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Big Black Holes Can Block New Stars

October 21, 2014
FOR IMMEDIATE RELEASE
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Massive black holes spewing out radio-frequency-emitting particles at near-light speed can block formation of new stars in aging galaxies, a study has found.

The research provides crucial new evidence that it is these jets of "radio-frequency feedback" streaming from mature galaxies' central black holes that prevent hot free gas from cooling and collapsing into baby stars.

Elliptical galaxy NGC 1132, as seen by NASA's Chandra X-Ray Observatory; the blue/purple in the image is the X-ray glow from hot, diffuse gas that is not forming into stars. (Credit: NASA, ESA, M. West (ESO, Chile), and CXC/Penn State University/G. Garmire, et al.)

"When you look into the past history of the universe, you see these galaxies building stars," said Tobias Marriage, assistant professor of physics and astronomy at Johns Hopkins and co-lead author of the study. "At some point, they stop forming stars and the question is: Why? Basically, these active black holes give a reason for why stars stop forming in the universe."

The findings have been published in the journal *Monthly Notices of the Royal Astronomical Society*. They were made possible by adaptation of a well-known research technique for use in solving a new problem.

Johns Hopkins postdoctoral fellow Megan Gralla found that the Sunyaev–Zel'dovich effect signature – typically used to study large galaxy clusters – can also be used to learn a great deal about smaller formations. The SZ effect occurs when high-energy electrons in hot gas interact with faint light in the cosmic microwave background, light left over from earliest times when the universe was a thousand times hotter and a billion times denser than today.

"The SZ is usually used to study clusters of hundreds of galaxies but the galaxies we're looking for are much smaller and have just a companion or two," Gralla said.

"What we're doing is asking a different question than what has been previously asked," Gralla said. "We're using a technique that's been around for some time and that researchers have been very successful with, and we're using it to answer a totally different question in a totally different subfield of astronomy."

"I was stunned when I saw this paper, because I've never thought that detecting the SZ effect from active galactic nuclei was possible," said Eiichiro Komatsu, director of the Max Planck Institute for Astrophysics in Germany and an expert in the field who was not involved in the research. "I was wrong. … It makes those of us who work on the SZ effect from galaxy clusters feel old; research on the SZ effect has entered a new era."

In space, hot gas drawn into a galaxy can cool and condense, forming stars. Some gas also funnels down into the galaxy's black hole, which grows together with the stellar population. This cycle can repeat continuously; more gas is pulled in to cool and condense, more stars begin to shine and the central black hole grows more massive.

But in nearly all mature galaxies – the big galaxies called "elliptical" because of their shape – that gas doesn't cool any more. "If gas is kept hot, it can't collapse," Marriage said. When that happens: No new stars.

Marriage, Gralla and their collaborators found that the elliptical galaxies with radio-frequency feedback – relativistic radio-frequency-emitting particles shooting from the massive central black holes at their center at close to the speed of light – all contain hot gas and a dearth of infant stars. That provides crucial evidence for their hypothesis that this radio-frequency feedback is the "off switch" for star-making in mature galaxies.

Marriage said, however, that it is still not known just why black holes in mature elliptical galaxies begin to emit radio-frequency feedback. "The exact mechanism behind this is not fully understood and there are still debates," he said.

Komatsu said that the new Johns Hopkins-led study, combined with others detecting SZ signals from more ordinary galaxies, “pose new challenges to the theory of galaxy formation, as there were hardly any data which told us how much hot gas there is around galaxies.”

Marriage and Gralla were joined as co-lead authors by Devin Crichton, a Johns Hopkins graduate student in physics and astronomy, and Wenli Mo, a physics and astronomy undergraduate student who earned her degree in May 2011. She is now studying at the University of Florida on a National Science Foundation Graduate Fellowship.

The team used data from the Atacama Cosmology Telescope, a 6-meter telescope in northern Chile; the National Radio Astronomy Observatory’s Very Large Array in New Mexico and its Green Bank Telescope in West Virginia; the Parkes Observatory in Australia; and the European Space Agency’s Herschel Space Observatory.

Collaborators were from the University of Pennsylvania; Carnegie Mellon; the California Institute of Technology; Princeton; Florida State; Rutgers; the University of Pittsburgh; the University of California, Santa Barbara; the University of Illinois at Urbana-Champaign; Cornell; Haverford College; Moorpark College; Stony Brook University; Pontificia Universidad Católica de Chile; the universities of British Columbia and Toronto in Canada; the University of KwaZulu-Natal in South Africa; the universities of Nottingham, Edinburgh and Sussex in the United Kingdom; Academia Sinica in Taiwan; Leiden University in the Netherlands; and NASA’s Jet Propulsion Laboratory and Goddard Space Flight Center. This research was supported by the National Science Foundation grants AST- - 0408698, AST- - 0965625, PHY- - 0855887 and PHY- - 1214379.

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October 21, 2014 Tags: astrophysics, black holes, galaxies, Megan Gralla, stars, Tobias Marriage
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