Supermassive black holes may frequently roam galaxy centers

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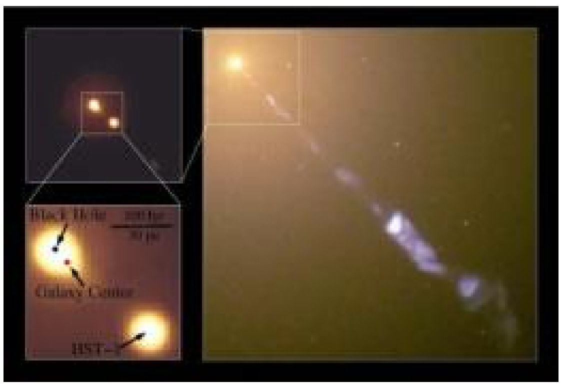

Hubble Space Telescope Images of M87. At right, a large scale image taken with the Wide-Field/Planetary Camera-2 from 1998 (NASA and the Hubble Heritage Team (STScI/AURA), J. A. Biretta, W. B. Sparks, F. D. Macchetto, E. S. Perlman). The two images at left show an image taken in 2006 with the Advanced Camera for Surveys' High Resolution Channel. The position of the supermassive black hole is indicated by the black dot in the lower left panel, and a knot in the jet (HST-1), which was flaring in 2006, is also indicated on this panel. The red dot indicates the center of the galaxy's light distribution, which is offset from the position of the black hole by 22 +/- 3 light years. Credit: (NASA and the Hubble Heritage Team (STScI/AURA), J. A. Biretta, W. B. Sparks, F. D. Macchetto, E. S. Perlman).

A team of astronomy researchers at Florida Institute of Technology and Rochester Institute of Technology in the United States and University of Sussex in the United Kingdom, find that the supermassive black hole (SMBH) at the center of the most massive local galaxy (M87) is not where it was expected. Their research, conducted using the Hubble Space Telescope (HST), concludes that the SMBH in M87 is displaced from the galaxy center.

The most likely cause for this SMBH to be off center is a previous merger between two older, less massive, SMBHs. "We also find, however, that the iconic M87 jet may have pushed the SMBH away from the galaxy center," said Daniel Batcheldor, Florida Tech assistant professor in the Department of Physics and Space Sciences, who led the investigation.

The study of M87 is part of a wider HST project directed by Andrew Robinson, professor of physics at RIT. "What may well be the most interesting thing about this work is the possibility that what we found is a signpost of a black hole merger, which is of interest to people looking for gravitational waves and for people modeling these systems as a demonstration that black holes really do merge," says Robinson. "The theoretical prediction is that when two black holes merge, the newly combined black hole receives a 'kick' due to the emission of gravitational waves, which can displace it from the center of the galaxy."

David Merritt, professor of physics at RIT, adds: "Once kicked, a supermassive black hole can take millions or billions of years to return to rest, especially at the center
of a large, diffuse galaxy like M87. So searching for displacements is an effective way to constrain the merger history of galaxies."

Jets, such as the one in M87, are commonly found in a class of objects called Active Galactic Nuclei. It is commonly believed that supermassive black holes can
become active as a result of the merger between two galaxies, the infall of material into the center of the galaxy, and the subsequent merger between their black holes.

Therefore, it is very possible that this finding could also be linked to how active galaxies—including quasars, the most luminous objects in the universe—are born and how their jets are formed.

This research will be presented at the American Astronomical Society (AAS) Conference on May 25 in Miami, Fla. It will also be published in *The Astrophysical Journal Letters* peer-reviewed scientific journal.

Because many galaxies have similar properties to M87, it is likely that SMBHs are commonly offset from their host galaxy centers. The potential offsets, however, would be very subtle and researchers would rely on the Hubble Space Telescope to detect them.

"Unfortunately, the highest spatial resolution camera onboard HST could not be revived during the recent servicing mission. This means we have to rely on the huge archive of HST data to find more of these vagrant SMBHs, as we did for M87," added Batcheldor.

Regardless of the displacement mechanism, the implication of this result is a necessary shift in the classic SMBH paradigm; no longer can it be assumed that all SMBHs reside at the centers of their host galaxies. This may result in some interesting impacts on a number of fundamental astronomical areas, and some
interesting questions.

For example, how would an accreting (growing by the gravitational attraction of matter) or quiescent SMBH interact with the surrounding nuclear environment as it moves through the bulge? What are the effects on the standard orientation-based unified model of active galactic nuclei and how have dynamical models of the SMBH mass been centered if the SMBH is quiescent?

Especially thought-provoking, added Eric Perlman, associate professor of physics and space sciences at Florida Tech, is that our own galaxy is expected to merge with the Andromeda galaxy in about three billion years. "The result of that merger will likely be an active elliptical galaxy, similar to M87. Both our galaxy and Andromeda have SMBHs in their centers, so our result suggests that after the merger, the SMBH may wander in the galaxy's nucleus for billions of years."

David Axon, Dean of Mathematical and Physical Sciences at Sussex, concludes by saying that "In current galaxy formation scenarios galaxies are thought to be
assembled by a process of merging. We should therefore expect that binary black holes and post coalescence recoiling black holes, like that in M87, are very common in the cosmos."

More information: "A Displaced Supermassive Black Hole in M87." The paper is available here: arXiv.org/abs/1005.2173

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