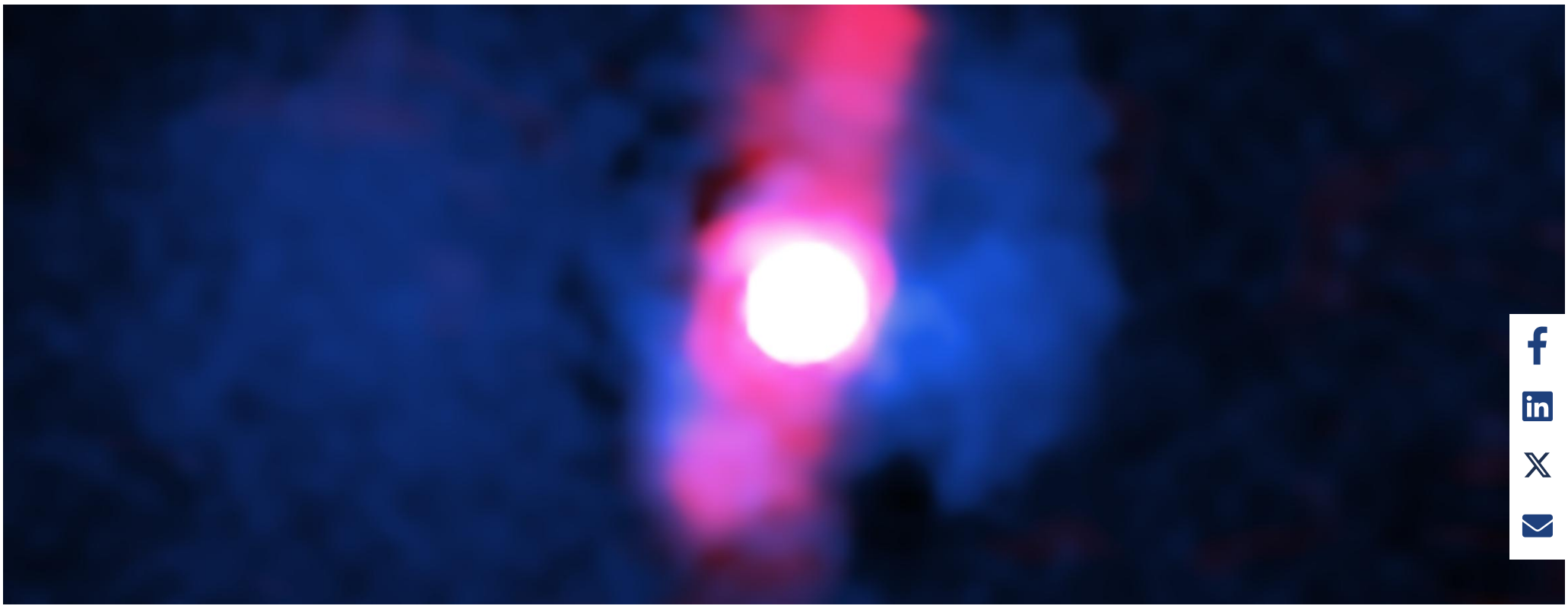

News

NASA’s Chandra identifies a black hole whose bark is worse than its bite

The quasar produces high levels of radiation and powerful jets, but it has less influence on its surroundings than expected

21 March 2024

Astronomers have revealed that a brilliant supermassive black hole is not living up to expectations. Although it is responsible for high levels of radiation and powerful jets, this giant black hole is not as influential on its surroundings as many of its counterparts in other galaxies.

A paper describing these results, by a team including **W. Niel Brandt**, the Eberly Family Chair Professor of Astronomy and Astrophysics and professor of physics at Penn State, appeared in the Monthly Notices of the Royal Astronomical Society.

The study, using data from NASA’s Chandra X-ray Observatory, looked at the closest quasar to Earth. Known as H1821+643, this quasar is about 3.4 billion light-years from Earth and sits in a cluster of galaxies. Quasars are a rare and extreme class of supermassive black holes that are furiously pulling material inwards,

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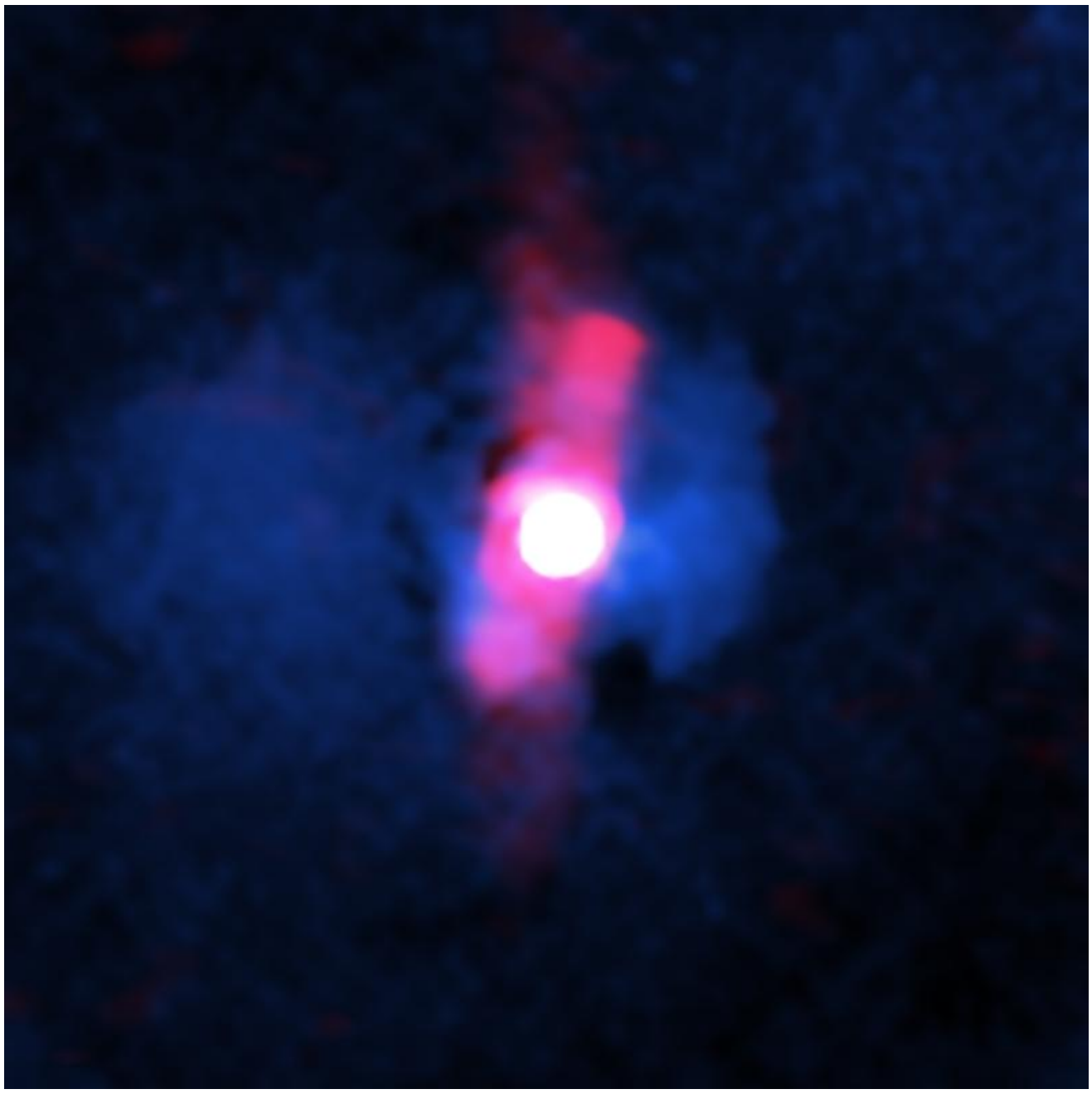
producing intense radiation and sometimes powerful jets.

"I have long desired to investigate this remarkable quasar better with Chandra's keen eyesight," Brandt said. "I suspected this quasar's `bark' would be worse than its `bite' — that is, its impressive pyrotechnics do not imply similarly impressive environmental impact. I'm delighted that our dogged determination eventually paid off and confirmed my suspicions!"



In the center of this image is the quasar H1821+643, a rapidly growing supermassive black hole that astronomers have found is underachieving, despite producing intense radiation and a jet of particles seen in radio data from the Very Large Array (red). Located in the middle of a cluster of galaxies, H1821+643 is surrounded by huge quantities of hot gas detected in X-rays by Chandra (blue). The high temperatures and densities of the hot gas around the quasar shows that the black hole is having a weaker impact on its host galaxy than many of its other counterparts in other galaxy clusters. H1821+643 is the closest quasar to Earth in a cluster of galaxies. It is located 3.4 billion light-years from Earth and the image is about a million light-years across at the distance of the quasar. Credit: X-ray: NASA/CXC/Univ. of Nottingham/H. Russell et al.; Radio: NSF/NRAO/VLA; Image Processing: NASA/CXC/SAO/N. Wolk

Most growing supermassive black holes pull material in less quickly than quasars. Astronomers have studied the impact of these more common black holes by observing ones in the centers of galaxy clusters. Regular outbursts from such black holes prevent the huge amounts of superheated gas they are embedded in from cooling down, which limits how many stars form in their host galaxies and how much fuel gets funneled toward the black hole. Much less is known about how much influence quasars in galaxy clusters have on their surroundings.

“We have found that the quasar in our study appears to have relinquished much of the control imposed by more slowly growing black holes,” said **Helen Russell** of the University of Nottingham in the United Kingdom, who led the new study. “The black hole’s appetite is not matched by its influence.”

To reach this conclusion, the team used Chandra to study the hot gas that H1821+643 and its host galaxy are shrouded in. The bright X-rays from the quasar, however, made it difficult to study the weaker X-rays from the hot gas.

“We had to carefully remove the X-ray glare to reveal what the black hole’s influence is,” said co-author **Paul Nulsen** of the Center for Astrophysics, Harvard

and the Smithsonian. “We could then see that it’s actually having little effect on its surroundings.”

The team found that the density of gas near the black hole in the center of the galaxy is much higher, and the gas temperatures much lower, than in regions farther away. Scientists expect the hot gas to behave like this when there are little or no sources of energy — typically outbursts from a black hole — to prevent the hot gas from cooling down and flowing towards the center of the cluster.

“The giant black hole is generating a lot less heat than most of the others in the centers of galaxy clusters,” said co-author **Lucy Clews** of the Open University in the U.K. “This allows the hot gas to rapidly cool down and form new stars, and also act as a fuel source for the black hole.”

The researchers determined that hot gas equivalent to about 3,000 times the mass of the sun per year is cooling to the point that it is no longer visible in X-rays. This rapid cooling can easily supply enough material for the 120 solar masses of new stars observed to form in the host galaxy every year, and the 40 solar masses consumed by the black hole each year.

The team also examined the possibility that the radiation from the quasar is directly causing the cluster’s hot gas to cool down. This involves photons of light from the quasar colliding with electrons in the hot gas, causing the photons to become more energetic and the electrons to lose energy and cool down. The team’s study showed that this type of cooling is probably occurring in the cluster containing H1821+643 but is much too weak to explain the large amount of gas cooling seen.

“While this black hole may be underachieving by not pumping heat into its environment, the current state of affairs will likely not last forever,” said co-author **Thomas Braben** of the University of Nottingham. “Eventually the rapid fuel intake by the black hole should increase the power of its jets and strongly heat the gas. The growth of the black hole and its galaxy should then drastically slow down.”

Brandt’s work on the project was supported by the Penn State Eberly Family Chair in Astronomy and Astrophysics and the Chandra X-ray Center.

Editor’s note: A version of this story appeared on the **Chandra X-ray Center website**.

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