Closest look yet at a distant black hole

Astronomers combine telescopes to measure features at the centre of a galaxy outside the Milky Way.

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In a technical tour de force, astronomers have peered closer than ever before at the edge of a supermassive black hole beyond the Milky Way, and have estimated the closest distance matter can approach it without getting sucked in.

Linking four radio dishes in California, Arizona and Hawaii, the team created a single radio telescope that was powerful enough to study the centre of the galaxy M87, thought to house a black hole as massive as 6.2 billion Suns.

The telescope enabled astronomer Sheperd Doeleman of the MIT Haystack Observatory in Westford, Massachusetts, and his colleagues to determine that the high-speed particle jet shooting from the core of M87 originates within a region that is just 5.5 times larger than the estimated radius, or event horizon, of the black hole — the first time scientists have made such a measurement. The team reports the findings today in *Science*[1].

NASA and The Hubble Heritage Team (STScI/AURA)

Galaxy M87 harbours a massive black hole at its centre, which blasts a stream of particles into space.

“It’s clearly a triumph that they’ve been able to get this high resolution” and probe a region so close to an extragalactic black hole, says theoretical astrophysicist Roger Blandford of Stanford University in Palo Alto, California.

Because the new measurement confines the massive central object in M87 to a tiny volume — the body has to be smaller than the jet’s source region — the evidence for the existence of a supermassive black hole in the galaxy is now almost as compelling as that for our own Milky Way, notes theorist Charles Gammie of the University of Illinois at Urbana-Champaign.

Beyond the abyss

The team went beyond the raw measurements of the jet to infer properties about the spin of the black hole and the rotation of its accretion disk — the swirling material that surrounds a black hole and provides its fuel. Doeleman and his colleagues used a model that assumes that the launch site of the jets in M87 is the same as the smallest stable orbit that matter can have without rapidly plunging into the black hole.

According to Einstein’s theory of gravity, the location of this innermost orbit depends on whether the black hole spins. Accounting for gravitational lensing, which magnifies and stretches the innermost light-emitting region seen by the telescope, the smallest stable orbit for a stationary black hole in M87 would be 7.35 times the radius of the black hole — significantly larger than Doeleman's measurement — allowing the researchers to conclude the black hole must spin.

Blandford and Gammie both note that the spin deductions are not as robust as the direct size measurements, because no one knows the correct model for explaining how a supermassive black hole generates jets.

The measurements and inferences “are baby steps, but they are baby steps in a regime [of strong gravity] that we haven’t had any access to before now”, says Doeleman. “And even tiptoeing around Einstein’s backyard is heady stuff.”

By 2015, Doeleman and his colleagues hope to double the resolution of their observation by adding 20 or so radio dishes from ALMA, the giant radio array now being built in Chile's Atacama desert. With ALMA, says Doeleman, the telescope network will have the sensitivity to make bona fide images of the region surrounding a supermassive black hole and search for a black hole’s shadow — a predicted feature in which light from a black hole jet headed away from Earth gets bent into a bright ring that may be visible.

The size and shape of this ring will provide a new measure of a black hole’s mass, says Doeleman. But it will also help to test Einstein’s theory of gravitation, he adds.

The theory predicts a relatively circular shape for the shadow, but if the structure of space-time deviates from Einstein’s prediction, then the shadow would have a different shape. “This is probably one of the few places in the Universe to actually pose the question, ‘Was Einstein right?',” says Doeleman.

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References

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