



PRESS RELEASE – PARIS – 24 MARCH 2021

Astronomers Image Magnetic Fields at the Edge of M87's Black Hole

- *Within the EHT collaboration, the CNRS and IRAM participated in the creation of a new image of the black hole in the M87 galaxy.*
- *Produced in so-called "polarized" light, this image makes it possible to observe the magnetic field and to better understand the physics around black holes.*

The Event Horizon Telescope (EHT) collaboration, who produced the first ever image of a black hole, has revealed today a new view of the massive object at the centre of the M87 galaxy: how it looks in polarised light. This is the first time astronomers have been able to measure polarisation, a signature of magnetic fields, this close to the edge of a black hole. The observations are key to explaining how the M87 galaxy, located 55 million light-years away, is able to launch energetic jets from its core. The Institute for Millimeter Radio Astronomy (IRAM), founded in 1979 by the CNRS and the Max-Planck-Gesellschaft (MPG, Germany)¹, played a key role in this result via its 30-meter telescope, located near Granada, the most sensitive single antenna of the EHT network. The results are published in *The Astrophysical Journal Letters*.

"We are now seeing the next crucial piece of evidence to understand how magnetic fields behave around black holes, and how activity in this very compact region of space can drive powerful jets that extend far beyond the galaxy," says Monika Mościbrodzka, Coordinator of the EHT Polarimetry Working Group and Assistant Professor at Radboud University in the Netherlands.

On 10 April 2019, scientists released the first ever image of a black hole, revealing a bright ring-like structure with a dark central region — the black hole's shadow. Since then, the EHT collaboration has delved deeper into the data on the supermassive object at the heart of the M87 galaxy collected in 2017. They have discovered that a significant fraction of the light around the M87 black hole is polarised.

"This work is a major milestone: the polarisation of light carries information that allows us to better understand the physics behind the image we saw in April 2019, which was not possible before," explains Iván Martí-Vidal, also Coordinator of the EHT Polarimetry Working Group and GenT Distinguished Researcher at the University of Valencia, Spain. He adds that *"unveiling this new polarised-light image required years of work due to the complex techniques involved in obtaining and analysing the data."*

Light becomes polarised when it goes through certain filters, like the lenses of polarised sunglasses, or when it is emitted in hot regions of space that are magnetised. In the same way polarised sunglasses help us see better by reducing reflections and glare from bright surfaces, astronomers can sharpen their vision of the region around the black hole by looking at how the light originating from there is polarised. Specifically, polarisation allows astronomers to map the magnetic field lines present at the inner edge of the black hole.

"The newly published polarised images are key to understanding how the magnetic field allows the black hole to 'eat' matter and launch powerful jets," says EHT collaboration member Andrew Chael, a NASA Hubble Fellow at the Princeton Center for Theoretical Science and the Princeton Gravity Initiative in the US.

The bright jets of energy and matter that emerge from M87's core and extend at least 5000 light-years from its centre are one of the galaxy's most mysterious and energetic features. Most matter lying close to



the edge of a black hole falls in. However, some of the surrounding particles escape moments before capture and are blown far out into space in the form of jets.

Astronomers have relied on different models of how matter behaves near the black hole to better understand this process. But they still don't know exactly how jets larger than the galaxy are launched from its central region, which is as small in size as the Solar System, nor how exactly matter falls into the black hole. With the new EHT image of the black hole and its shadow in polarised light, astronomers managed for the first time to look into the region just outside the black hole where this interplay between matter flowing in and being ejected out is happening.

The observations provide new information about the structure of the magnetic fields just outside the black hole. The team found that only theoretical models featuring strongly magnetised gas can explain what they are seeing at the event horizon².

"The observations suggest that the magnetic fields at the black hole's edge are strong enough to push back on the hot gas and help it resist gravity's pull. Only the gas that slips through the field can spiral inwards to the event horizon," explains Jason Dexter, Assistant Professor at the University of Colorado Boulder, US, and coordinator of the EHT Theory Working Group.

To observe the heart of the M87 galaxy, the collaboration linked eight telescopes around the world, including IRAM's 30-meter telescope located in the Spanish Sierra Nevada, the most sensitive single antenna of this network, co-funded by the CNRS, the ALMA interferometer and ESO's APEX telescope, including France is one of the member states, to create a virtual Earth-sized telescope, the EHT. The impressive resolution obtained with the EHT is equivalent to that needed to measure the length of a credit card on the surface of the Moon.

This allowed the team to directly observe the black hole shadow and the ring of light around it, with the new polarised-light image clearly showing that the ring is magnetised. The results are published today in two separate papers in *The Astrophysical Journal Letters* by the EHT collaboration. The research involved over 300 researchers from multiple organisations and universities worldwide.

"IRAM's 30-meter telescope plays a key role in the EHT and opens up new, hitherto inaccessible and probably unexpected perspectives on the physics on the edge of black holes", concludes Frédéric Gueth, CNRS researcher and deputy director of IRAM.

The list of telescopes in the EHT network: ALMA, APEX, the IRAM 30-metre telescope, the James Clerk Maxwell Telescope, the Large Millimeter Telescope Alfonso Serrano, the Submillimeter Array, the Submillimeter Telescope and the South Pole Telescope.

The thirteen partner organisations making up the EHT consortium: Academia Sinica Institute of Astronomy and Astrophysics, University of Arizona, University of Chicago, East Asian Observatory, Goethe-Universität Frankfurt, IRAM, Large Millimeter Telescope, Max Planck Institute for Radio Astronomy, MIT Haystack Observatory, National Astronomical Observatory of Japan, Perimeter Institute for Theoretical Physics, Radboud University and the Smithsonian Astrophysical Observatory.

Notes

1- Joined in 1990 by l'Institut Geográfico Nacional (IGN, Espagne)

2- A black hole's event horizon is the limit from which nothing, not even light, can escape its gravitational field.



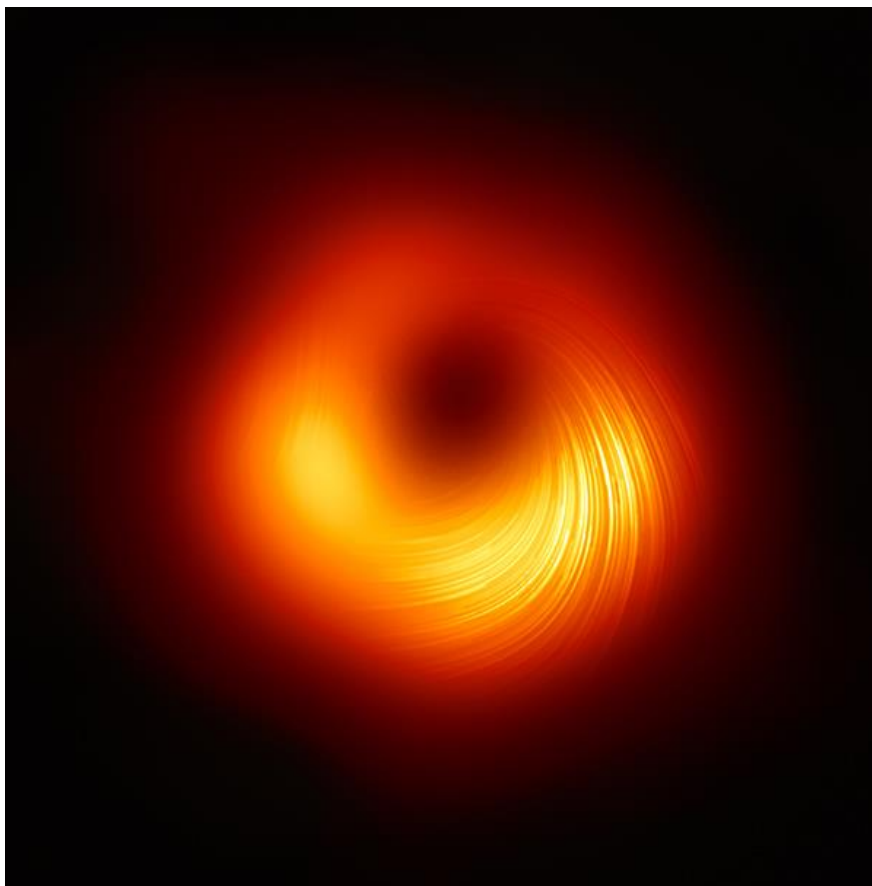


Image of the supermassive black hole within the galaxy M87 in polarized light. In 2019, the EHT collaboration released the first image of a black hole. Today, she presents a new view of this supermassive object at the center of the galaxy M87: its silhouette in polarized light. This is the first time that astronomers have successfully measured polarization so close to the edge of the black hole. The lines in the image represent the orientation of polarization, a signature of the magnetic field.

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References

First M87 Event Horizon Telescope Results VII: polarization of the ring. *The EHT collaboration.* *The Astrophysical Journal Letters*, 24 March 2021. <https://doi.org/10.3847/2041-8213/abe71d>

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