# Black hole nurtures baby stars a million light years away

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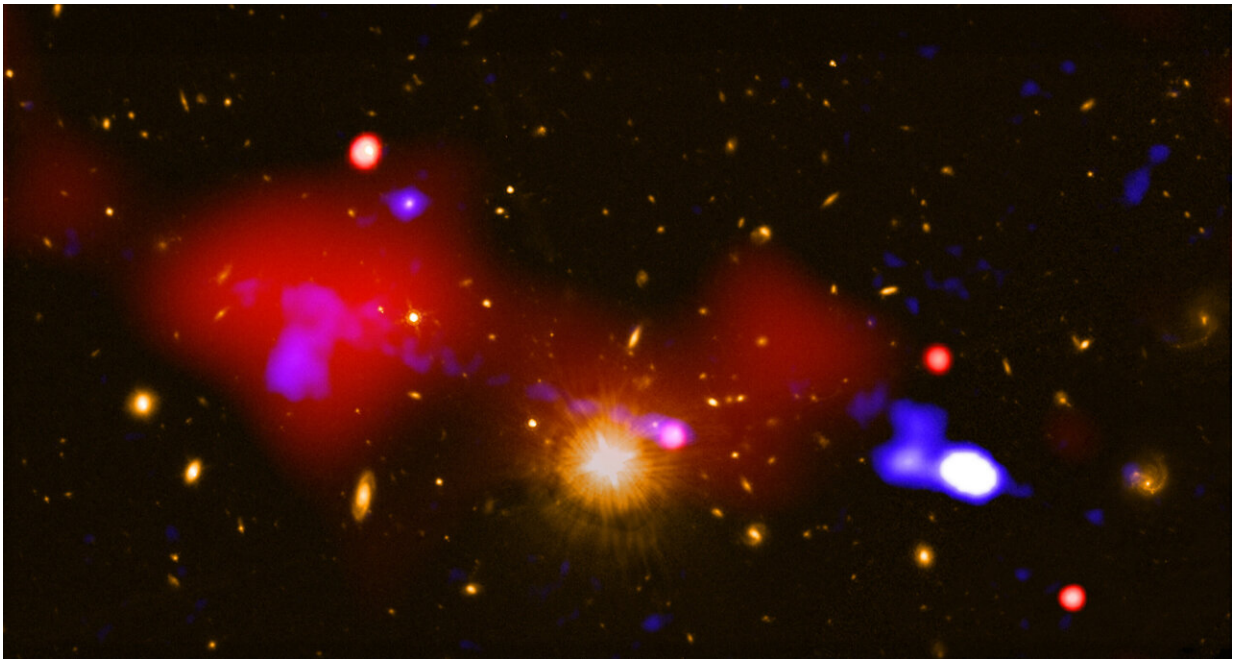

Credit: X-ray: NASA/CXC/INAF/R. Gilli et al.; Radio NRAO/VLA; Optical: NASA/STScI

Black holes are famous for ripping objects apart, including stars. But now, astronomers have uncovered a black hole that may have sparked the births of stars over a mind-boggling distance, and across multiple galaxies.

If confirmed, this discovery, made with NASA's Chandra X-ray Observatory and other telescopes, would represent the widest reach ever seen for a black hole acting as a stellar kick-starter. The black hole seems to have enhanced star formation more than one million light-years away. (One light-year is equal to 6 trillion miles.)

"This is the first time we've seen a single black hole boost star birth in more than one galaxy at a time," said Roberto Gilli of the National Institute of Astrophysics (INAF) in Bologna, Italy, lead author of the study describing the discovery. "It's amazing to think one galaxy's black hole can have a say in what happens in other galaxies millions of trillions of miles away."

A black hole is an extremely dense object from which no light can escape. The black hole's immense gravity pulls in surrounding gas and dust, but particles from a small amount of that material can also get catapulted away instead at nearly the speed of light. These fast-moving particles form two narrow beams or "jets" near the poles of the black hole.

The supermassive black hole scientists observed in the new study is located in the center of a galaxy about 9.9 billion light-years from Earth. This galaxy has at least seven neighboring galaxies, according to observations with the European Southern Observatory's Very Large Telescope (VLT) and the Large Binocular Telescope (LBT).

Using the National Science Foundation's Karl Jansky Very Large Array, scientists had previously detected radio-wave emission from a jet of high-energy particles that is about a million light-years long. The jet can be traced back to the supermassive black hole, which Chandra detected as a powerful source of X-rays produced by hot gas swirling around the black hole. Gilli and colleagues also detected a diffuse cloud of X-ray emission surrounding one end of the radio jet. This X-ray emission is most likely

from a gigantic bubble of hot gas heated by the interaction of the energetic particles in the radio jet with surrounding matter.

As the hot bubble expanded and swept through four neighboring galaxies, it could have created a shock wave that compressed cool gas in the galaxies, causing stars to form. All four galaxies are approximately the same distance, about 400,000 light-years, from the center of the bubble. The authors estimate that the star formation rate is between about two to five times higher than typical galaxies with similar masses and distance from Earth.

"The story of King Midas talks of his magic touch that can turn metal into gold," said co-author Marco Mignoli, also of INAF in Bologna, Italy. "Here we have a case of a black hole that helped turn gas into stars, and its reach is intergalactic."

Astronomers have seen many cases where a black hole affects its surroundings through "negative feedback"—in other words, curtailing the formation of new stars. This can occur when the black hole's jets inject so much energy into the hot gas of a galaxy, or galaxy cluster, that the gas can't cool down enough to make large numbers of stars.

In this newly discovered collection of galaxies, astronomers have found a less common example of "positive feedback," where the black hole's effects increase star formation. Moreover, when astronomers previously encountered positive feedback, it either involved increases in the star formation rate of 30% or less, or it occurred over scales of only about 20,000 to 50,000 light-years on a nearby companion galaxy. Whether the feedback is positive or negative depends on a delicate balance between the heating rate and cooling rate of a cloud. That is because clouds that are initially cooler when hit by a shock wave are more prone to experience positive feedback, and form more stars.

"Black holes have a well-earned reputation for being powerful and deadly, but not always," said co-author Alessandro Peca, formerly at INAF in Bologna and now a Ph.D. student at the University of Miami. "This is a prime example that they sometimes defy that stereotype and can be nurturing instead."

The researchers used a total of six days of Chandra observing time spread out over five months.

"It's only because of this very deep observation that we saw the hot gas bubble produced by the black hole," said co-author Colin Norman of the Johns Hopkins University in Baltimore, Maryland. "By targeting objects similar to this one, we may discover that positive feedback is very common in the formation of groups and clusters of galaxies."

A paper describing these results has been published in the most recent issue of the journal *Astronomy and Astrophysics*.

**More information:** "Discovery of a Galaxy Overdensity Around a Powerful, Heavily Obscured FRII Radio Galaxy at z=1.7: Star Formation Promoted by Large-Scale AGN Feedback?" R. Gilli et al., 2019, *Astronomy and Astrophysics*: arxiv.org/abs/1909.00814

Provided by Chandra X-ray Center