Unexpected discovery of a correlation between black holes' jets and their host galaxies

In a study published today, November 14, 2024, in the journal Nature Astronomy, an international team of astrophysicists, including a researcher from the Paris Observatory, demonstrate that there is a connection between the nearby region of a black hole and its host galaxy because the jets emitted by the black hole are aligned with the rest of the galaxy.

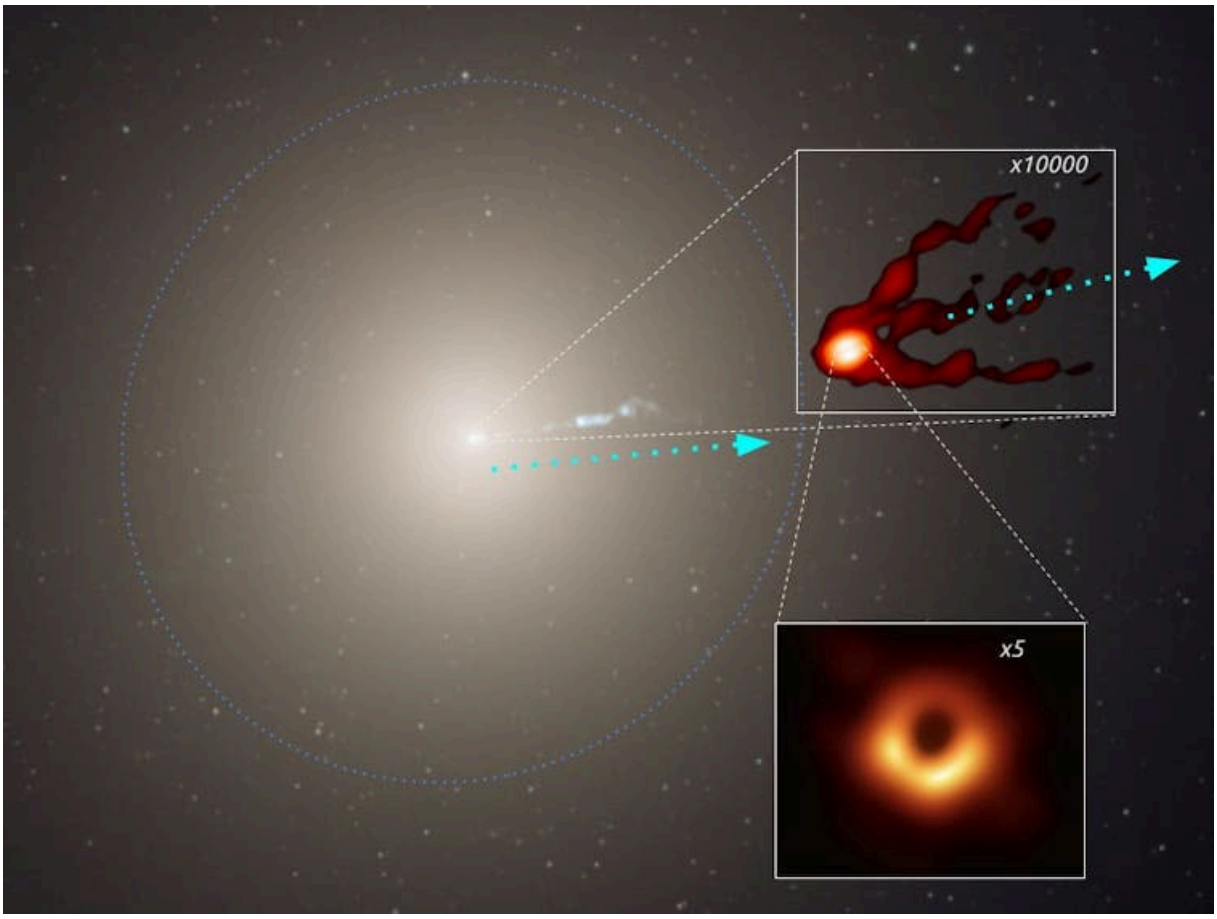
Supermassive black holes have masses ranging from millions to billions of solar masses. Our galaxy, the Milky Way, has one (named Sagittarius A* for the constellation in which it is located) at its center. All galaxies also appear to harbor a supermassive black hole at their core. The centers, or nuclei, of these distant galaxies can become active, as gas and dust are drawn to the nucleus under the gravitational pull of the black hole.

Before falling into the black hole, the highly rotating gas forms a hot disk of matter, called an accretion disk. This accretion disk, because of its intense magnetic field, in turn generates a superheated jet of charged particles that are ejected from the nucleus at very high speeds, close to the speed of light. It is a jet that emits synchrotron radiation, visible in radio wavelengths: a radio jet.

A common way to study radio jets is to use very long baseline interferometry (VLBI). The VLBI allows different radio telescopes to work in tandem, turning them into a single telescope the size of the Earth. The spatial resolution is then much higher than that obtained with optical or infrared telescopes. This "massive eye" is far more efficient at resolving fine details than any individual telescope, allowing astronomers to see objects and structures that are much smaller than those visible with an optical telescope. This is the technique that was used to make the "Black hole shadow image" surrounded by a halo of light generated by the supermassive black hole hosted by the galaxy M87.
Thus, thanks to this high-resolution approach, the VLBI allows astronomers to study these jets up to a few light-years or less from their origin: the black hole. The direction of the jet at such small scales tells us about the orientation of the accretion disk, and thus potentially about the properties of the black hole itself. What about the host galaxies themselves? We can measure the shape of these galaxies, by plotting the profile of starlight, and measure the major axis and the minor axis of the two-dimensional shape.

In this paper, astronomers compared the direction of quasars' jets with the direction of the galaxy's ellipse minor axis, and they found that they are connected. This is surprising, because the black hole is so small (the measured jet is only a few light-years long), compared to the host galaxy (which can be hundreds of thousands of light-years wide). It is surprising that such a small object (in comparison) can affect, or be affected, by the environment on such large scales. This discovery will help to better understand the symbiosis between supermassive black holes and their host galaxies.

Figure The galaxy M87 with the black hole M87* at its centre. Black holes are thousands of times less massive than galaxies, and yet they produce jets that point in the same direction. M87: HST/NASA. Top right: GMVA/Lu et. al. 2023 (Nature) Bottom right: Event Horizon Telescope Collaboration



Reference: D. Fernandez Gil, J. A. Hodgson, B. L'Huillier, J. Asorey, C. Saulder, K. Finner, M. J. Jee, D. Parkinson, F. Combes: 2024, Detection of an orthogonal alignment between parsec scale AGN jets and their host galaxies, Nature Astronomy, 14 November, 2024, https://arxiv.org/abs/2411.09099