the form of mostly radio waves, would have travelled trillions of kilometres and for the telescope to observe them would be the equivalent of trying to snap a picture of an ant from the moon.

The EHT team observed M87 and Sagittarius A (Sgr A), the black hole at the centre of our Milky Way, over five nights in April 2017, using eight radio telescopes that are sensitive to the wavelengths of a millimetre. The telescopes they used stretched from Hawaii to Arizona, Mexico to Spain, and Chile to the South Pole. The data generated were so voluminous that they couldn't be transmitted on the internet and had to be recorded on disk and shipped to the Massachusetts Institute of Technology, Boston. It took nearly a year for data from the South Pole to be shipped because of inclement weather. A total of 4 petabytes were recorded — the equivalent of 8,000 years of MP3-format music played non-stop — and was crunched in supercomputers by teams of scientists working 16-18 hour shifts. A report in *Science* said four independent teams duplicated the data processing to eliminate biases and over four days of observations of M87, the shape and size of the shadow was consistent with theoretical expectations. The team did not report results from Sgr A because the picture quality from M87 was better.

Coupled with the momentous discovery of gravitational waves, generated by two black holes, in 2015 by the Laser Interferometer Gravitational-Wave Observatory, the black hole image of M87 is a testament to engineering skills. It will help to form international collaborations to pool the capabilities of disparate scientific instruments and perceive phenomena that cannot be comprehended by individuals. It also underlines that international scientific collaboration is now essential to scientific advancement. The image and the data generated could better illuminate black holes, how they work, how the jets of luminosity that enabled us to see them, actually behave. An actual image also confirms a century of theoretical work that has built up over the years, premised on the assumption that black holes are indeed real objects and not the fantasy fallout of abstruse mathematical equations. It allows scientists greater confidence to proceed with more involved questions such as the surface of the regions around black holes, how they rotate, how quickly their characteristics vary and how earthlings need to shift and shape their instruments accordingly to learn more about them.

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