Measuring a black hole 660 million times as massive as our sun

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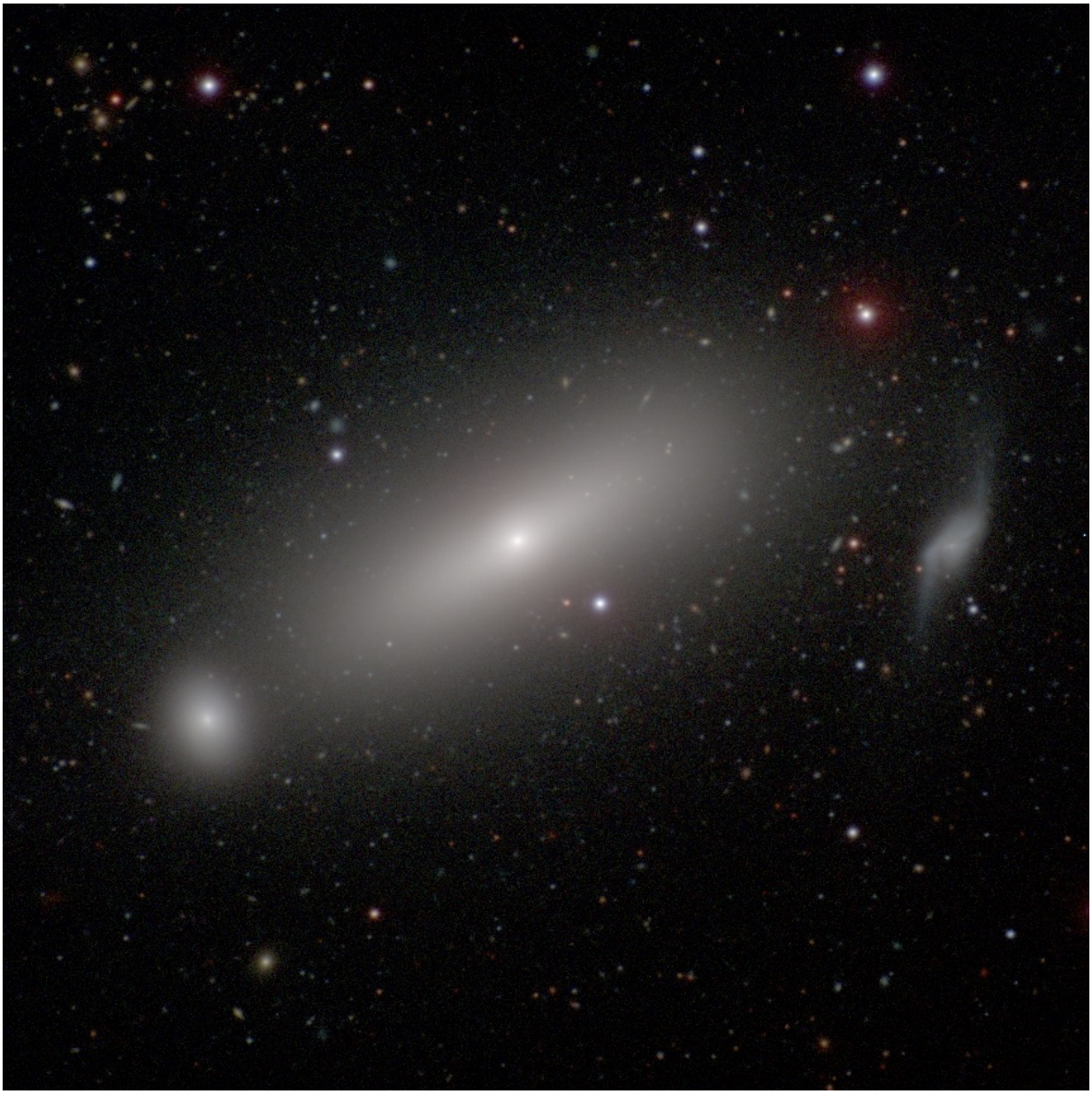


NGC 1332, a galaxy with a black hole at its center whose mass has been measured at high precision by ALMA. Credit: Carnegie-Irvine Galaxy Survey

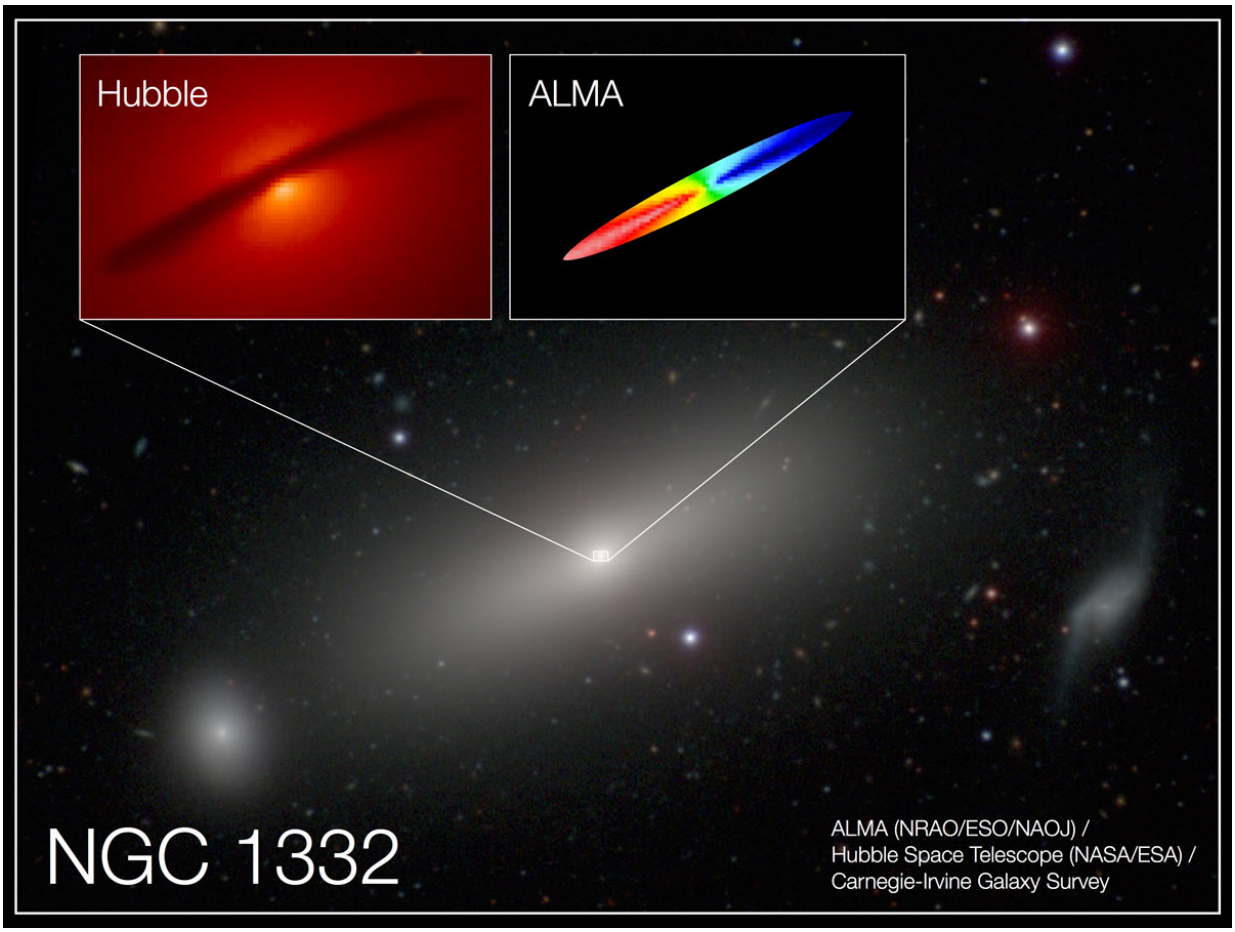
It's about 660 million times as massive as our sun, and a cloud of gas circles it at about 1.1 million mph.

This supermassive black hole sits at the center of a galaxy dubbed NGC 1332, which is 73 million light years from Earth. And an international team of scientists that includes Rutgers associate professor Andrew J. Baker has measured its mass with unprecedented accuracy.

Their groundbreaking observations, made with the revolutionary Atacama Large Millimeter/submillimeter Array (ALMA) in Chile, were published today in the *Astrophysical Journal Letters*. ALMA, the world's largest astronomical project, is a telescope with 66 radio antennas about 16,400 feet above sea level.

Black holes - the most massive typically found at the centers of galaxies - are so dense that their gravity pulls in anything that's close enough, including light, said Baker, an associate professor in the Astrophysics Group in Rutgers' Department of Physics and Astronomy. The department is in the School of Arts and Sciences.

A black hole can form after matter, often from an exploding star, condenses via gravity. Supermassive black holes at the centers of massive galaxies grow by swallowing gas, stars and other black holes. But, said Baker, "just because there's a black hole in your neighborhood, it does not act like a cosmic vacuum cleaner."



Combined image of NGC 1332 shows the central disk of gas surrounding the supermassive black hole at the center of the galaxy. New ALMA observations traced the motion of the disk, providing remarkably precise measurements of the black hole's mass: 660 million times the mass of our Sun. The main image is from the Carnegie-Irvine Galaxy Survey. The box in the upper left is from the Hubble Space Telescope and shows the galaxy's central region in infrared light and the dusty disk appears as a dark silhouette. The ALMA image, upper right box, shows the rotation of the disk, enabling astronomers to calculate its mass. The red region in the ALMA image represents emission that has been redshifted by gas rotating away from us; the blue represents blue-shifted gas rotating toward us. The range of colors represent rotational speeds up to 500 kilometers per second. Credit: A. Barth (UC Irvine), ALMA (NRAO/ESO/NAOJ); NASA/ESA Hubble;Carnegie-Irvine Galaxy Survey.

Stars can come close to a black hole, but as long as they're in stable orbits and moving fast enough, they won't enter the black hole, said Baker, who has been at Rutgers since 2006.

"The black hole at the center of the Milky Way, which is the biggest one in our own galaxy, is many thousands of light years away from us," he said. "We're not going to get sucked in."

Scientists think every massive galaxy, like the Milky Way, has a massive black hole at its center, Baker said. "The ubiquity of black holes is one indicator of the profound influence that they have on the formation of the galaxies in which they live," he said.

Understanding the formation and evolution of galaxies is one of the major challenges for modern astrophysics. The scientists' findings have important implications for how galaxies and their central supermassive black holes form. The ratio of a black hole's mass to a galaxy's mass is important in understanding their makeup, Baker said.

Research suggests that the growth of galaxies and the growth of their black holes are coordinated. And if we want to understand how galaxies form and evolve, we need to understand supermassive black holes, Baker said.

Part of understanding supermassive black holes is measuring their exact masses. That lets scientists determine if a black hole is growing faster or slower than its galaxy. If black hole mass measurements are inaccurate, scientists can't draw any definitive conclusions, Baker said.

To measure NGC 1332's central black hole, scientists tapped ALMA's high-resolution observations of carbon monoxide emissions from a giant disc of cold gas orbiting the hole. They also measured the speed of the gas.

"This has been a very active area of research for the last 20 years, trying to characterize the masses of black holes at the centers of galaxies," said Baker, who began studying black holes as a graduate student. "This is a case where new instrumentation has allowed us to make an important new advance in terms of what we can say scientifically."

He and his coauthors recently submitted a proposal to use ALMA to observe other massive black holes. Use of ALMA is granted after an annual international competition of proposals, according to Baker.

More information: "Measurement of the Black Hole Mass in NGC 1332 from ALMA Observations at 0.044 Arcsecond Resolution," Aaron Barth et al., 2016 May 10, *Astrophysical Journal Letters* iopscience.iop.org/article/10. … /2041-8205/822/2/L28 , *Arxiv*: arxiv.org/abs/1605.01346

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